Clinton School Demonstration Project Final Report

A greenhouse and compost station to enhance the ecology focus in the Clinton community

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Abstract

The theme of our demonstration project was ESCAPE—Energized Students at Clinton Applying Principles of Ecology. Our goal was to bring students into the beautiful outdoor setting surrounding the Clinton school to let them pursue inquiries regarding ecology. As part of this goal, we built a new greenhouse available to all grade levels at the school (K-8). Implementation of the greenhouse was stalled in the Fall semester due to a variety of factors including inclement weather. We completed the greenhouse during the Spring semester, thanks in large part to Jon Roske, the president of the school board and father of one of our fourth grade students.

Introduction

Our demonstration project involved the construction of a greenhouse. This structure provides an outdoor laboratory that will engage students in several energy concepts, including solar energy, photosynthesis, and biodegradation. The greenhouse will be available for years to come as an environment in which students can conduct experiments to discover energy relationships in the natural world. We also planned to build a compost station, but we were not able to obtain enough donations for the building materials required for the greenhouse. Therefore, the compost station was not completed. Our goals are in line with the ECOS mission in that the students will conduct outdoor experiments to learn about ecological concepts. They will grow plants and learn about the interactions between heat, soil, and biology.

Schoolyard Demonstration Project Description

Our demonstration project theme was ESCAPE—Energized Students at Clinton Applying Principles of Ecology. Our goal was to bring students into the beautiful outdoor setting surrounding the Clinton school to let them pursue inquiries regarding energy and ecology. To accomplish our goal, we built a new greenhouse available to all grade levels at the school (K-8).

The construction of the greenhouse occurred during the second semester of the 2006-2007 school year. We designed and built the majority of the greenhouse ourselves, but we also enlisted volunteers from the community for certain tasks, including some construction. We also sought guidance from greenhouse experts from Missoula, Clinton, and Billings (see below). We solicited donations from local companies for gravel.

Our greenhouse design was relatively simple. We built a wooden frame composed of 4x4s and 2x4s, with ½ inch plywood walls. The south-facing wall and roof (also south-facing) are composed of corrugated polycarbonate. The dimensions of the greenhouse are approximately eight feet wide and twenty feet long.

The construction of the greenhouse could not have been completed without the generous help of Roy Pete, who dug the hole for the concrete block foundation, and Jon Roske, who provided appropriate building expertise, tools, and much time.

The greenhouse is functional. It has a gravel floor, polycarbonate ceiling and south-facing wall, steel door with a lock, air vents on the east- and west-facing walls, and painted sides. Electricity may be added in the future. Several police departments donated grow-lights that can be used with an extension cord until electricity is added. Brooke McBride, former ECOS fellow and current wife of the Clinton Elementary principal, plans to paint a mural on the east-facing wall soon. Mandy McGill and the rest of the Clinton Elementary teachers are excited to begin planting in the greenhouse at the beginning of the 2007-2008 school year.

Key Contributors

Jon Roske is the president of the school board, the father of one of the fourth grade students, and a furniture maker in the Clinton area. He generously offered his skills, and we couldn't have completed such a project without him.

Debbie Lorenzo is the owner of *Clinton Farms*, a local greenhouse company in Clinton that sells potted flowers and bedding plants to the greater Missoula community. We have already enlisted her advice and support for the construction and maintenance of the greenhouse.

Adam Grigsby is the owner of *Continental Horticultural Supply*, a company in Billings, MT, that sells greenhouse frames and internal components. In addition he is a former agriculture teacher from Bridger, MT, and oversaw the construction of a greenhouse for his students there. He has given us advice on greenhouse construction and has offered discounted prices on equipment ordered through his company.

The Missoula Police Department has offered confiscated goods for educational purposes, including grow lights and shelves.

Joss McKinnon's advisor is Paul Alaback. Paul is one of the leading greenhouse experts in Missoula, as well as a forest ecologist. His expertise will be invaluable in our efforts to construct and use the greenhouse as a teaching and learning tool.

Johnny MacLean's advisor is Jim Sears. Jim is a leading expert in the geologic history of the northern Rockies in Montana. His expertise could be utilized in relating earth processes to the natural habitats and ecosystems in the region.

Sustainability

Teachers must use this greenhouse each year to sustain it. Little upkeep is necessary, besides keeping it neat and tidy, and possibly killing hornets nests, etc. Eventually (~ten years from now), the corrugated polycarbonate ceiling may need to be replaced. The best way for future fellows to integrate the greenhouse with an additional project would be to purchase weather devices and incorporate the greenhouse into inquiries.

Summary

We constructed a new, permanent greenhouse to serve as a laboratory for K-8 students at Clinton Elementary. For years to come, they will be able to perform experiments that involve plants, energy, weather, microorganisms, and much more. We accomplished our goal of allowing students to learn in the beautiful outdoor setting surrounding the Clinton school and to pursue inquiries regarding energy and ecology.

Appendix 1—Selected Pictures (We also provided the ECOS office with a CD of all of our photos for the entire year).

From Left: Nathaniel, Dalton, Jack, Connor, Dakota, Joss, Stevie, Kathy, Dakoda, Anna, Brittnea, Morgan.

From Left: Chance, Becca, Callie, Daniel, Joss, Austin, Kaitlin, Alyssa, Kayla, Christian.

From Left: Blade, Chance, Becca, Callie, Austin, Joss, Daniel, Kaitlin, Kayla.

From Left: Connor, Marina, Jack, Johnny.

From Left: Johnny, Marina, Connor, Jack, Brittnea, Morgan, Zane, Alex.

From Left: Dalton, Nathaniel, Joss, Dakoda, Jack, Brittnea, Kathy, Grace, Connor, Morgan, Zane.

From Left: Dalton, Joss, Jack, Grace, Kathy, Damion, Dakota, Morgan, Stevie, Zane.

Appendix 2—Curricula

ECOS
Ecologists Educators and Schools: Partners in GK-12 Education

ECOS Inquiry

1. CONTRIBUTOR'S NAME: JOHNNY MACLEAN

2. NAME OF INQUIRY: ENERGY IN SUSPENSION

3. GOALS AND OBJECTIVES:

a. Inquiry Questions: How much energy is required to put clay, silt, sand, and gravel into suspension in water?

b. Ecological Theme(s): Effect of erosion on aquatic and riparian habitats

c. General Goal: Students will conduct an experiment to determine the energy required to put various particles such as sand, silt, and clay into suspension.

d. Specific Objectives: Measure the amount of energy required to suspend clay particles, silt particles, sand particles, and gravel particles in water. Compare the results with natural environments containing differing energies, such as mountain streams, big rivers, lakes, near shore environments, etc.

e. Grade Level: 4,5

f. Duration/Time Required:

→ Prep time: 30 minutes
→ Implementing Exercise During Class: 45 minutes
→ Assessment: 10 minutes

4. ECOLOGICAL AND SCIENCE CONTEXT:

Background: The number one pollutant of surface water is sediment. It transports pollutants and pathogens that affect the recreational value and the aesthetics of our waterways. Suspended particles cloud the water and screen out sunlight which impacts water quality by degrading the habitat for aquatic organisms, plants and fish. It also promotes the growth of weeds and algae. Neighborhood flooding and further erosion is produced when storm water drainage channels become clogged with sediment. In addition, sedimentation decreases the capacity of reservoirs to hold water and restricts infiltration of moisture into our wells and ground water storage. Understanding sediment transport connects earth processes to ecological processes by relating erosion to aquatic and riparian habitats.

5. MOTIVATION AND INCENTIVE FOR LEARNING:

Inquiry is done outside. Students design their own experiment (hopefully). Students use hoses, running water, and real sediment.

6. VOCABULARY (definitions from www.wikipedia.com):

- Clay—minerals that are typically less than 2 μm (micrometers) in diameter.

- Erosion—the displacement of solids (soil, mud, rock and other particles) by the agents of wind, water or ice, by downward or down-slope movement in response to gravity or by living organisms (in the case of bioerosion).
- Gravel—any loose rock that is at least two millimeters in its largest dimension (about 1/12 of an inch), and no more than 75 millimeters (about 3 inches).
- Sand—a naturally occurring, finely divided rock, comprising particles or granules ranging in size from 0.0625 (or 1/16) to 2 millimeters.
- Sediment—any particulate matter that can be transported by fluid flow and which eventually is deposited as a layer of solid particles on the bed or bottom of a body of water or other liquid.
- Silt—particles below 0.0625 mm down to 0.004 mm in size.
- Suspension—the transport of sediments in rivers and oceans. Particles that are suspended remain suspended so long as energy (provided in the form of a current) is applied to the system. The amount of energy determines the maximum size of particle that can be suspended. In the absence of additional energy (agitation), all particles down to colloidal size will eventually settle out into a distinct phase.

7. SAFETY INFORMATION:

Take care to provide a safe environment for the use of water. Beware of using water in cold weather. Make clear rules regarding use of hoses and buckets.

8. MATERIALS LIST (including any handouts or transparency masters):

Water faucets
Hoses
Buckets (4 buckets per group of ~4 students)
Gravel (enough for each group to have one bucket 25% filled with gravel)
Sand (same)
Silt (same)
Clay (same)
Large spoons for stirring
Data sheet (attached)
Optional: flumes from Hellgate High School (thanks to Dave Oberbillig)

9. METHODS/PROCEDURE FOR STUDENTS:

a. Pre-investigation work: Teacher introduces the concepts of erosion, sediment, suspension, and the effects of erosion on habitats. Teacher leads class in a discussion of how to measure the energy required to put different types of sediment into suspension. Students design an experiment using the materials provided to answer the question: How much energy is required to put clay, silt, sand, and gravel into suspension in water?

b. Investigation work:

1) What evidence (data, samples) do students collect? Students (in groups of 4 or so) design their own experiment, but they will collect some sort of data regarding the force of the water resulting from stirring (vigorous, medium, or calm) that is necessary to agitate each kind of sediment into suspension (the sediment should be at rest under water in the bottom of a bucket).

2) How do students present the evidence (data)? Students present their data on the data sheet (attached).

3) What conclusions are drawn from the evidence students collect? Students conclude the relative (and possibly quantitative) energy requirements to suspend different types of sediment.

10. ASSESSMENT:

Teacher will monitor experiment designs and will review data sheets. Once the groups have completed their experiments, the class will reconvene and discuss results and ecological implications.

11. EXTENSION IDEAS:

With Hellgate High School's flumes, students could measure more accurately the amount of force necessary to suspend particles.

It could be possible to observe a stream bed at different times of the year and to discuss how spring flooding causes cloudy, fast-moving water compared to autumn's low streams. This could lead into more discussion on how local ecosystems change during the course of the year. Students could also investigate erosion rates in big flat rivers compared to small steep rivers.

12. SCALABILITY

This could be scaled to higher levels by adding more quantitative measurements and increasing the discussion of ecological impacts.

13. REFERENCES:

www.wikipedia.com

14. LIST OF EXPERTS AND CONSULTANTS

Marc Hendrix—sedimentary geology professor at University of Montana

15. EVALUATION/REFLECTION BY FELLOWS AND TEACHERS OF HOW IT WENT:

ENERGY IN SUSPENSION

DATA SHEET

Names of Group Members

____

1. How did you measure the energy required to put the gravel, sand, silt, and clay into suspension?

2. What were your results?

	Gravel	Sand	Silt	Clay
Energy on 1st try				
Energy on 2nd try				
Energy on 3rd try				
Average *(add the 3 together and divide by 3)*				

3. How much energy is required to put gravel, sand, silt, and clay into suspension in water?

Ecologists Educators and Schools: Partners in GK-12 Education

ECOS Inquiry

1. CONTRIBUTOR'S NAME: JOHNNY MACLEAN

2. NAME OF INQUIRY: COMPARING GRAVELS

3. GOALS AND OBJECTIVES:

a. Inquiry Questions: How do rounded river rocks, angular river rocks, and glacial till differ? Why?

b. Ecological Theme(s): The physical environment directly affects ecosystems and habitats. Earth processes contribute to the continual change in the physical environment.

c. General Goal: Students will begin to make connections between biotic and abiotic processes. They will learn one way to deduce ancient environments from observations of breccias and conglomerates.

d. Specific Objectives: Students will make observations regarding gravel morphology (size and shape of rock particles) of gravels from glacial till, a riverbed collecting gravel from a nearby source, and a riverbed with well-traveled gravel. They will conclude from their observations which environment will produce which morphology. They will infer possible ancient environments by observing breccias and conglomerates from Western Montana.

e. Grade Level: 4,5

f. Duration/Time Required:

→ Prep time: 30 minutes
→ Implementing Exercise During Class: 30 minutes
→ Assessment: 10 minutes

4. ECOLOGICAL AND SCIENCE CONTEXT:

Background: Geologists deduce ancient environments by studying the size, shape, and sorting of clasts within breccias and conglomerates (definitions provided below). Students can infer ancient environments as well, once they learn the reasoning involved. There are 2 main concepts to review: roundness and sorting.

Roundness is obviously how rounded a rock is. Gravel that has been transported for many miles in a river typically undergoes physical erosion, causing the sharp corners to break off. The river system acts as a tumbler, and the gravel becomes quite rounded. Alternatively, a river that collects gravel from a nearby mountain will contain angular gravel because it has not yet undergone the physical erosion. Geologists can look at a conglomerate or breccia and determine whether the source mountain for the gravel was close to where the gravel ended up, or whether the gravel traveled miles and miles from the source mountain.

Sorting refers to whether the gravel particles are all the same size, or whether there are 2 or more sizes of particles present. A well-sorted gravel has particles that are all the same size: a poorly-sorted gravel has particles of multiple sizes. River rocks typically have two sizes of particles: one size of gravel and one size of sand. Glacial till typically has multiple sizes of particles. Geologists can discern ancient environments by studying the sorting of breccias and conglomerates.

5. MOTIVATION AND INCENTIVE FOR LEARNING:

Students get to observe rocks and use the same scientific techniques as real geologists. And who doesn't like to 'play with rocks?'

6. VOCABULARY (from www.wikipedia.com):

- Breccia—a sedimentary rock composed of angular fragments in a matrix that may be of a similar or a different material.
- Clasts—broken pieces of older weathered and eroded rocks.
- Conglomerate—sedimentary rocks consisting of rounded fragments and are thus differentiated from breccias, which consist of angular clasts. Both conglomerates and breccias are characterized by clasts larger than sand (>2 mm).
- Glacial till—rock debris, fallen or plucked from a mountain and transported by glaciers or ice sheets.

7. SAFETY INFORMATION:

Students should not throw rocks.

8. MATERIALS LIST (including any handouts or transparency masters):

Rounded river rocks
Angular river rocks
Poorly sorted glacial till
Well-sorted conglomerate (from an ancient valley river)
Well-sorted breccia (from an ancient mountain river)
Poorly-sorted conglomerate (from an ancient glacier)
Data sheet (attached)

9. METHODS/PROCEDURE FOR STUDENTS:

a. Pre-investigation work: Teacher leads students in a discussion of the difference between three environments—mountain glaciers, mountain rivers, and valley rivers. They discuss what types of organisms live in each environment. Then they discuss how these environments could have changed through time, and why people may be interested in what the environment was like a long time ago. Students are then presented with 3 rocks: a poorly-sorted conglomerate, a well-sorted conglomerate, and a well-sorted breccia. They should focus especially on the clasts within the rock. They are asked, "Which rock came from an ancient glacier, which from an ancient mountain river, and which from an ancient valley river? Why did you guess the way you did?"

b. Investigation work:

1) What evidence (data, samples) do students collect? Students discuss and collect observations regarding the three rocks. They make predictions based on their observations as to which rock corresponds to which environment. Then they should come up with (or be led to ask) the question of what current gravels look like in each of the three environments. The teacher presents the three types of gravel, and tells them where they came from (if there are rivers nearby, a short fieldtrip to the river could be

very useful). The students make more observations regarding the sizes and shapes of the clasts.

2) How do students present the evidence (data)? Students are to draw pictures and write down observations regarding the clasts' shapes and sizes in each rock and in each gravel sample. This can be done on the observation sheet or in their science journal.

3) What conclusions are drawn from the evidence students collect? Students draw conclusions regarding which gravel sample corresponds to which rock sample based on their environments.

10. ASSESSMENT:

The teacher should oversee discussions and observations of rock samples and gravels. They should also review the observation sheets or science notebooks.

11. EXTENSION IDEAS:

Students could find different rivers around Missoula and discern whether it contains well-traveled gravel (rounded) or gravel from a proximal source (angular). There are also areas with glacial till near Missoula that parents could take their children to.

Students could discuss the ancient environments around the Missoula area based on the presence of glacial till. The organisms that inhabit western Montana are affected by its climate and physical landscape.

12. SCALABILITY

This inquiry could be scaled to older ages by incorporating more variables such as composition, and by relating all variables to plate tectonic processes.

13. REFERENCES:

www.wikipedia.com

14. EVALUATION/REFLECTION BY FELLOWS AND TEACHERS OF HOW IT WENT:

COMPARING GRAVELS

DATA SHEET

Name ____

Write down your observations in the appropriate box.

Observations of Rock Sample #1	Observations of Rock Sample #2	Observations of Rock Sample #3

Observations of Gravel A	Observations of Gravel B	Observations of Gravel C

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ECOS Inquiry

1. Contributor's Name: Joss McKinnon

2. Name of Inquiry: So Many Soils, Why are They Different?

3. Goals and Objectives:

a. Inquiry Questions: How is soil formed? What factors impact the type of soil present in a particular location?

b. Ecological Theme(s): Soil formation and differentiation.

c. General Goal: To introduce students to the process of soil formation and the factors that affect it.

d. Specific Objectives: Observe the transportation of materials through the soil profile. Examine the effects of increased rainfall, litter, mineral content, and time on this process.

e. Grade Level: 4-5

f. Duration/Time Required:

→ **Prep time:** 1 Hour

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

→ **Assessment:** 10 minutes

4. Ecological and Science Context:

a. Background (for Teachers):

The formation of soil in the environment is governed by five major factors:

1) Parent Materials: The geologic or organic precursors to the soil.

2) Climate: Primarily precipitation and temperature.

3) Biota: Living organisms, especially native vegetation, microbes, soil animals, and human beings.

4) Topography: Slope, aspect, and landscape position.

5) Time: The period of time since the parent materials became exposed to soil formation.

Soils are often defined as "dynamic natural bodies having properties derived from the combined effects of climate and biotic activities, as modified by topography, acting on parent materials over periods of time". In other words the particular soil at a location has been formed through the interaction of the five soil forming factors, and an alteration to any of the first four factors will result in an alteration in the soil present (given sufficient time).

b. Background (to present to Students):

Because the students will have already been exposed to different soil types in a previous inquiry (A Tour of Soils), a general explanation of the influence of the five soil forming factors will provide the students with sufficient background knowledge for this investigation.

5. Motivation and Incentive for Learning:

Soil represents the intersection between geologic materials and the biologic organisms that live on or near the earth's surface. Because of this, soil is the foundation of all terrestrial (non-aquatic) ecosystems throughout the world. As such, any attempt to study these ecosystems must include some attention to the role of soil, and the various factors that have influenced its formation. Additionally this investigation will allow the children to *escape* the classroom and get outside, and the colorful, dynamic nature of the experiment should ensure their interest.

6. Vocabulary:

Aspect: The direction that a slope faces (e.g., north or south).
Biota: The plant and animal life of a region or area.
Clay: Soil particles that are less than 0.002 mm in diameter.
Climate: The weather of a region or area averaged over a long period of time.
Parent Materials: The geologic or organic materials that undergo weathering to produce soil.
Sand: Soil particles that are between 0.05 and 2.0 mm in diameter.
Silt: Soil particles that are between 0.002 and 0.05 mm in diameter.
Slope: The angle of a surface as it deviates from horizontal, usually measured as percent, numerical ratio, or degrees.
Time: In this case, the period of time since parent materials became exposed to soil formation.
Topography: Refers to the lie of the land, or other characteristics of physical geography in a region; in this case slope, aspect, and landscape position.
Translocation: The movement of materials, either vertically or horizontally, through the soil, often linked with the movement of water.
Weathering, chemical: Changes produced in rocks and minerals through chemical processes (dissolving, acidic reactions, oxidation/reduction reactions, etc.).
Weathering, physical: produced in rocks and minerals through physical processes (temperature changes, abrasion by water, ice and wind).

7. Safety Information:

Nothing to note.

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

Clear plastic cups with holes in the base and 1.0 cm increments marked on the sides.

Paper chips (~1cm^2)
Food coloring (red and green)
Water
Gypsum sand (white)
Data sheet handouts

9. Methods/Procedure for students:

a. Pre-investigation work:

Think about the various soil types that were seen in the previous inquiry (A Tour of Soils). What were some of the major differences between each soil type? What factors might account for these differences?

b. Investigation work:

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

Students (in groups of 4 or so) will conduct an experiment that will illustrate the impact of a change in one of the soil forming factors (biota, climate or parent material) over time. This will be accomplished through the use of chips of paper soaked in food coloring, which will represent minerals in the parent material (red) and dead leaves on the surface (green). The soil system will be represented by a sand filled cup which has red paper scattered throughout, and a specified number of green pieces will be added to the top prior to each watering. The students will alter either the amounts of one color of paper, or alter the amount of water added to the system for each period of soil development. As water is added the food coloring will leach off of the paper and translocate to a new position in the "soil". Students will quantify this "soil development" on their data sheet for each period.

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

Students will present their data on the data sheet provided. Following the experiment each group should discuss their findings and present a brief explanation to the rest of the class.

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

Following the presentations students should have an understanding of the potential influence of each of the three soil forming factors on soil development, and should also see the importance of time as it relates to each.

4) Include examples of data sheets.

The data sheet is attached at the end of the inquiry.

10. Assessment:

The teacher will monitor experiments and will review all data sheets. Once the groups have completed their experiments and presentations, the class will discuss the overall results and ecological implications.

11. Extension Ideas:

Following this investigation it might be beneficial to return to the soil pits visited during the Tour of Soils inquiry in order to further cement the connection between the soil forming factors and the resulting soil that has been formed. This could lead to a new discussion of the factors that might differ between each site and the resulting differences in each soil.

12. Scalability:

This investigation can be scaled up to be more appropriate for high school students by focusing more on the specific nutrients/compounds that are undergoing this translocation process, and perhaps by adding a new element to the experiment involving uptake by plant roots. In addition, students might make some more quantitative measurements of water and dye leaching out from the system, and even attempt to set it up using combinations of sand, silt and clay to mimic actual textural classes of natural soil.

This investigation can be scaled down to be more appropriate for younger students by making it a demonstration project illustrating the transportation of materials through the soil system over time, but removing the experimental aspect.

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.

Physical Science: Properties of objects and materials.

Life Sciences: Organisms and environments.

Earth and Space Science: Properties of earth materials, Changes in the earth and sky.

Science in Personal and Social Perspectives: 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.

Physical Science: Properties and changes of properties in matter.

Life Sciences: Populations and ecosystems.

Earth and Space Science: Structure of the earth system.

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

History and Nature of Science: Nature of science.

14. References:

Brady, N.C., and Weil, R.R. 2002. The Nature and Properties of Soils, Thirteenth Edition. Prentice Hall, Upper Saddle River, NJ.

www.wikipedia.com

15. List of Experts and Consultants:

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

SO MANY SOILS

DATA SHEET

Names of Group Members

____

3. Which soil forming factor did your group decide to alter? Describe how you made these alterations.

4. What were your results?

	Cup #1	**Cup #2**	**Cup #3**
Year 1			
Year 2			
Year 3			

Year 4			
Year 5			
Year 6			
Year 7			
Year 8			
Year 9			
Year 10			

5. Describe the trend you noticed in the results, what was the effect of your alterations, what was the effect of time?

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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				