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A unique professional development and science enrichment opportunity for teachers and students grades 5-8

2011-2012 Workshops

EARTH SYSTEMS SCIENCE:

EXPLORING CHANGE IN THE CRITICAL ZONE

Science Discovery
UNIVERSITY OF COLORADO BOULDER

BOULDER CREEK CZO

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UNIVERSITY OF COLORADO BOULDER

Science Explorers 2011-2012

A unique professional development and science enrichment opportunity for teachers and students grades

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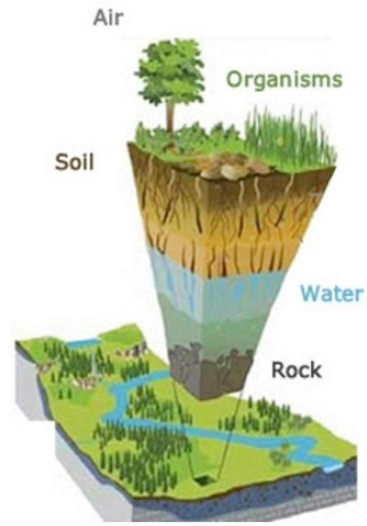
Earth Systems Science: Exploring Change in the Critical Zone
www.colorado.edu/sciencediscovery/teachers/sciex.html

EARTH SYSTEMS SCIENCE:

EXPLORING CHANGE IN THE CRITICAL ZONE



The Critical Zone is Earth's porous near-surface layer, from the tops of the trees down to the deepest groundwater. It is a living, breathing, constantly evolving boundary layer where rock, soil, water, air, and living organisms interact. The Critical Zone is home to complex interactions that control the availability of life-sustaining resources like food and water.

Scientific research in the Critical Zone focuses on understanding how the system operates, how it evolves, and how it will respond to future changes in land-use and climate. Research in the Boulder Creek Watershed, part of the National Science Foundation's Critical Zone Observatory Program, strives to understand how the area's geology, hydrology, ecology, and climate interact to provide and control the availability of water resources in three key areas represented in the learning modules described below.

Foundations for Flow:
In this module, learners and teachers will build a Colorado watershed from the bedrock up and wear it down with constructive and destructive forces over time. Using snow, ice, and summer rains they will create glaciers, streams, and rivers to grind the mountains down to the landforms that we see today. They will see how events in our geological past, including the formation of sedimentary rock layers, mountain building, uplift, and erosion combine to form the foundations of the watershed.

Fire and Water:
Using computer mapping and hands-on experiments, participants will explore the relationships between ecosystems, wildfires, soils, and water. They will predict fire intensity and see how wildfires impact soils, erosion, and water quality. They will conduct experiments to help them understand how different soils impact water flow and storage, how forest fires change soil and surface structures, and how these factors combine to impact both water quality and water availability in the watershed.

Ice, Snow and H_2O:
This chilly module focuses on how weather, climate, snow, and ice impact the Earth System Interactions that supply year-round water to Colorado, with only the occasional flood or landslide. Participants will conduct experiments with snow, ice, and use weather data, measurements, and math to understand the relationship between glaciers, snowpack, and our water supply.

For more information of the Boulder Creek Critical Zone Observatory Program visit the program website at: http://czo.colorado.edu

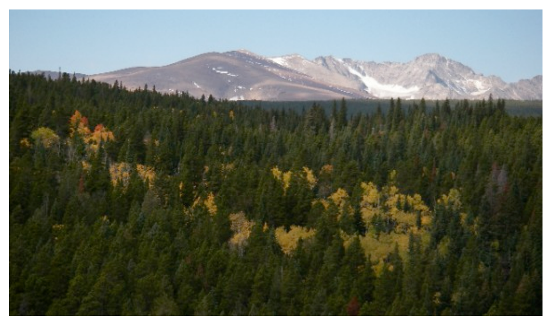
EARTH SYSTEMS SCIENCE:

EXPLORING CHANGE IN THE CRITICAL ZONE

2011-2012 Workshop Schedule

8:45 – 9:15	Registration
9:15 – 9:35	Introduction
9:40 – 10:55	First Module
11:00 – 11:45	Lunch
11:45 – 1:00	Second Module
1:00 – 1:15	Break
1:15 – 2:30	Third Module
2:30 – 3:00	Wrap-up/Evaluation

First Module:
Team A: Foundations for Flow
Team B: Ice, Snow, and H20
Team C: Fire and Water



Second Module:
Team A: Ice, Snow, and H20
Team B: Fire and Water
Team C: Foundations for Flow

Third Module:
Team A: Fire and Water
Team B: Foundations for Flow
Team C: Ice, Snow, and H20

Ice, Snow and H_2O Module

Module Overview:
Ice and snow play a critical role in supplying Colorado's rivers, streams, and communities with water throughout the year. The amount of snow that falls and is stored in the snowpack and glaciers is carefully monitored across the state, and around the world. Understanding how ice and snow impact our water supply, and how that may change in the future, is an important part of the scientific research conducted in the Boulder Creek Critical Zone Observatory Program.

Colorado Academic Standards:
Standard 1: Physical Science

- Prepared Graduates: Apply an understanding of atomic and molecular structure to explain the properties of matter, and predict outcomes of chemical and nuclear reactions
    - Grade 6-Concept 4: Distinguish among, explain, and apply the relationships among mass, weight, volume, and density

Standard 3: Earth Systems Science:

- Prepared Graduates: Describe how humans are dependent of the diversity of resources provided by the Earth and Sun
    - Grade 5-Concept 1: Earth and Sun provide a diversity of renewable and nonrenewable resources
    - Grade 6-Concept 2: Water on Earth is distributed and circulated through oceans, glaciers, rivers, ground water, and the atmosphere

Guiding Questions:
- What impact does snow compaction have on its weight, volume, and density?
- What impact does snow density likely have on its melting rate?
- What role do snow and ice play in Colorado's water supply?
- What Earth System interactions regulate the flow of water throughout the year?
- What impact will climate change and land use decisions likely have on water resources in Boulder Creek, and across Colorado in the future?

Timing and Flow:
- 5 Minutes - Instructor and Module Introduction
- 15 Minutes - Activity 1: Snow Density and Glacial Ice
- 15 Minutes - Activity 2: Weather Data and Snow Tubes
- 30 Minutes - Activity 3: The Boulder Creek Hydrology Game
- 10 Minutes - Wrap Up and Clean Up

Activity 1: Snow Density and Glacial Ice

Overview:
This activity focuses on measuring and calculating the physical properties of snow and ice, and the forces needed to create glacial ice. It begins by discussing the formation of snowfields, the snowpack, glaciers, and the role of slow-melting snow and ice in Colorado's year-round water supply. The teams will use worksheets, tools and calculators to measure, compare, and contrast the physical changes associated with the snow before attempting to compress it to a density between 0.8 and 0.9, or the approximate density of glacial ice.

Procedures

1. Introduce the module by discussing the formation of the snowpack, snowfields, glaciers, and ask the students to describe the role of slow-melting snow in Colorado's year round water supply.
2. Distribute the worksheets and materials, reminding students about safety and expectations.
3. Go over the steps outlined in the first section of the worksheet and facilitate the distribution and measurement of the snow. Explain water weight equivalence and its role in measuring the snowpack.
4. Review the results and key concepts including weight, mass, volume, and density, before allowing the learners to attempt compressing the snow and calculating its density once or twice.
5. Begin wrapping up by first pointing out the conservation of mass, and therefore water weight equivalence throughout the experiment, then ask the learners to describe how snow compaction impacts its physical appearance, weight, volume, and density.
6. Finally, ask students to describe the forces needed to create glacial ice and the relationship between snow density and its melting rate.
7. Before moving on, have the students empty the beakers, wipe down the laminated worksheets, turn off the scales and clean up any snow, water or ice left on the surfaces or floor near their workstation.

Activity 2: Weather Data and Snow Tubes

Overview:
In this activity learners will use their understandings of snow, snow density, and weather to theorize about potential relationships between weather events and the snowpack as represented in a simulated snowpack core or snow tube. Then learners will examine weather data and graphs, compare, contrast, and test their theories about the weather events, and finally find trends in the data represented in the snow tubes.

Procedures

1. Begin by distributing the snow tubes and explain that the source data comes from a weather station on Niwot Ridge, a mountain in the Boulder Creek Watershed near the Continental Divide, and represents the snowpack accumulated during the month of January 2010.
2. Ask the students to use their experiences and understandings of snow density to create and share some theories about weather events that may be represented by the snowpack sample.
3. Distribute the data sheets and describe the characteristics below:
    - The precipitation events measure centimeters of snow, but not the consistency of the snow, which can vary from fine, light powder to wet, dense snow.
    - The wind speed is measured in meters per second and represents an average for the day, not the highest wind speeds measured. Though there is almost always wind on the ridge, there are only a few times when the average wind speed is above 30 meters/second or 65 miles/hour.
    - The temperature in January, measured in degrees C, rarely reaches the melting point of water.
    - Solar radiation is measured in watts/meter^2 and, as anyone who has been high in the mountains can tell you, it is a powerful force limited only by clouds and mountain fogs!

4. Have the learners locate and identify weather events in the data and snow tube, describe the accuracy of their theories, and discuss some of the key relationships represented in the samples including:
    - Snow compression at the bottom of the tube and compressions relationship with melting rates
    - Ice layers, the events that lead to their formation, and the role of ice in melting
    - The presence of wind driven dust on the snow and the Blackbody Effect's role in melting

Activity 3: The Boulder Creek Hydrology Game

Overview:

The last activity in this module is a fun game focused on the Earth System interactions that control hydrology in the Boulder Creek watershed. This activity was created using local weather and stream flow data and can be adapted to any region or watershed by changing the names, flow regimes, and features. The game is played around a large-scale floor map showing the Boulder Creek Watershed, but could easily be played using another map, outdoors, or by laying out streams and water bodies on the floor with blue tape. It is also designed to accommodate up to 40 learners, but could be adapted for smaller groups.

Procedures

1. Begin by allowing students time to explore the map and identify features of the watershed.
2. Explain that each Earth System has a role in supplying Colorado's streams, rivers and communities with year round water and have the students provide some examples from each sphere.
3. Show each section of the watershed that is represented in the game, and assign an area or areas to each group of participants.
4. Explain the materials and give the students time to read and discuss their introduction cards.
5. Have each group give a brief overview of their area, focusing on the fast facts.
6. Explain how the game works by walking them, step by step, through the first season.
7. Once the tasks are complete, organize the groups in lines to represent stream flow and have them pass the chips downstream. Discuss with the class ways to improve the flow and passing for the next round.
8. At the end of the first year, redistribute game chips back to the original containers, have the groups read their first game card of year two, and highlight the following events:
    - It is a record snow year for the entire watershed and more precipitation is stored as snow and ice, while the amount of precipitation remains the same.
    - Fires will impact parts of the watershed, changing soil storage and runoff patterns.
    - Areas that contain reservoirs will gain the ability to choose how much water to hold or release, hopefully to limit flooding and store water for the summer and fall.
9. Run through the second season of the game, stopping each season to highlight changes to the watershed and flow regimes.
10. At the end of the game, have students describe how their area changed or adapted overall, the impacts of the events, and what they would do differently if given the opportunity.
11. Have the students re-set the game board back to its original position and organize the game cards for the next group.
12. In the wrap up for the module, have the students again describe how each Earth System impacts water storage and flow, before asking them how changes to climate, land use, and other factors will likely impact the water flow in Boulder Creek, and (ending on a positive note) what scientists, planners and citizens can do about it!
13. Review the guiding questions, allow the students to refine their answers, and finally have the learners discuss why this science and the concepts in the module are important or significant.

Foundations for Flow Module

Module Overview:
The distribution of surface and ground water is controlled by the structural geology of the Earth's watersheds. Research in the Boulder Creek Critical Zone Observatory strives to understand how geologic processes shaped the land, and therefore the watersheds, over time. The current topography, rock layers, and the size and shape of the drainage basins can be understood using geologic evidence, research tools, and Earth Systems Science.

Colorado Academic Standards:
Standard 3: Earth Systems Science:

- Prepared Graduates: Evaluate evidence that Earth's geosphere, atmosphere, hydrosphere, and biosphere interact as a complex system
    - Grade 5-Concept 2: Earth's surface changes constantly through a variety of processes and forces
    - Grade 6-Concept 1: Complex interrelationships exist between Earth's structure and natural processes that over time are both constructive and destructive
    - Grade 8-Concept 2: Earth has a variety of climates defined by average temperature, precipitation, humidity, air pressure, and wind that have changed over time in a particular location

- Prepared Graduates: Describe and interpret how Earth's geologic history and place in space are relevant to our understanding of the processes that have shaped our planet
    - Grade7-Concept 2: Geologic time, history, and changing life forms are indicated by fossils and successive sedimentation, folding, faulting, and uplifting of layers of sedimentary rock

Guiding Questions:

- How has Colorado's geologic history influenced the structures and materials we find here?
- What destructive forces were involved in those changes?
- What constructive forces were involved in those changes?
- How have changes in climate and weather impacted the Boulder Creek Watershed over time?

Timing and Flow:
- 5 Minutes - Instructor and Module Introduction
- 15 Minutes - Activity 1: Introduction and Rock Sample Identification
- 25 Minutes - Activity 2: Orogeny, Uplift and Glacial Erosion
- 15 Minutes - Activity 3: Stream Erosion and Watershed Structure
- 15 Minutes - Wrap Up and Clean Up

Activity 1: Introduction and Rock Sample Identification

Overview:
The introduction uses a PowerPoint presentation featuring scientifically guided, artist's renditions of Colorado's geologic history to explain the role of large-scale tectonic and climactic events in the formation of the current geological features. The slides use current Colorado maps and images to establish sense of place, and then show a series of map-based pictures of Colorado over a two hundred million year period highlighting major events that coincide with significant rock layers found in the Boulder Creek Watershed. Each team will be provided rock samples linked to the major events described in the presentation and asked to identify the rock samples based on descriptions of the events that formed them. The assessment section asks learners to describe features of the landscape, including rock layers, and the processes or events that lead to their formation.

Procedures

1. As the students enter the room, encourage them to examine the rocks on the table with the guiding questions: What are they made of and what events or processes helped make these rocks?
2. Show PowerPoint and, if time allows, the optional video segments.
3. Demonstrate the folding and uplift of sedimentary layers by the granitic basement rocks using the play-foam and/or fault block demonstrations.
4. Read the description of the four rocks (below) and have the teams pick, as a group, a sample matching each. If using Front Range samples, they are:
    - One rock sample started as mud, laid down at the bottom of an ancient sea. Over many, many years it was compressed into this soft, brittle rock called shale.
    - This rock is made from sand and pebbles washed downstream as the Ancestral Rockies were eroded over two hundred million years ago. Which is the conglomerate?
    - This rock sample was made from fine sands, originally in sand dunes that covered this part of Colorado. Which of these is the sandstone?
    - One of these rocks is not like the others. It is very hard and made of many small crystals tightly locked together. This is a sample of the uplifted basement rock called granite.
5. If time allows, elaborate on the team's selections with details like the ones below:
    - This type of shale was originally mud on the bottom of the ancient seas that covered the Great Plains. In some places it is thousands of feet deep and shales like these can be found under the surface soils from the Rockies to the Mississippi River.
    - As the Ancestral Rockies were eroding, rocks, pebbles and sand were washed down ancient streams and some of the materials were left in streambeds and deltas. The sand and pebbles have been cemented in this rock for over 200 million years!
    - There are many types of sandstone in Colorado, depending on the source and size of the materials. They come in greens, blues, reds, browns, and yellow/tan like the beaches and dunes they are made from.
    - The sample of Granite was part of the massive layer of basement rock pushed up by the tectonic forces. Over millions of years of erosion it was exposed to the elements and though it is very hard, it too was ground down and broken off a much larger layer.
6. To wrap up, ask the students the guiding questions below, telling them that they will have a chance to refine their answers as the module progresses:
    a. How has Colorado's geologic history influenced the structures and materials we find here?
    b. What destructive forces were involved in those changes?
    c. What constructive forces were involved in those changes?
    d. How have changes in climate and weather impacted the Boulder Creek Watershed over time?

Activity 2: Orogeny, Uplift and Glacial Erosion

Overview:
In this activity learners will place an approximately one inch thick layer of simulated Fountain Formation sedimentary rock on a slope and erode it with repeated glaciations. Using snow or crushed/shaved ice, teams will deposit layers of snow on the slopes and compress it to simulate the compaction of snow layers over time. The results will be contrasted with the learners understanding of the difference between snowpack, snowfields and glaciers, before repeating the process a number of times. In the second part of the activity learners will be asked to focus the snow in one central area and compress the snow to simulate glacial erosion. The class will then be shown examples of the characteristic features of glacial erosion and asked to identify any of those features present in their model and strive to recreate them while the simulations are repeated. The wrap-up uses sample images, diagrams of common glacial features, and asks learners to evaluate their model's ability to simulate the characteristic features of glacial erosion.

Procedures

1. Explain the relationships between the stream table, watershed shape and function, the mountain feature, and the sedimentary layers used in the first part of the activity.
2. Using the table demonstration, show how the layers go on the model and describe the four-step, student-directed erosion cycle, using the PowerPoint Slide as a guide, and how the process represents millions of years of erosion prior to glaciation and the general cooling as the continent drifted North.
    - Step One: Liberally and evenly douse the mountain area with the watering can for a total of five seconds representing millions of years of rain. Though the area would have had vegetation like fern-forests on it, we are focusing on the geosphere-hydrosphere interactions in this module. Step Two: Retrieve 250ml of unpacked snow, sprinkle it evenly over the mountain surface, and spray it evenly with pump bottle about 10-times per side. This represents cooler years when snow fell on the mountains, and the summer rains that limited the formation of snowfields and glaciers.
    - Step Three: Retrieve 500ml of unpacked snow, sprinkle over the mountain surface and spray with the pump bottle 10-times per side. Press down or compress the remaining snow into snowfields representing years of accumulating snow.
    - Step Four: Retrieve 500ml of snow, compress it into two small piles or snowballs, one for each side, and place them in the central part of the model on an existing snowfield. Press the piles of snow down and outward with the heel of your hand, and then spray with the pump bottle10 times per side representing the first of many glaciers forming from compressed snow over years and years.

3. Have the students describe any changes they have seen in the models thus far and show the students the PowerPoint slides with features of glacial landscapes, explain the critical features and inform them that they are going to simulate more glaciations in an effort to recreate some of these features after the model is completed.
4. Use the table model to demonstrate how the base-level sedimentary layers are placed at the foot of the mountains and describe the process for the next section of the inquiry before distributing the sedimentary layer sets:
    - Step One: Add the sedimentary layers, a small handful of base material on top, then liberally douse the entire mountain area with the watering can for a total of five seconds representing a brief 'interglacial period' of warm weather and melting.
    - Step Two: Retrieve 500 ml of snow, compress it into two small piles or snowballs, and place them in the central part of the model on what remains of the existing glacier. Press the piles of snow down and outward with the heel of your hand, and then spray with the pump bottle10 times per side representing yet another glacial period.

   - Step Three: Repeat the step above, again focusing on the center of the model. Try to make moraines and lakes at the bottom of the glacier!
   - Step Four: Retrieve 500 ml of snow and divide into a number of smaller glaciers along the edges of the model and attempt to create some of the more complex glacial features described in the slide. The features we see today are from the last major glaciation, only a little over 10,000 years ago! Just a drop in the bucket in geologic time!
5. Show the class the corresponding slides showing the Front Range Mountains, common features of glacial erosion, and have them identify any features they recognize in their models (U-shaped valleys, cirques, moraines, glacial lakes, etc.)
6. Ask the students to describe how changes in climate have helped shape Colorado over time (from sea levels to sand dunes and from rain forest to glaciers).
7. Finally, ask the students the guiding questions below, reminding them will have a chance to refine their answers as the module progresses:
   - How has Colorado's geologic history influenced the structures and materials we find here?
   - What destructive forces were involved in those changes?
   - What constructive forces were involved in those changes?
   - How have changes in climate and weather impacted the Boulder Creek Watershed over time?

Activity 3: Stream Erosion and Watershed Structure

Overview:

This activity focuses on stream erosion, canyon cutting and the erosion/deposition features in the lower reaches of the watershed. Beginning with the features created in the first two activities as a base, learners will again be asked to use water and tools to recreate common watershed features and, in theory, recreate some of the Boulder Creek Watershed. In the wrap-up teams are asked to compare and contrast the features in their models to images and diagrams from the PowerPoint presentation.

Procedures

1. Show the learners the slides representing the lower reaches of the watershed and common erosion/deposition features. Explain the steps in the final inquiry and the role of the sanding block before allowing students to get beakers, tools, and refill their conveyances.
   - Step One: Liberally and evenly douse the entire mountain area with the watering can for a total of five seconds representing, this time, only thousands of years of rain.
   - Step Two: Using the sanding block, spray bottle and the beaker of water (sparingly) improve the glacial features of the landscape, define the canyons and water flow with the goal of having the water in the creek drain out the bottom of the pan on both sides!
   - Step Three: Take a moment to clean up and prepare for the final flood. Check the drain, improve the flow and look for terraces!
   - Step Four: Let it rain! For 10,000 years, let it rain!

2. Have each team share the highlights of their models, review the slides in the presentation and have the students link the features of their models to the processes and events shown, ending with the lower reaches of the watershed.

Activity 4: Wrap Up and Clean Up

Overview:
Following the clean-up, the wrap-up uses three dimensional, shaded-relief maps of Colorado or the Denver area as a reference for evaluating the stream table model's ability to simulate structures, features and processes found in the Boulder Creek Critical Zone Observatory.

Procedures

1. Demonstrate the process for deconstructing the models, cleaning the surfaces and finally wiping/sweeping the floors around their work stations. Introduce the map handling guidelines, the role of the place marks and when they are done with clean up, send them to the maps and provide some unstructured time for exploration.
2. Ask the students to compare and contrast features of the map with their models and to share an overall summary of their model's ability to simulate the processes and features of the watershed.
3. If time allows, have the teams find points along the watershed boundaries for the major rivers or creeks, focusing their attention on the more subtle edges in the plains.
4. Finally, ask the students the guiding questions below, reminding them this will have to be their final answer.
    - How has Colorado's geologic history influenced the structures and materials we find here?
    - What destructive forces were involved in those changes?
    - What constructive forces were involved in those changes?
    - How have changes in climate and weather impacted the Boulder Creek Watershed over time?

The Fire and Water Module

Module Overview:

Wildfires have been an important part of the ecosystems, nutrient cycling and natural history in Colorado for thousands of years. Though potentially devastating, wildfires play an important role in shaping the ecosystems and watershed structures we see today. Scientific research in the Boulder Creek Critical Zone Observatory focuses on the impacts of the 2010 Fourmile Fire and the Earth System interactions between wildfires, soils, erosion, and water quality in Boulder Creek. This module, following the current research, explores the complex relationships that exist between wildfires and the environment.

Colorado Academic Standards:

Standard 2: Life Science

- Prepared Graduates: Explain and illustrate with examples how living systems interact with the biotic and abiotic environment
    - Grade 6-Concept 1: Changes in environmental conditions can affect the survival of individual organisms, populations, and entire species
    - Grade 6-Concept 2. Organisms interact with each other and their environment in various ways that create a flow of energy and cycling of matter in an ecosystem
    - Grade 8-Concept 1: Human activities can deliberately or inadvertently alter ecosystems and their resiliency

Standard 3: Earth Systems Science:

- Prepared Graduates: Evaluate evidence that Earth's geosphere, atmosphere, hydrosphere, and biosphere interact as a complex system
    - Grade 5-Concept 2: Earth's surface changes constantly through a variety of processes and forces
    - Grade 6-Concept 1: Complex interrelationships exist between Earth's structure and natural processes that over time are both constructive and destructive

Guiding Questions:

- What Earth System interactions influence and are influenced by wildfires?
- What role do wildfires play in the transfer of nutrients, materials and energy?
- How do wildfires, topography, soil structures and precipitation regimes combine to impact how water is transferred throughout the Earth's systems?
- How do fuels and fire management, as well as post-fire erosion control efforts, impact the landscape, water quality and flow regimes?
- How will changes to the environment associated with climate, land use change, management, and Pine Bark Beetles impact fire ecology in the Boulder Creek Watershed?

Timing and Flow:

- 5 Minutes - Instructor and Module Introduction
- 10 Minutes - Activity 1: Fire Ecology, Soils, and Earth Systems Science
- 20 Minutes - Activity 2: Fire Intensity, Erosion, and Water Quality
- 20 Minutes - Activity 3: Just Passing Through, or Not
- 20 Minutes - Wrap Up and Clean Up

Activity 1: Fire Ecology, Soils, and Earth Systems Science

Overview:

The introduction to this module uses PowerPoint slides, Google Maps and soil/land cover samples to familiarize students with land cover patterns and forest types in the Boulder Creek Watershed, common soils and soil structures, as well as introduce or reinforce concepts related to fire ecology and fire intensity. Learners will then use the Google Earth's Historical Imagery Tool to predict patterns in fire intensity across the Fourmile Fire impact area and use current images, along with fire data, to test the accuracy of their predictions. The class will hypothesize about the impacts of changes to surface structures and soils on water quality and flow regimes in the Boulder Creek Watershed.

Procedures

1. Introduce the module by relating learner's experiences with wildfires, their understandings of fire ecology, as well as the local and global impacts.
2. Use the PowerPoint presentation to discuss the dominant land cover types in the Boulder Creek Watershed, as well as fire ecology and fire intensity.
3. Using Google Earth, show students the extent of the Boulder Creek Watershed and, combined with the soil and land cover samples, refine their understandings of the distribution of soils, slopes, and land covers.
4. Next, using Google Earth's Historical Imagery Tool, add the Fourmile Fire Boundary layer (kml) to a pre-fire land cover image.
5. Explore the Fourmile area, focusing on the slopes, streams and land covers. Carefully address the presence of houses, roads, and developed areas, as well as the fire's impacts.
6. Navigate to an appropriate part of the impact area and have students describe the varying land covers and slopes.
7. Applying their understandings of fire intensity, have students predict, mark or outline areas they believe will have low, medium, and high intensity fires.
8. Using the Fourmile Fire Intensity layer (kml), show the students the estimated fire intensity for each area, compare it to their predictions and, turning off the Historic Imagery Tool, explore the post-fire images, fire variations, and impacts.
9. Focusing on Fourmile Creek, explore the fire intensities, slopes, and evidence of erosion to prepare the students for the next activities in the module.
10. If time allows, explore the layers and land covers from historical fires in the watershed and across the State

Activity 2: Fire Intensity, Erosion and Water Quality

Overview:

In this activity, learners will explore the impacts of different intensity fires on erosion and water quality by simulating precipitation events on recently burned slopes. In order to facilitate this inquiry students will be introduced to the concept of flow, its measurement in volume over time, and practice their pouring and science process skills. Next, students will be introduced to the concepts of pH and electrical conductivity as indicators of water quality and practice using the meters while collecting baseline data on the water used in the inquiry. Students will then pour a fixed amount of water, over a fixed amount of time, on similar locations in four prepared models simulating unburned, low, medium, and high intensity fires in the Gordon Gulch area. Next, learners will compare the results of the erosion and runoff collection, or lack thereof, noting the visual differences in the movement of materials and water quality. Finally, learners will measure, compare and contrast differences in pH and electrical conductivity in the available samples. The wrap up will focus on using the Earth Systems Science model to explore wildfire impacts on erosion, water quality, and hydrology.

Procedures

1. Introduce the activity using the slopes and soil boxes to describe the impacts of different fire intensities on soils and surface structures.
2. Prepare the class for the inquiry by reviewing the steps and considerations for a scientific investigation and explaining the use of the models.
3. Define and explain the role of consistent pouring location and flow for validity and variable control.
4. Have the teams practice pouring 250 ml of water, over 5 seconds, between the beakers until they have a consistent pour and flow rate.
5. Introduce the concepts associated with electrical conductivity, pH, and water quality.
6. Have the learners collect and record baseline data on the water used for the experiment.
7. Have the learners hypothesize about the potential differences in runoff and erosion in each section of the model
8. Conduct the experiment, compare observed results, and measure pH and electrical conductivity.
9. Have each team share the results of the inquiry and as a group, explain how this experiment can inform us about changes in the real world.
10. Have the teams replace as much of the eroded material as possible, empty the water collection containers, and return the models to their original state as best they can.
11. Finally, have the learners clean the tables, floors, and refill the beakers with water.

Activity 3: Just Passing Through, or Not

Overview:

This inquiry is an adaptation of a GLOBE Program activity originally titled “Just Passing Through” that is available for download at http://www.globe.gov/tctg/passthrough_beg.pdf?sectionId=101. The original activities focused on soil structures, infiltration rates, as well as the ability of different soils hold and retain water. Simple modifications of the container and the addition of fire related materials allow the activity to serve its original purposes, as well as demonstrate the impacts of varying fire intensities on runoff, groundwater and water quality.

Procedures

1. Introduce the activity using the bottles and soil boxes to describe the differences in soil structures and fire impacts.
2. Prepare the class for the inquiry by reviewing the steps and considerations for a scientific investigation, explaining the use of the models, introducing infiltration and the relationships between soil structures and water holding capacity.
3. Remind the class of the importance of consistent pouring and flow for variable control.
4. Have the teams remove high mountain and canyon sets from the containers and prepare the beakers for catching the runoff.
5. Pour 250 ml of water into the models, and simultaneously start the stopwatch.
6. Compare the differences in runoff while waiting one minute for the water to drain.
7. Record, compare, and contrast the quality and volume in the lower beakers and relate to differences in soil structures.

8. Have the students create a set of hypotheses describing the differences in runoff, infiltration and water holding capacities for the inquiry section of the activity.
9. Remove the valley and low intensity soils and explain the valley soils role as the control for the experiment, before repeating the steps above for them and the remaining sets.
10. Introduce the concept of hydrophobicity, explain how it was simulated, and its role in the relationships between wildfires, soils, and hydrology.
11. Have the students organize their data, compare the results and create evidence-based generalizations about the relationships between soil structures, wildfires and changes to soils, and ground and surface water.
12. At the end of the activity, have the teams empty and rinse the beakers, clean up any water and materials, and reset the materials for the next team.
13. Finally, returning to the slide with the Earth Systems Science Model, ask the students what Earth System interactions influence and are influenced by wildfires, then the rest of the guiding questions listed below:
    - What role do wildfires play in the transfer of nutrients, materials. and energy?
    - How do wildfires, topography, soil structures and precipitation regimes combine to impact how water is transferred throughout the Earth's systems?
    - How do fuels and fire management, as well as post-fire erosion control efforts, impact the landscape, water quality and flow regimes?
    - How will changes to the environment associated with climate, land use change, management and Pine Bark Beetles impact fire ecology in the Boulder Creek Watershed?
14. As a concluding statement, remind students that wildfires are not only a natural occurrence, but are an important part of the Earth System in Colorado and that we, as a society, are learning to better understand and live with wildfires.