GLOBAL CHANGE

GENERAL SCIENCE UNIT
MIDDLE SCHOOL

Sixth, Seventh or Eighth Grade
Timeframe: Three to Four Weeks

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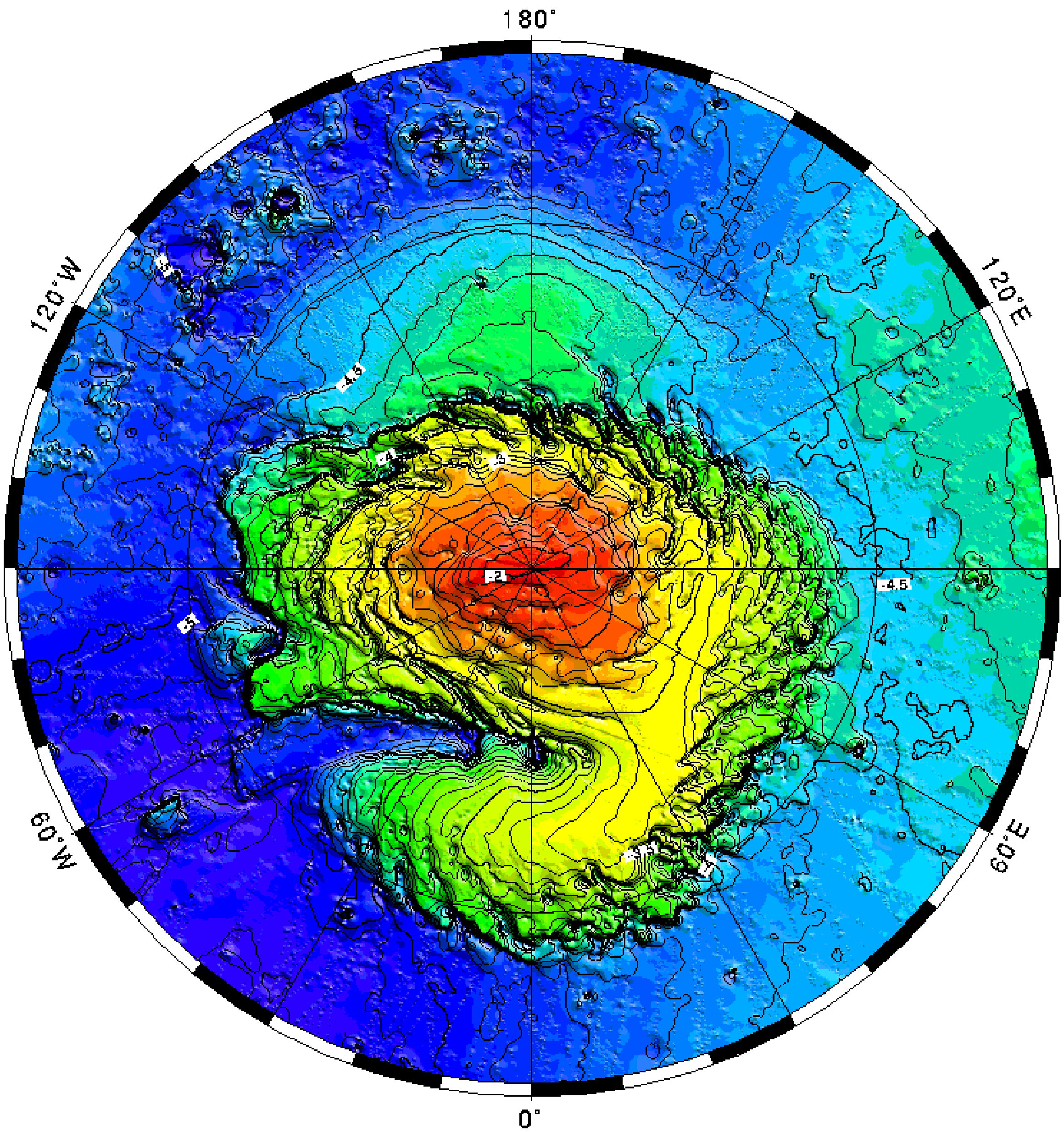
2005



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Background and Motivation

Change is a part of life. As students begin to learn about their world, they need to realize that what is true today environmentally, is not necessarily true for the future. With the tremendous differences man is making to the world environment, there is potential for great global change within the course of one human lifetime. Students need to realize that they have impact on the global ecosystem and ownership for its care. The goal of this unit and its embedded research projects is to develop ecological understanding and scientific skills, while preserving an atmosphere of calm and empowerment within the students. It is only when citizens understand how and why change occurs, and feel empowered to make decisions concerning those changes, does good environmental policy and action take place.

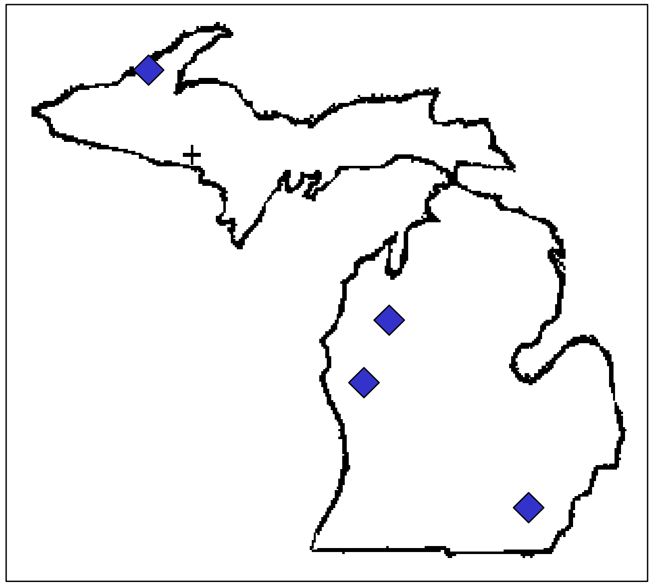
Educators in both traditional and non-traditional settings must involve middle school students in authentic experiences that will help them identify and think about issues of global change. By giving students experiences in a local, real world setting, they develop ownership for the global environment. They will then recognize that their actions affect all of our futures. Global change is not a problem to be 'solved.' It is an on-going flux that will ultimately determine the quality, and perhaps, the success of all types life on this planet. This unit illustrates some changes that are taking place now, and involve students in investigations that help them to observe those changes, and understand that man has a role in their management. Ultimately students must feel empowered act on their knowledge to make a difference in the future of our world.

Change can be scary. Middle Schoolers, with their intense interest and focus on new information, can easily become stressed about environmental change. Stress without positive action can lead to despondency. Teaching about these issues is a delicate balancing act. Students need to understand global change and be able to interpret information using background knowledge and scientific skills. In addition, children need to make connections between the actions of humans and the resulting repercussions. However, this new awareness must occur while still sheltered by the protective and caring climate of the classroom. The research subjects used in this unit (lichen, earthworms and rainwater) were chosen specifically for their innocuous identities. It is unlikely that students will become emotionally involved with their subjects, but they will still learn the core scientific concepts. In addition, students will collaborate with others across the state, creating a statewide peer group, exchanging data and discussing observations. As they mature, students will translate the concepts learned in this study to other species and ecosystems. This choice of research subjects, and the power created by a large, cooperative group, is designed to help prevent students from feeling an overwhelming sense of concern about our ecological fate, thereby encouraging a state of disassociation and apathy.

Four educators have collaborated on this project. Each will approach the task slightly differently, but all have agreed to share information and coordinate their student research. Because we live on a Southeast/Northwest gradient, we will perform these research activities with our students at each of our four locations and exchange data for discussion and comparison purposes.

Our locations from south to north are:

South to North, our locations are:



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There are three areas of focus for our research. Lichen studies, as well as worm identification and population research, will be done in the fall and again in the spring. Air quality information will be collected regularly, and reported to all participants at the end of each month. Digital photography will be used to communicate visual information to the groups of students as well as numerical data. When appropriate, samples can be sent to participants at each gradient station. All digital information will be posted on the Western Upper Peninsula SM&EE website and will be available to all interested parties.

The following research projects are only suggested activities. Many more possibilities are feasible.

This unit teaches basic State of Michigan science benchmarks through authentic hands-on experiential learning. Through their research activities, students will not only practice real world co-operative research skills and analysis, but also may be motivated to continue and expand their exploration of global change. Their knowledge, interest, skills, and actions can and should make a difference to the future of this planet.

Unit Overview

	Objective	State Benchmark(s)	Activity at a Glance	Materials Needed
Day 1	TSW recognize that change is a normal part of life. TSW give examples of physical and chemical changes. TSW demonstrate that chemical change creates whole new properties.	SCI.IV.2.MS.1 *Describe common physical changes in matter.* SCI.IV.2.MS.2 *Describe common chemical changes in terms of properties of reactants and products.*	Discuss physical and chemical changes. Demonstrate both. Emphasize energy, and change.	Pocket change, Several Apples or other fruit, Marshmallows, Toasting stick, Candle, holder Sparkler, Matches
Day 2	TSW create a model of the earth's atmosphere. TSW practice the concept of *parts per million,* and *parts per billion.*	SCI.I.1.MS.4 Use *measurement devices to provide consistency in an investigation.* SCI.IV.1.MS *Describe and compare objects in terms of mass, volume and density.* SCI.V.3.MS.2 *Describe the composition and characteristic of the atmosphere.*	Create a model of the earth's atmosphere using a 1-gallon glass jar and various liquids. Students will create a second model using various dried seeds.	Large glass jars Water. Food coloring Graduated cylinders Dried seeds & grains
Day 3	TSW explain how our atmosphere is changing in terms of CO2, NOx, and O3. TSW recognize that changes in the atmosphere can be natural or man-made. TSW demonstrate that burning fossil fuels accelerates atmospheric change.	SCI.VI.2.MS2 Describe common chemical changes in terms of reactants and products. SCI.IV.2MS.3 Explain physical changes in terms of the arrangement and motion of atoms and molecules. SCI.III.5.MS.6. describe ways in which humans alter the environment. SSII.CS.5.MS.1*Describe how social and scientific changes in regions may have global consequences***.**	Discuss atmospheric change, natural and man-made causes. Introduce volatile organic compounds (VOC's), Co2, NOx and Ozone.	Lecture Notes Filmstrip NWF <u>Air: We Can't Live Without It!</u>
Day 4	TSW review cycles, water, carbon and nitrogen.	SCI.1.MS.5 Use sources of information to support scientific investigations. SCI.II.1.MS.5 Develop an awareness and sensitivity to the natural world.	Review cycles: water, carbon, nitrogen.	Whiteboard, Colored markers National Geographic Filmstrip <u>Cycles</u> (opt) Blank ditto paper Colored pencils
Day 5	TSW recognize how people's actions can change natural cycles. TSW Demonstrate how ozone forms in the atmosphere and discuss how ozone in the lower atmosphere can effect organisms.	SCI. II.1.MS.4 Describe the advantages and risks of new technologies. SCI.4.MS.2 Explain how new traits might become established in a population and how species become extinct. SSII.CS.5.MS.1*Describe how social and scientific changes in regions may have global consequences.*	Nitrogen deposition Lab Background information and set-up	Cycle posters 4 small potted plants (per section) Plant food (Nitrogen) Graduated cylinder

	Objective	State Benchmark(s)	Activity at a Glance	Materials Needed
Day 6	TSW demonstrate how ozone forms in the lower atmosphere. TSW recognize that ozone can damage sensitive organisms	SCI.III.5.MS.6 *Describe ways in which humans alter the environment.* SCI.IV.4.MS.4 *Describe how light interacts with matter.* SCI.V.3.MS.4 *Describe the health effects of polluted air.*	Teach students how volatile organic compounds create ground level ozone by involving them in the 'ozone dance'	Atmosphere model jar Student signs; 6 'Oxygen', 2 'VOC', 1 Light Energy Strong flashlight
Day 7	TSW observe the effects of ozone on a common, well-known plant,, milkweed.	SCI I.1 MS.5 *Use sources of information in support of scientific investigation.* SCI.II. 1.MS.5 *Develop an awareness of and sensitivity to the natural world.*	Students will observe common milkweed plants for signs of ozone damage.	Computer lab with access to the Internet Color printer
Day 8	TSW learn to use a simple ozone monitor and collect daily ozone level readings..	SCI.I.MS.3 *Use tools and equipment appropriate to scientific investigations.*	Students will learn to use weather station and begin taking daily temperature, precipitation, and ozone readings.	Weather Station, including rainfall gauge, maximum/minimum thermometer, and ozone reader with enough disposable ozone cards for the school year.
Days 9&10	TSW engage in an on-going, cooperative gradient study of air quality using the school outdoor classroom. TSW learn about lichen. TSW recognize lichen are sensitive to air pollutants. TSW complete a field investigation. TSW compare and analyze the data.	SCI I.1.MS.3 *Use tools and equipment appropriate to scientific investigation.* SCI.I.1.MS.4 *Use metric measurement devices to provide consistency in an investigation.* SCI.II.1.MS.5 *Develop an awareness of and sensitivity to the natural world.* SCI.II.1.MS.2 *Describe limits in personal knowledge.*	Students will begin an on-going co-operative gradient study of local lichen as an indicator or air quality.	lichen keys magnifying lens clear plastic grid sheets red, blue, green washable markers data sheet, clip boards EPA poster of six criteria pollutants digital camera

	Objective(s)	State Benchmark(s)	Activity at a Glance	Materials Needed
Day Eleven & Twelve	TSW collect and analyze rainwater for nitrogen and pH.	SCI.I.1 MS.2 *Design and conduct scientific investigations.* SCI.I.1.MS.3 *Use tools and equipment appropriate to scientific investigations.* SCI.III.5.MS.6 *Describe ways in which humans alter the environment.*	Students will investigate the chemistry of rainwater across Michigan.	PH meter 1.0 to 15 pH Rain Gauge (Globe) Nitrate test kit (Golbe or La Motte) Overhead of gradient study map. Data collection sheets
Day Thirteen	TSW define the exotic species, and recognize how they may impact an environment. TSW name three exotic species common to the Great Lakes Region and how they were introduced. TSW explain why exotic species can sometimes cause environmental change.	SCI.III.5.MS.3 *Predict the effects of changes in one population in a food web on other populations.* SCI.III.5.MS.1 *Describe common patterns of relationships among populations.* SCI.III.5.MS.6 *Describe ways in which humans alter the environment.*	Students will define exotic species, and learn about common Michigan exotics, and their impact on our State's ecosystem.	Any media concerning exotic species of Michigan Pictures of Michigan exotics
Day Fourteen	TSW explore earthworms as an example of exotic species whose presence changes their ecosystem. TSW define and give examples of environmental engineers	SCI.I.1.MS.1 *Generate scientific questions about the world based on observation.* SCI.II.1.MS.3 *Show how common themes of science, mathematics, and technology apply in a real-world context.* SCI.I.1.MS.6 *Write and follow procedures in the form of step by step instructions, formulas, flow diagrams, and sketches.*	Students will explore a natural area for evidence of earthworm activity, classify any worms located, and report their data to other schools participating in the gradient study.	Square meter plot markers Trowels PH test kit Nitrates test kit Digital camera Thermometer Plastic containers Metric ruler Earthworm taxonomic key Data sheet Computer and internet
Day Fifteen	TSW demonstrate an awareness of on-going natural and man-made changes in the global environment. TSW show confidence and competency when using the language of global environmental change.	State Benchmarks to date will be reviewed	The students will work with a partner to recall, organize and communicate ideas learned throughout this unit.	Any resource materials, notes, posters, or other references used to date, should be available as needed. No new references may be used.

Lesson Plan, Day One

Objective(s):
TSW recognize that change is a normal part of life.
TSW give examples of physical and chemical changes.
TSW demonstrate that chemical change creates whole new properties.

State Benchmark(s):
SCI.IV.2.MS.1 *Describe common physical changes in matter.*
SCI.IV.2.MS.2
Describe common chemical changes in terms of properties of reactants and products.

Materials:

Pocket change,	Toasting stick,
Sparkler	Matches
Marshmallows,	Candle, holder

Activity:

Hook: Standing in front of the students, ask them to get really quiet and use their powers of observation. Have them raise their hands if they recognize something happening. Jingle a handful of coins in your pocket as you walk around the room. As soon as they guess, begin a discussion about the change in your pocket. Help them to see that change from a dollar is created when the dollar is used for something. It still has value, but the change is not exactly the same as the original dollar.

Lesson: Using the apple, or other piece of fruit, discuss ways you can change the apple. Sort ideas on board into two lists: physical, and chemical change, without labeling the lists. When you have several things in each list, have the students explain how the two lists are different (physical change, takes small amounts of energy, and the materials remain the same 'stuff'- a smashed apple is still an apple. Chemical change takes more energy and creates new materials with new properties.)

Do the same with the marshmallow, and the sparkler.

Things to remember: Energy is involved in all change (Definition: Energy- the ability to cause a change) Physical change happens when a small amount of energy is applied, and the material remains the same basically. (The molecules that form it remain the same.)

Chemical changes happen when a large amount of energy is added to a substance, and the molecules rearrange themselves. Whole new substances with mostly new properties are formed. (The molecules that form the substance change.)

Direct student to make a list of five kinds of physical changes and five types of chemical changes in their notes for tomorrow.

Lesson Plan, Day Two

Objective(s):
TSW create a model of the earth's atmosphere.
TSW practice the concept of *parts per million*, and *parts per billion.*

State Benchmark(s): SCI.I.1.MS.4 *Use measurement devices to provide consistency in an investigation.*
SCI.IV.1.MS *Describe and compare objects in terms of mass, volume and density.*
SCI.V.3.MS.2 *Describe the composition and characteristic of the atmosphere.*

Materials:
Large glass jars one for each group, plus two for demonstration.
Water
Food coloring
Graduated cylinders
Dried seeds & grains

Activity:

Hook: Start the class by sharing the lists of physical and chemical changes the students created yesterday. Correct any errors in classification and discuss. Explain that in order to see change in materials, a person has to know what they are made of, and how they exist naturally. That is very true if it is something, like the atmosphere, which we may take for granted every day.

Lesson: Create a demonstration model of the Earth's atmosphere for the students by using a wide-mouth gallon glass jar (It should hold 4 liters) An aquarium will work as well, but the amounts will be different. Be sure you ask the students what the air is made of and dispel their typical misconceptions as you work through this activity.
Add to your jar:

Permanent Gases (These two compose 99% of the atmosphere!)

- 78 parts clear water (3.12 liters) - this represents nitrogen gas, which only a few specialized bacteria can use for nitrogen. (all living things must have nitrogen to build and repair cells, but most cannot use nitrogen gas.)
- 21 parts milk (880mls) - this represents oxygen. We all know what that is used for! (Maybe not-ask the students. If they can't tell you that all consumers require oxygen to release energy stored in simple sugars in a process called respiration, you have a teachable moment!)

Other permanent gases:

- Argon .9 parts or 3.6 mls (yellow colored water)
- Neon .002 parts or 8 drops (not accurate, but it works visually) (red)
- Helium .0005 or ½ a drop (blue)
- Also a 'tad' of a drop of Krypton (.0001) and Hydrogen (.00005) Wet a toothpick and pass it through the model. (green and orange)

Variable gases in the atmosphere (Varies depending on conditions)

- Water Vapor 0 to 4% (Use 2.5% which is one ml – use blue-green)
- Carbondioxide .035% at present That would be about 1.4 drops or less! (use purple)
- Methane is ,0002% that's the wet toothpick (brownish)
- Ozone .000004% Yikes! That is less than a 'tad' of a 'splash'! (orange-red)

The important thing in this model is the students visualize the amounts. It is a very abstract concept, and they have to work with it, to begin to understand it.

Introduce the idea of 'parts per million' by showing them a PPM jar. This one gallon jar has one million tiny balls in it. PPM jars are available through most major scientific supply companies. The colors represent the different fractions or 'parts'. There is ONE black ball. This black ball represents one part per million. Methane gas is 2 parts per million. It would mean 2 black balls. Ozone gas occurs in the atmosphere most often in less than that amount.

Point out that even though some of these gases aren't very plentiful, they are important, because they can cause physical and chemical changes to living and non-living things on our planet.

Now have students make their own atmosphere jars. They can use liter measures and seed for their percents. You may want to make only one jar per class, because this can get expensive. Be certain the students create a key for their model before they begin, and you have figured exactly how much of each seed type you need.
*Remind students that scientists use models all the time when things are too small, too large, or too inconvenient, to work with first hand. It is great to make a model of something that you can't see, because the parts are too small.

Suggested seed for this model: popcorn, gray sunflowers, white and brown rice, millet, peanuts, and leftover garden seed for the trace elements. Save the student's models with their keys, on display throughout the unit. You may want to work with them later when the students discuss the six main types of air pollution. I save the black sunflower seed for a contaminant. It shows up very well. So will larger seeds like pumpkin or Indian corn.

Assessment: Ask the students to write a paragraph in their notes describing 3 things they learned today about the atmosphere.

Lesson Plan Day Three

Objective(s):
TSW explain how our atmosphere is changing in terms of CO_2, NO_x, and O_3.
TSW recognize that changes in the atmosphere can be natural or man-made.
TSW demonstrate that burning fossil fuels accelerates atmospheric change.

State Benchmark(s):
SCI.VI.2.MS2 *Describe common chemical changes in terms of reactants and products*.
SCI.IV.2MS.3 *Explain physical changes in terms of the arrangement and motion of atoms and molecules.*
SCI.III.5.MS.6. *Describe ways in which humans alter the environment.*
SSII.CS.5.MS.1*Describe how social and scientific changes in regions may have global consequences*

Materials:

- Lecture Notes
- Filmstrip: NWF Air Pollution

Activity:

Hook: Have a large shallow pan of clear water on demo table. As the students watch, add a variety of materials to the water-mustard, chocolate syrup, dirt, powdered jello, chalk dust- make a mess. Ask the students; 'What has happened to the water?' (Its dirty, messed up, nasty...) Now ask them; 'How will the water will get clean again?' (The water will be pure if it evaporates. It can evaporate when enough energy is added to it in the form of heat. Define *Heat-the movement of molecules.* The mess gets left behind.) Now ask about the air. 'What happens when 'stuff' gets added to the air?' (It gets polluted.) Define *Pollution- non-living or abiotic material that gets into the wrong place, and creates problems there*. Explain that today we will find out about some things that get added to air that 'messes it up.'

Lesson: Lead students in a discussion of non-living things (abiotic factors) that are present in our atmosphere. They will be quick to talk about chemical contaminants because of yesterdays' work with making atmospheric models, but try to get them to acknowledge that light, heat, sound, and wind (air movement) are also abiotic factors present.

Show National Wildlife Federations' filmstrip on air pollution, AIR: We Can't Live Without It! or other similar age appropriate film. Outline the six major air pollutants and their most important characteristics.

- Sulfur dioxide
- Nitrogen Oxide
- Lead
- Particulates
- Volatile Organic Compounds (VOCs)
- Ozone

Be certain to discuss how each pollutant is created, how it effects human health, and how it effects the atmosphere.

Expand your discussion of the ‘Big Six’, to include carbondioxide and water vapor. Explain that these two molecules are not traditionally thought of as pollutants, because they are naturally already present in the atmosphere, and up until recently, we didn’t realize that too much of them might change, or create problems in our atmosphere.

Emphasize that atmospheric change is natural. Scientists already know that temperature and chemical amounts have changed throughout time. But as people are beginning to learn more about our environment, we are learning that humans speed up the changes, and we have to pay attention to what is happening so we can make good choices about our actions.

Introduce and teach the use of weather station equipment and ozone monitors. Explain and set up the daily monitoring of local temperature, rainfall, and ozone. (Protocols for correct use of weather monitoring equipment are available on the GLOBE website. See References section).

Assessment: Student notes and participation in discussion.

Lesson Plan, Day Four

Objective:
TSW review cycles, water, carbon and nitrogen.

State Benchmark(s):

SCI.1.MS.5 *Use sources of information to support scientific investigations*.
SCI.II.1.MS.5 *Develop an awareness and sensitivity to the natural world.*

Materials:

- Whiteboard,
- Colored markers
- National Geographic Filmstrip Cycles (opt).
- Blank ditto paper
- Colored pencils

Activity:

Hook: Have a bicycle, tricycle, a bike wheel, or pictures of various bikes at the room's front. Direct students to respond to these questions in their notebooks; 'What are these objects? How did they get their names? How are they alike? How are they different?' After students are finished with their thoughts, share a few ideas, and begin to define the word 'cycle.' Ask, 'What kind of a cycle did you learn about earlier in school?' (They will probably recall work with the water cycle.) Define: *Cycle- a pattern that repeats itself over and over again.*

Rename the water cycle as the hydrologic cycle. Be sure the students understand the parts of the word, *hydrologic*. Hydro – water, logic – step by step, cycle – circle.

Lesson: Using the whiteboard and colored markers, review the carbon and nitrogen cycles. Remember that these cycles are not benchmarked knowledge for Middle Schoolers, but are very important for students to have some conception of, to understand the 'big picture' of environmental function and change. Therefore, mastery of these cycles is not important, but a familiarity with them is. National Geographic has a filmstrip on cycles that is a very clear and simple presentation, and there are several animated explanations available over the Internet. (See References).

Continue the monitoring of weather and ozone begun yesterday. Assign the creation of labeled drawings or 'posters' of carbon or nitrogen cycle to each student. You may want to partner students together, and have each team create the two posters together. Blank ditto paper, colored pencils and classroom notes will be needed.

Assessment: Quality and accuracy of cycle posters.

Lesson Plan, Day Five

Objective(s):

TSW recognize how people's actions can change natural cycles.
TSW Demonstrate how ozone forms in the atmosphere and discuss how ozone in the lower atmosphere can effect organisms.

State Benchmark(s):
SCI. II.1.MS.4 *Describe the advantages and risks of new technologies*.
SCI.4.MS.2 *Explain how new traits might become established in a population and how species become extinct.*
SSII.CS.5.MS.1 *Describe how social and scientific changes in regions may have global consequences.*
Materials:

- Cycle posters from yesterday
- Small potted plants, 4 per section
- Plant food with high Nitrogen content
- Graduated cylinder or other suitable measurement tool

Activity:

Warm Up: Go over yesterday's posters on the Nitrogen cycle. Review how solid nitrogen compounds are created by nitrogen fixing bacteria and lightning.

Lesson: Remind students that living things need nitrogen to create cells. Remind them that anything that has lived and died has nitrogen in its body. Students should be able to understand that fossil fuels, because the plant materials that created them were once alive, are full of nitrogen. Fertilizer manufacturers create bagged fertilizers from fossil fuels!

When humans mine or pump fossil fuels, like coal or oil, to create fertilizer, and then spread that fertilizer on fields, it adds nitrogen to the soil. That might be really good, if your soil is low on nitrogen. Some plants, (but not all of them) grow much bigger and faster, when they have more solid nitrogen in the soil. So if you want to grow a plant like corn, increased nitrogen is really helpful to that plant. Some plants, however, are not adapted to lots of nitrogen, because it isn't in their environment naturally, and they have trouble staying healthy, growing and reproducing with too much nitrogen in their ecosystem. Even a 'nitrogen dependent' plant like corn, will have a tough time if too much nitrogen is in the soil.

Now, think about burning fossil fuels. We already know that burning coal or gasoline made of oil adds nitrogen oxides to the atmosphere. This addition of chemicals can contribute to air pollution and acid rain problems. What most people do not realize, however, is that when nitrogen oxides inside the engines of machines are subjected to the very high temperatures of internal combustion, the heat also 'fixes' nitrogen in a process very similar to what happens when lightning strikes, or nitrogen fixing bacteria are at work. Solid nitrogen particles are created in the air, that then fall to the ground with rainwater, or even as dry particles of nitrate.

This changes the amount of usable nitrogen available to plants all over the world- anywhere there are cars and other vehicles being driven!

Adding nitrogen to ecosystems this way can really change the plants that live there comfortably. And that changes the animals that can live there as well. This process is called *nitrogen deposition.* It is a kind of change that some scientists are just beginning to research. The class can do some research as well.

Using the four potted plants and the plant food, set up the following simple demonstration.

Question: What effect does adding nitrogen have on the growth of a geranium plant? (You can use any type of plant that is easily available. Some are more sensitive than others.)

Research: We know about the nitrogen cycle, and that all plants need nitrogen to make new cells. We know that nitrogen is a main nutrient in plant food.

Hypothesis: We believe that adding solid nitrogen compounds to a plant's soil should increase the size of the plant. (Allow students to create their own hypothesis.)

Design: Materials: Four plants, potting soil, plant food (the higher the nitrogen content, the better), distilled water, graduated cylinder, balance.

Method: Set aside one plant to be the control. This will receive exactly the same treatment as the other three, but without the addition of any plant food. The variable is the amount of nitrogen in the added plant food. Depending on the size of the plants, decide on a reasonable amount of water needed for them each day. (For example, 100 ml.in a four inch pot) Label plants X, Y, Z and C (control). X will have .05 grams of plant food added to each 100mls of H_2O. Y will receive .1 grams, and plant Z will receive 1 gram of nutrient each time it is watered. Measure out the dry plant food on the balance, and add each day. This is great practice in the use of equipment, but if it is too time consuming, students may wish to premix up 1 or 2 liters of each concentration the first day, and then shake the containers, and pour out 100 mls each time the students water the plants.

Data: Use a table similar to this:

Observations				
Date	Plant C (control)	Plant X (.01 gms)	Plant Y (.1gms)	Plant Z (1gm)

Conclusion: Have students observe plants for several days, recording their observations daily. It usually only takes a few days for the plants with the higher concentration plants to show signs of yellowing and stress. When you feel the students have recorded enough observations to understand that there can be too much of a good thing, stop the experiment and have them write their conclusions.

*** *It is always a good idea to try a lab out yourself first. Different plants will have different sensitivities to nitrogen deposition. You can then adjust the amounts of plant food you add, making certain that plant Z gets enough nitrogen to react negatively in a reasonable timeframe.****

<u>Assessment:</u> Experimental lab write ups, especially the quality of observations and the conclusions drawn.

<u>Lesson Plan, Day Six</u>

Objective(s):
TSW demonstrate how ozone forms in the lower atmosphere.
TSW recognize that ozone can damage sensitive organisms.

State Benchmark(s):
SCI.III.5.MS.6 *Describe ways in which humans alter the environment.*
SCI.IV.4.MS.4 *Describe how light interacts with matter.*
SCI.V.3.MS.4 *Describe the health effects of polluted air.*

Materials:
Atmosphere model jar from day two.
Student signs, 6 'Oxygen', 2 'VOC', 1 Light Energy
High powered, hand-held flashlight

Activity:

<u>Hook:</u> Students should observe Nitrogen lab from yesterday, and record observations. Using data collection as a springboard for discussion, ask for other chemicals in the air, that human activity might increase. Review the 6 main air pollutants, and direct the classes' attention to ozone. Create a list of everything we know about ozone and what we do not know. Students will probably not remember how it forms and how it effects things, only that it is considered a pollutant.

<u>Lesson:</u> (Note: This lesson is adapted from an activity that explains upper atmospheric ozone by Dr. Mary Ann H. Smith NASA Langley Research Center, February, 1993.)

Teacher Background: "Ground level ozone is formed by a chemical reaction between volatile organic compounds (VOCs), also known as hydrocarbons and oxides of nitrogen (NOx) in the presence of sunlight. Nitrogen oxides and hydrocarbons are also known as the chief 'precursors' of ozone. These compounds react in the presence of sunlight to produce ozone. These gaseous compounds mix like a thin soup in the atmosphere, and when they interact with sunlight, ozone is formed. Due to the nature of this reaction, ozone concentrations can reach unhealthy levels when the weather is hot and sunny with little or no wind. As a result, ground level ozone pollution, or smog, is mainly a daytime problem during the summer months.

The photochemical reaction that produces ground level ozone requires several factors to be present and tends to occur when a stagnant air mass develops during hot and sunny conditions. The air will not become stagnant if the weather systems continue to move through the area and displace the air with cleaner, 'fresher 'air.

One day alone is usually not enough to form excessive ozone. Usually it takes several days in a row, with hot temperatures, the wind speeds low, and the sky sunny for an ozone event to occur."
Taken from: *Air Pollution: What's the Solution?*

Found at: http://njnie.dl.stevens-tech.edu/curriculum/airproject/learnmorecore4.html

Show the students the three types of signs: *Sunlight*, *VOC's* (Volatile organic compounds) and *Oxygen*. Ask for 9 volunteers to demonstrate how ozone forms in the lower atmosphere.

Have 6 students hold the oxygen signs and partner, holding hands and bouncing on the balls of their feet. Remind students that oxygen is a colorless, odorless gas, the molecules of which move very swiftly in the atmosphere. They are never alone for long, and usually partner with one other molecule, but can make threesomes for short periods (ozone). Instruct the student pairs to move about at random, still bouncing and joining hands.

Next have 2 students hold VOC signs. Remind students that VOC stands for Volatile Organic Compound – meaning, basically, quickly evaporated petroleum-based fossil fuels. This would include things like gasoline, charcoal lighter, and alcohol based products like nail polish remover. These chemicals are 'volatile' because they have lots of energy, and evaporate very quickly. They could be thought of as 'cutter' molecules for purposes of this model. This energy can cause changes in the atmosphere. Instruct these students to turn around in place moving slowly around the area amongst the oxygen molecules.

Explain, when both of these things are in the air, it isn't a problem, if there aren't too many VOC's and they aren't too 'hyper' (highly energized). But when you add more VOC molecules, and more energy to the mixture, (Define: *Energy- the ability to cause change*) that's when there are problems.

Instruct the 'sunlight' student to turn on a high powered flashlight. (The stronger the light, the more effective the model.) When the light is turned on, both the Oxygen partners and the VOC's should move and turn about more quickly. If they bump together, the VOC will 'cut' the Oxygen molecule and it must split and join another Oxygen partnership. After two or more splits, instruct the class to "freeze". Observe what took place physically.

Review what just happened. Oxygen molecules are a normal part of the atmosphere. So are VOC's, Ozone (O3) and sunlight. But when there are <u>LOTS</u> of VOC's and strong direct sunlight, regular oxygen molecules can get transformed into ozone molecules. That is a big problem in the lower atmosphere, because ozone likes to recombine with other things, like moist membranes in animals' (like us) lungs, and sensitive cells in plant tissues. It can combine with the rubber in tires, and the paint on cars. It can make your eyes sting, your nose run, and make it hard to breathe- especially if you like to be physically active outside or you have a respiratory problem like asthma or emphysema.

The good thing is that ozone falls apart pretty quickly, and if the wind mixes the air up ozone will dissipate. It falls apart during the night when the sun is not shining. Humans can make ozone problems worse, or better, once they know how it forms. Other organisms especially plants, cannot, so people have to make good decisions about their actions to control ozone formation.

Now lead a discussion on how to impact ozone formation. Basically review the guidelines for ozone action days. These include ideas such as: Don't mow your lawn, fire up the grill, run 2 and

4 stoke engines (jet skis, chain saws etc.) or refuel your car during peak sunshine hours. Limit all fossil fuel consumption during these times and try to reduce electric demand. Do not use paint thinner or any other volatile organic compounds, so they will not evaporate during high sunlight times.

Assessment: Instruct students to create a personal family poster teaching their family about ozone, and reminding their family members about what to do on an Ozone Action Day.

Lesson Plan Day Seven:

Objective(s):
TSW observe the effects of ozone on a common, well-known plant.

State Benchmark(s):
SCI I.1 MS.5 *Use sources of information in support of scientific investigation.* SCI.II. 1.MS.5 *Develop an awareness of and sensitivity to the natural world.*

Materials:

Computer lab with access to the Internet

Color printer

Activity:

Warm up: Bring to class a few common milkweed plants in various stages of growth. You might also be able to find several monarch butterflies, or larva. (If you do not have access to living plants, you can substitute photographs.) Discuss what these plants are and where to find them. Most rural students, and many urban ones, will have experience with milkweed. It is a common pioneer plant on road edges and in vacant lots. Explain to the students that milkweed is one of those plants that is very sensitive to ozone damage. We can look at milkweed plants and tell if there is very much ozone common in the plant's environment.

Lesson: Help students log on their to computers to:
www.dnr.state.wi.us./org/caer/ce/eek/earth/field/milk

Explore this site and review together, the slide show on ozone damage on milkweed plants. If a color printer is available, students can create their own guide to milkweed ozone damage.

Assessment: Ask students to be on the lookout for milkweed. If they find anything that looks like ozone damage, they should collect one typical damaged leaf and bring it in to show the class. This assignment, while not a evaluative one, will encourage students to be aware of the plants and living things in their own environment. It also helps students recognize that something as humble as a weed can be damaged by human actions. This allows children to see atmospheric change without focusing on just the effect on human life. Most Middle Schoolers will make the connection from the milkweed damage to change in food supply for monarchs and other insects and further effects on the food chain. This assignment also encourages students to develop an awareness of their environment and the other living things within it. Allow students to bring in evidence of ozone damage at any time throughout the school year.

Lesson Plan Day Eight

Objective:
TSW learn to use a simple ozone monitor and collect daily ozone level readings.

State Benchmark(s):
SCI.I.MS.3 *Use tools and equipment appropriate to scientific investigations*.

Materials:
Weather Station, including rainfall gauge, maximum/minimum thermometer, wind direction instrument, and ozone reader with enough disposable ozone cards for the school year.
Globe Atmospheres Data Collection Sheets

Activity:

Hook: Share with the students several copies of ozone maps. These can be printed out from US Environmental Protection Agency at www.epa.gov.airnow If you have a class sized computer monitor, these maps are animated, and can be projected to the entire class. Explain that many scientists trace ozone by using simple equipment that the students can learn to use as well. By tracking ozone at your school, you can add to the body of knowledge scientists use to learn more about air quality.

Activity: Introduce and teach the use of Globe Atmospheres equipment using Globe protocols. Complete instructions including teacher tips, background, and troubleshooting can be located at www.globe.gov Click on atmospheres protocols.

Take class to weather station, and together record air temperature, wind speed and direction, cloud cover, and expose and collect the ozone strip. Divide class into data collection 'teams' of three students each to collect atmospheres data daily, on a weekly rotation. The actual data collection, once students are familiar with the equipment, only takes 5 to 7 minutes. Teams should take data for at least a week, then rotate so everyone has the experience. One person from the previous week's team should accompany the next team for a day or two to 'retrain' them. Teacher should monitor data collection to check for accuracy.

Assessment: Daily atmosphere data. As interesting ozone 'events' occur, teachers should make time for a discussion of what is happening, how it has happened, and what action humans should take.

Lesson Plan Day Nine & Ten

Objective(s):

TSW engage in an on-going, cooperative gradient study of air quality using the school outdoor classroom. TSW learn about the unique characteristics of lichen and are able to recognize three different kinds of lichen**.**

TSW understand that lichens are sensitive to air pollutants and sometimes used as indicators of air quality.

TSW complete a field investigation to locate and identify lichen types growing on maple trees, complete size measurements using a grid sheet (based on % of area) and record data.

TSW compare and analyze the data from this site and three other geographical sites in Michigan and form conclusions. The four study sites are Bloomfield Hills, Grant, Tustin and Houghton, Michigan.

State Benchmark(s):

SCI I.1.MS.3 *Use tools and equipment appropriate to scientific investigation.*
SCI.I.1.MS.4 *Use metric measurement devices to provide consistency in an investigation.*
SCI.II.1.MS.5 *Develop an awareness of and sensitivity to the natural world.*
SCI.II.1.MS.2 *Describe limitations in personal knowledge.*

Materials:

Color picture keys for three kinds of lichen, (crusty, leaflike, shrubby).
Magnifying lens
Clear plastic grid sheets
Red, blue and green washable markers
Data sheet and clip boards
EPA information poster of six criteria pollutants as indicators of air quality
Digital camera

Activity:

Hook: Introduce samples or photos of lichens. Review with students that lichens are symbiotic organisms consisting of an algal cell surrounded by a fungal body. The alga is a producer, must live in a moist or wet environment that is rich in nutrients and it can make its own food. The fungus has root-like hyphae that can pull in water and nutrients from the most hostile of environments, but it is a consumer, it cannot make its own food. Together they can live almost anywhere successfully. Alone neither can survive except in just the 'right' environments.

Explain that lichens live all around us, but most people pay almost no attention to them. Some scientists find them pretty interesting because they, like milkweed are very sensitive to air pollution problems. Lichens are sensitive to all air pollution, not just ozone. They are natural, living, air quality sensors, and scientists are very interested in what they can tell us about air quality.

Explain we have been invited to participate in a gradient study. Define: *gradient- across time and space.* We will be looking at lichens that exist here in Grant in our school forest, and send our information to a group of students near Detroit, one near Traverse City, and one in the Upper Peninsula. (Introduce Michigan map with study sites marked.)

Lesson:
Adapt the following lesson as needed.

Comparative Field Investigation of Lichens as Air Quality Indicators of a SE to NW Gradient.

By Global Change Team: Dan Bagley, Joan Chadde, Andrea Grix, Sarah Pregitzer

Scientific Investigation

Question:
What populations (type and size) of lichen are found in each of the four geographical areas?

Research/Teacher Background:
The US Environmental Protection Agency has identified six criteria pollutants as air quality indicators. These are ozone, particulate matter, carbon monoxide, sulfur dioxide, nitrogen oxides and lead. Based on scientific research lichens have been recognized as extremely sensitive to air pollution especially the air's acidity and sometimes used as indicators of air quality. Scientists study both the type of lichens present and the size of the lichens. Lichens are not plants. They are composite, symbiotic organisms, mutually beneficial to each other, made up from as many as three kingdoms (fungi, algae and bacteria). The photosynthesizing alga provides food for both, while fungi appear to provide moisture, minerals and support. The lichen fungi cannot live without their algal partners but most of the algae can live by themselves, but only in wet environments. Together, they are able to survive extreme conditions of heat, cold and drought. There are three kinds of lichen based on their physical appearance; crusty, leaflike and shrubby. The crusty lichens usually grow flat on rocks and tree trunks and can be orange, yellow, green, brown, gray or black in color. Leaflike lichen has lobed surfaces that are only partially attached to surfaces and green in color. Shrubby lichen is branched and either stand upright or hang from other surfaces and is green in color. Lichens are often confused with moss, but mosses are tiny plants with leaves and stems. The shrubby and leaflike lichens can only survive in air without harmful pollutants.

Hypothesis:
Students should develop their own hypothesis, based on what they know about air quality and lichens. For example: Shrubby and leaflike kinds of lichen will be found in greater amounts in geographical areas with less human development and less air pollution.

Experimental Design:

Materials for each group of 3:
Color picture keys for three kinds of lichen, (crusty, leaflike, shrubby).
Magnifying lens
Clear plastic grid sheets
Red, blue and green washable markers
Data sheet and clip boards
EPA information poster of six criteria pollutants as indicators of air quality
Digital camera

Leaflike

Crusty

Shrubby

Procedure:

1. Take students outside to a selected study site with maple trees located in a mature, closed canopy forest.
2. Make observations once in the spring (March, April) and once in the fall (September, October).
3. Ask students to examine the three flagged maple trees in the selected study area. Examine the 20cm x 20cm marked area on each flagged tree for lichen using the magnifying lens and regular vision. Identify those present as crusty, leaflike or shrubby lichen, count the number of each species and record on the data sheet. (Do not push or pull on the lichen because it could cause damage. Light touching will not harm the organism)
4. Place clear plastic grid sheet over the 20cm X 20cm area without touching the lichen and color in the squares occupied by the three types of lichen. Red color for crusty lichens, blue color for leaflike lichens, and green for shrubby lichen. Have students determine percentage of each kind of lichen by counting the number of squares occupied by each type. There is a total of 400 squares. Use ratios to determine percentage of total area.

Example: $\frac{40}{X} - \frac{400}{100}$, $40 \times 100 = 4000$, $4000 = 400x$, 4000 divided by 400, $x = 10\ \%$

5. Take digital photo of the three marked 20 cm x 20 cm study area on the maple trees.
6. Record data on website for comparison with three other study sites.

Data:

Lichen Data Collection Date _______________ Team Members_________________

Tree One	Number of Lichens Found	Percent of Coverage	Other Observations
Crusty			
Leafy			
Shrubby			

Tree Two	Number of Lichens Found	Percent of Coverage	Other Observations
Crusty			
Leafy			
Shrubby			

Tree Three	Number of Lichens Found	Percent of Coverage	Other Observations
Crusty			
Leafy			
Shrubby			

Conclusion:

Analysis of results:

Are there shrubby and leaflike lichens present in the study site? The presence of shrubby and leaflike indicates good air quality based on the scientific research.

What was the percentage of area for each type of lichen? Mostly shrubby and leaflike- good to excellent air quality. Mostly crusty with few leaflike – good to fair. Crusty lichen indicates only fair to poor air quality.

Optional size interpretation: Are there shrubby and leaflike lichens greater than 10-12 square centimeters in size? Greater than 10-12 cm indicates excellent air quality.

Compare results with pH, nitrates, particulate matter and conductivity of recent precipitation to the results of this investigation. (Days 11 and 12.)

Comparison Analysis:

1. Did all sites have the same results? How did they differ? Why did they differ?

2. Create a graph showing the number and percentage of each type of lichen at each study site. Did the two seasons show different results? If that occurred why is there a noticeable difference?

3. Is there shrubby and leaflike lichen present at each study site? If not why? The presence of shrubby and leaflike indicates good air quality based on the scientific research.

<u>Assessment:</u> Students can write a lab report based on the results of their research. They can compare their data to the data across the gradient in the conclusion paragraph of the report using their answers to the preceding questions.

Lesson Plan Day Eleven & Twelve:

Objective(s):
TSW collect and analyze rainwater for nitrogen and pH.

State Benchmark(s):
SCI.I.1 MS.2 *Design and conduct scientific investigations.*
SCI.I.1.MS.3 *Use tools and equipment appropriate to scientific investigations.*
SCI.III.5.MS.6 *Describe ways in which humans alter the environment.*

Materials:
pH meter 1.0 to 15 pH
Rain Gauge (Globe)
Nitrate test kit (Globe or La Motte)
Overhead of gradient study map.
Data collection sheets

Activity:

Hook: Remind students of the results of their nitrogen deposition experiment. Ask them to recall how nitrogen gets into the soil naturally (Lightning and nitrogen-fixing bacteria). Now have them recall how people's activities change the rate of nitrogen deposition. (Internal combustion engines also 'fix' gaseous nitrogen into solid nitrogen compounds. In addition, people add fertilizer made from fossil fuels to the environment.) Ask them what other chemicals do they remember that are part of human impact on air quality? (They should recall the 5 other main air pollutants.) Explain that along with the general air quality, (from the lichen study) and our ozone monitoring, we also are going to monitor two chemicals that can be sometimes present in rainfall. Specifically, we will start to monitor rainfall for nitrogen and acidity (pH).

Lesson: Adapt the following procedure.

Rainwater Chemistry Along a NW-SE Gradient in Michigan

By Global Change Team: Dan Bagley, Joan Chadde, Andrea Grix, Sarah Pregitzer

Problem: Does the chemistry of rainwater vary across Michigan?

Research/Teacher Background:

Casiday, Rachel and Regina Frey. Department Of Chemistry, Washington University, St. Louis, MO 63130. ***Acid Rain: Inorganic Reactions Experiment.*** Retrieved July 15, 2005 from http://www.chemistry.wustl.edu/~edudev/water/acidrain.html

Pure water has a pH of 7.0 (neutral); however, **natural, unpolluted rainwater actually has a pH of about 5.6 (acidic)**. pH is a measure of the hydrogen ion (H^+) concentration. The acidity of rainwater comes from the natural presence of three substances (CO_2, NO, and SO_2) found in the troposphere (the lowest layer of the atmosphere). Carbon dioxide (CO_2) is present in the greatest concentration and therefore contributes the most to the natural acidity of rainwater. Unfortunately, human industrial activity produces additional acid-forming compounds in far greater quantities than the natural sources of acidity. In some areas of the United States, the pH of rainwater can be 3.0 or lower, approximately 1000 times more acidic than normal rainwater. When rainwater is too acidic, it can cause problems ranging from killing freshwater fish and damaging crops, to eroding buildings and monuments.

United States Geological Survey. ***Online Data And Reports On Acid Rain, Atmospheric Deposition And Precipitation Chemistry.*** Retrieved July 15, 2005 from http://bqs.usgs.gov/acidrain/ Provides map of acid rain monitoring stations in the United States, links to data, and list of current research reports on acid rain.

U. S. Environmental Protection Agency. ***Acid Rain Program homepage***. Retrieved July 15, 2005 from http://epa.gov. Provides information on impacts of acid rain, regulations, emissions, and ways to reduce acid rain through energy conservation and renewable energy incentives.

U. S. Environmental Protection Agency. ***Response of Surface Water Chemistry to the Clean Air Act Amendments of 1990.*** 2003. Retrieved on July 15, 2005 from http://www.epa.gov/ord/htm/CAAA-2002-report-2col-rev-4.pdf Includes maps indicate the acid rain sensitive regions of the northern and eastern United States (Blue Ridge/Appalachian Plateau, Adirondack Mountains and the New England areas).
Nox and Sox from the combustion of fossil fuels react with water in the atmosphere ot produce acid rain, a dilute solution of nitric and sulfuric acids. This acidity (and the acid anions sulfate and nitrate) may travel hundreds of miles before being deposited on the landscape. The northern and eastern U.S. receives precipitation with mean pH that ranges from 4.3 in Pennsylvania and New York, to 4.8 in Maine and the Upper Midwest. The acidity (hydrogen ion concentration) in precipitation in eastern U.S. is at least twice as high as in pre-industrial times. Atmospheric deposition is one of the most ubiquitous non-point sources of chemicals to ecosystems.

National Science Teachers Association (NSTA) recently released *Inside Rain: Working with Precipitation Chemistry Data*, a science activity book and package. Developed with support from the USGS, this innovative package enables high school students and teachers to answer environmental-chemistry questions using the actual online database of the National Atmospheric Deposition Program (NADP) http://nadp.sws.uiuc.edu/

National Atmospheric Deposition Program. 1994.Isopleth maps of pH (H ion deposition) the United States showing the concentrations of many different pollutants throughout the country. Retrieved July 15, 2005 from http://nadp.sws.uiuc.edu/isopleths/
pH is lowest in northeast part of the United States. In Michigan, pH follows a NW-SE gradient from Houghton, MI in the northwest part of the Upper Peninsula with a pH of 4.8 to the greater Detroit area with a pH of 4.4. Grand Rapids and surrounding areas have a pH of 4.5 and the northern lower peninsula of Michigan is 4.6

Hypothesis: Students should form their own hypothesis, based on what they know about urban areas, and acid rain/ nitrogen deposition. For example: The further a site is from an urban area (further north), the more pure the rainwater quality (pH=7.0; N-NO_2=0, particulates = 0, conductivity = 0).

Design:

<u>Materials Needed:</u>
pH meter (Range: -1.0 to 15.0 pH. Resolution: 0.1 pH.) $59.50

Rain gauge (GLOBE protocol) – use clear view plastic rain gauge with an opening at least 102 mm diameter, and at least 280 mm in height with a scale indicating rain collected at 0.2 mm or less on an inner clear cylinder.

Other equipment depending upon parameters to be measured:
LaMotte Nitrate Test Kit**:** 0, 0.2, 0.4, 0.6, 0.8, 1.0 ppm NO_3^-–N using Octa-Slide color comparator. Range: 0 to 15 ppm. Increments: 0, 1, 2, 4, 6, 8, 10, 15 ppm. $44.90

GLOBE-approved Nitrate-Nitrogen water quality kit. Range:0, 0.2, 0.4, 0.6, 0.8, 1.0 ppm NO_3^-–N (price NA)

Overhead transparency of map displaying the pH monitoring network for Michigan.
Printout of values for pH

<u>Experimental Procedure:</u>

1. Introduce pH (a measure of how acidic or basic water is) and provide typical pH values for unpolluted rainwater (7.0). Discuss ways that the pH of rainwater can be changed: air pollution from the combustion of fossil fuels introduces CO2 and industrial stack discharges introduce SO2. Both can combine with rainwater to form an acid...

2. Show a map of the United States, so students can find their location in Michigan. Show the locations of the other three Michigan schools collaborating in the study: Houghton, Tustin, Grant, and Bloomfield Hills. Ask students to find the locations of several major cities within 1,000 miles: Detroit, Chicago, Minneapolis. Students can use a piece of yarn to measure the distance from their school to these large cities in the U.S.

3. Ask students to hypothesize how the pH of rainwater might differ between the upper and lower peninsulas of Michigan. What might influence air quality in each of these locations in Michigan?

4. At each of the four locations along a NW-SE gradient in Michigan (Houghton, Tustin, Grant, and Bloomfield Hills area), students will read their rain gauge daily within one hour of local solar noon. (Students in all sections will read their rain gauge, but only data taken within the window is accordance with Globe Protocols.) Student must be sure that their eyes are level with the water in the measuring tube and they read the bottom of the meniscus.

5. After taking the measurement, students must empty the water from the measuring tube into a clean beaker or jar for the pH measurement and then reassemble and remount the rain gauge.

6. Record the number of centimeters of rainfall in the past 24 hours into your data form.

7. Using the pH meter, record the pH of the sample and record in the data table.

8. Compare the pH value to other pH values measured in Houghton, Tustin, Grant, and Bloomfield Hills; in Michigan; and the United States.

Data:
Students may use the following table.

Table 1. pH Values for Selected Locations in Michigan 2005-2009

	Michigan Locations			
Date	Houghton	Tustin	Grant	Bloomfield Hills
Fall 2005				
Spring 2006				
Fall 2006				
Spring 2007				
Fall 2007				
Spring 2008				
Fall 2008				
Spring 2009				
Fall 2009				
Spring 2010				
Fall 2010				

Conclusion:

Show students an overhead of the map displaying the pH monitoring station network for Michigan. Next to each station, write the pH value. How do these values compare to the rainfall measurements taken at the four locations?

Compare 2004 values to those taken in 2002 and 2003. Are pH values becoming more acidic or less?

Create a conclusion statement giving three things that students have learned from this experiment. This can be done as a class, or by small teams of students. Students will continue to measure, record and submit rainfall data throughout the school year. If desired, snowfall can also be monitored, using Globe snowfall measuring protocols.

Assessment: Lab reports and conclusions can be used for assessment.

Lesson Plan Day Thirteen

Objective(s):
TSW define the exotic species, and recognize how they may impact an environment.
TSW name three exotic species common to the Great Lakes Region and explain how they were introduced.
TSW explain why exotic species can sometimes cause environmental change.

State Benchmark(s):
SCI.III.5.MS.3 *Predict the effects of changes in one population in a food web on other populations.*
SCI.III.5.MS.1 *Describe common patterns of relationships among populations.*
SCI.III.5.MS.6 *Describe ways in which humans alter the environment.*

Materials: Any available posters, pictures, or other materials dealing with common exotic species

Activity:

Hook: Collect and display posters, photos, bookmarks, bumper stickers and any other materials available concerning exotic species known in Michigan. After looking these displayed items over, together instruct students to write down three things these organisms all have in common. Typical answers might include; they are all living things, they all live in nature, they are all found in Michigan.
Activity:
Introduce the idea of 'exotic' which can be generally defined as 'belonging by nature or origin to another part of the world' (Funk &Wagnall's Standard Collegiate Dictionary, 1968). In science, especially ecology, an 'exotic' is an organism that is introduced or brought into an area in which it has not naturally evolved. (Define *exotic species: an organism introduced into an ecosystem in which it has not evolved naturally.)*

Explain that exotic species can sometimes fit right into an ecosystem and adapt, creating few known problems. Then we might say that they are 'well adapted'—meaning they fit in and their populations are somewhat controlled by natural factors. Give examples like pheasants and rainbow trout in Michigan.

Sometimes exotics create massive problems, creating unchecked competition, even crowding out natural members of an ecological community that are very important to the survival of others. Examples might be purple loosestrife, and Norway maples. Sometimes they prey upon other members of a community, reducing their populations to a threatened or endangered status, or even causing them to become extinct, like the sea lamprey in the Great Lakes and our present problem with Emerald Ash Borer. Other times they can cause disease as with Dutch Elm disease which caused the extirpation of elm trees in most of lower Michigan and many other states during students' grandparents' lifetimes.

Another problem exotic species may cause could be physical changes created in an ecosystem. Zebra mussels in the Great Lakes filter the water so well, that they have changed the amount of light present at depths in Lake Erie, and their bodies can clog pipes that bring fresh water to cities along the lakeshores.

As you discuss several of these exotics, the important idea to emphasize is that whether humans feel that an exotic is 'good' or 'bad' the really important thing to remember is that all exotics cause changes in the ecosystems that they arrive in. Humans are quite often are the ones responsible for transporting them into that ecosystem.

All organisms move into and out of habitats naturally. Sometimes they move quickly. An example of this might be exotic birds that are blown to an island by a big storm. If the exotic finds food, shelter, and other basic needs, they will adapt and reproduce in that ecosystem. That is natural, normal population change. But because humans have learned to move so quickly around the globe, and they like to take lots of 'stuff' with them, people have made it much easier for other living things to move as well. Those 'hitchhikers' can create changes in natural ecosystems very quickly when they adapt and reproduce. These changes in communities often occur too fast for other organisms to adapt as well.

Allow students to discuss when and where they have seen evidence of exotic species. Some they will be surprised at. A conversation about European diseases such as smallpox, and Native American human populations may ensue as students synthesize prior knowledge from social studies or health classes.

Allow time for students to read and discuss information available about new exotics recently introduced to our state, and how to stem their spread. You may wish to discuss economic impact of exotics- both positives, as in stocking streams and lakes with salmon, increasing fisheries and sporting opportunities, and negatives, such as the quarantine of ash trees in Michigan and the impact it has had upon tree nursery owners.

Assessment:
Quality of conversation and student participation will indicate level of understanding. Students will need the definition of exotic species, and a general understanding of their potential for creating environmental change for tomorrow's lesson.

Lesson Plan Day Fourteen

Objective(s):
TSW explore earthworms as an example of exotic species whose presence changes their ecosystem.
TSW define and give examples of environmental engineers.

State Benchmark(s):
SCI.I.1.MS.1 *Generate scientific questions about the world based on observation.*
SCI.II.1.MS.3 *Show how common themes of science, mathematics, and technology apply in a real-world context.*
SCI.I.1.MS.6 *Write and follow procedures in the form of step by step instructions, formulas, flow diagrams, and sketches.*

Materials:

- Square meter plot markers
- Trowels
- PH test kit
- Nitrates test kit
- Digital camera
- Thermometer
- Plastic containers
- Metric ruler
- Earthworm taxonomic key
- Data sheet

Activity:

Hook: Share the following information with your students. To make it more fun, you might want to have a dish of nice fresh earthworms to catch their interest. You may want them to write down three things that they already know about earthworms before you present the following information.

Background:

'Earthworms in glaciated North America are all exotic species. Because of the action of the glaciers 12,000 years ago, worms were not present when Europeans settled Michigan. Worms are environmental engineers. Their physical presence so alters the structure and composition of their ecosystem, the area can never be the same. Define: *Environmental engineer—an organism that by its life processes so changes an environment, the ecosystem cannot return naturally to its original state.* Other examples of environmental engineers would include beavers, ants, and man. Worms, just by their life processes, alter the structure of the soil and the nutrients available to other organisms. Their movement brings minerals up to the surface, pulls organic matter deep into burrows and creates spaces and areas for water, nutrients, and other organisms to move into and through. Because of their introduction by humans, they are drastically changing the forest floor in Michigan. Native forest species that are sensitive to these changes will have to adapt, find areas without worms to migrate into, or become extinct.'

Because worms are very widespread, easy to find, and attractive to children, they are a convenient vehicle to teach the concept of invasive or exotic species and their impact on the environment. Students can use their powers of observation to describe the forest floor in an infested area, look for evidence of earthworms, capture local earthworms, identify the species, and describe how their actions have created change in different areas. Their data can be compared to ‘worm fronts’ (boundaries of uninfested land) to track the movement of these invertebrates into uncolonized areas overtime. Students’ studies will help them understand the issues of management of many other invasive species, and the role these organisms play in global change. They will also witness a clear example of man’s role in the introduction of exotic species, and it will help them to be more aware of how human action effects natural ecosystems. The following research experience was designed for 10-15 year-olds working at a nature center, using data they collect on site, as well as data recorded from other sites across the gradient study area.

Adapt the following experiment for your students.

Worm Watch

By Global Change Team: Dan Bagley, Joan Chadde, Andrea Grix, Sarah Pregitzer

Question: How does location affect the population of earthworms?

Research: We know that earthworms are not native to Michigan. Earthworms have been introduced along riparian boundaries. Earthworms only move a few meters a year. Earthworms disturb the forest floor and leave castings and burrows on the surface. Evidence of earthworms can also include mineralization at the surface. Some organisms are sensitive to earthworm excavations and will no longer grow where earthworms have been introduced.

Hypothesis: (suggested) The southern maple forest site will have two exotic species, while the others will have only one native species.

Design:

Materials:

square meter plot	Trowels	earthworm taxonomic key
markers	clipboard	short metric measuring stick
pH test kit	soil thermometer	small containers
Nitrates test kit	data sheet	
Digital camera	pencil	

Procedure:
Students should be warned in advance to approach their sampling areas carefully due to the sensitivity of earthworms. Once the site is disturbed, earthworms may disappear underground. As the students work, the teacher should photograph the sample sites and any earthworm species found.

1. Working in small teams, locate two sampling areas, one in a sugar maple deciduous forest, the other in a pine forest.

2. Lay square meter plots randomly in each sampling area. Photograph forest floor.

3. Measure the depth of the forest litter. Record depth and description of color and composition.

4. Measure the soil temperature using the soil thermometer. Record.

5. Carefully peel back the layers of leaf litter searching for earthworms. Be ready to capture any that you find. Place any worms found in container for later identification.

6. Once you have reached mineral soil, look for worm castings. Count the castings. Record. Use the trowel to carefully sift through the top few inches of soil looking for worms.

7. Identify worms collected using taxonomic key. Record your findings.

8. Collect soil samples for nitrate and pH tests using testing tube. Push probe into mineral soil to a depth of 10 centimeters. Place in plastic bag and label Pine or Hardwood and add your teams' name.

9. Carefully level your sample area, return the worms to the area, replace the leaf litter.

10. Conduct the pH and nitrates tests. Record values for each.

11. Clean all equipment and return to proper storage area.

Data: Use the following table to collect data, and then record all data on the web site.

Worm Watch Data Table

Team Name________			Date___________	
Habitat	**Coniferous Forests**	**Notes**	**Deciduous Hardwoods**	**Notes**
Soil Temperature				
Description of Litter				
Depth of Litter Layer				
Number of Castings				
Number of Worm Type 1 Species?				
Number of Worm Type 2 Species?				
Soil pH				
Soil Nitrates				

Conclusion:
Once the data has been collected in the field there are a number of ways it could be analyzed. In the above procedure the question was focused on the species found and whether there was a difference from south to north. In order to answer the question and test the hypothesis the students will need to review the data from the other three Michigan locations found on the website. Students can also compare their findings with the random plot tests (multiple trials) and compare the results between hardwood forest and coniferous forest at any one location. The data could be graphed comparing data collected at one trial, across the gradient, or after multiple groups have collected data over time. We expect students to see a difference in number of worms found between types of forests, and geographical locations along the gradient. A difference in depth and description of forest floor is also likely to occur.

Assessment:
Data collection and conclusions drawn are both suitable for assessment purposes.

Lesson Plan Day Fifteen

Objective(s):
TSW demonstrate an awareness of on-going natural and man-made changes in the global environment.
TSW show confidence and competency when using the language of global environmental change.

State Benchmark(s):
Review of benchmarks cited to date.

Materials:
All materials used in previous lessons—posters, student made materials, notes, lab data tables and reports should be made available for student use.

Hook: Ask students to brainstorm a list of all the different topics and activities we have explored in our study of global change. Share ideas together as a class, and record the ideas where all students can view the list.
As the list gets long, comment on how much we have learned and explored. Explain that instead of a 'test' over all of these ideas, there will be a team challenge. Have students choose partners for the challenge. (Depending on the competence of your class, you may wish to assign partners.)

Activity: Announce that today we are going to bring together many different parts of our study of global change to try to review what we have learned about the changes taking place on our planet. Everything we have used in the last three weeks is available for students to use, but they can only talk to one other person in the class, and that person is their partner. At the end of the period, they will receive a grade based on the criteria found on the rubric. Give each student a copy of the rubric. (Rubric follows lesson).

Directions: (Note this activity assumes students are well acquainted and comfortable with using a variety of graphic organizers.) Choose 3 of the topics we have discussed in class (see brainstormed list). For each topic, create a graphic organizer explaining at least 3 important ideas you have learned about that type of global change. Give appropriate details and examples. Each topic must then be written in the form of a complete, well written paragraph, using all of the rules for good expository writing. For each choice, three ideas, with support, are a minimum, so 4 or5 is even better. Each paragraph must show good solid understanding of the topic and be clear and legible. The graphic organizers should be completed first for all three, before the paragraph writing begins. The expectation is that the paragraphs should be finished before the end of class, but you may need to give students more time, depending on their written skills. (LD and 504 students may have extended time and any other appropriate accommodations.) Graphic organizer sketches must be done with your partner, and attached to the finished paragraphs.

Assessment: Use the following rubric to assess the student's learning. Finished paragraphs could be published, shared with parents, or posted for others to read. They can also be shared orally, as time allows.

Global Change Rubric

Scored on 50 points

	9-11	7-8	4-6	0-5
Graphic Organizers	All three topics complete	Two topics are finished, or all three almost complete	Only a little is finished, or only one is complete	Graphic organizers are omitted
Knowledge	Big ideas and details are accurate	Most of the ideas are accurate.	A few of the ideas are correct.	Very little of the 'science' is correct
Big Ideas (p2's)	More than 3 supporting ideas for some or all topics.	Three supporting ideas for each topic	One or two supporting ideas for each topic	Some or all supporting ideas are missing
Details & Examples (p3's)	Two or more details for each big idea	At least one supporting detail for each	Some ideas do not have support	Very few, or no details are given
Paragraphs	Well written, clear and descriptive.	Written simply, with some description or explanation	Writing is minimal.	Writing was not completed or very poorly done.
Total Points				

Global Change Teacher References

Websites

NASA http://asd-www.larc.nasa.gov/edu_act.html Information on global warming, radiation, ozone and other atmospheric topics.

EPA www.epa.gov/airnow/consumer.html Air Quality Guide and background information. Also daily ozone map and student worksheet and projects suitable for middle school age students.

AIRNOW www.cfpub.epa.gov/airnow/index.cfm?action=airnow.mail Excellent information, student friendly, about research taking place at the present.

DNR Wisconsin www.dnr.state.wi.us./org/caer/ce/eek/earth/field/milk Interesting site for students. Exceptionally good slide show demonstrating to kids how to tell ozone damage on milkweed. Very realistic and useful.

ARM http://education.arm.gov/ Good middle level stuff on global warming. Excellent online quizzes, updated constantly

EPA www.epa.gov/globalwarming/kids/carbob_cycle_vers Good demo oncarbon cycle and its contribution to global warming. There is an on-line demo for global warming as well.

FACE (Free Air Carbon CO2 Enrichment)
http://cdiac.esd.ornl.gov/programs/FACE/face.html Current research on Carbondioxide and ozone on the growth of plants.

GLOBE program (NASA) www.globe.gov Student cooperative research on global change through schools world-wide.

Lichen Study References

Environmental Resource Guide Air Quality, Grades 6-8. Air & Waste Management Association. Developed by Tennessee Valley Authority Environmental Education Section

www.lichen.com , North American Lichens

http://tbaker.com/academics/papers/dissertation/public_release/Lichens_as_bioindicators.pdf Lichens as indicators of air quality

Glime, Janice. Dept. of Biological Sciences. Michigan Technological University. Personal Communication. July 15, 2005.

Worm Study References

Alban, D. and E. Berry, 1994. Effects of earthworm invasion on morphology, carbon, and nitrogen of a forest soil, *Applied Soil Ecology* 1:243-249

Hendrix, Paul F. and Patrick J. Bohlen, 2002. Exotic earthworm invasions in North America: ecological and policy implications, *BioScience* 52 : 9 801-811

Krasny, Marianne E, 2003 Invasion Ecology NSTA Press

Lilleskove, Erik, July 14, 2005. Personal Communication

Books

A New Leaf A Handbook for Perserving Michigan's Environment, Ramsdell, Melissa, Michigan United Conservation Clubs, Lansing, Michigan 1992

Big Blast of Science, Nye,Bill, Perseus Books, Reading Massachusette c. 1993

The Truth About Science A Curriculum for Developing Young Scientists, Kelsey, Kathryn, and Steel, Ashley, NSTA Press, Arlington, Virginia c. 2001

Blueprint for a Green Planet A Practical Guide to Restoring the Planet, Seymour, John and Giradet, Herbert, Prentice Hall, New York, New York c. 1987

The Kids Guide to Social Action, Lewis, Barbara, Free Spirit Publishing Inc. c. 1991