Drought in Georgia
Standards-Based Activities and Background Information
for Earth Science Teachers

Lesson 3
Investigating Drought
Scientific Processes for Determining Drought

Teacher Background Information

A variety of scientists study drought conditions, including climatologists, meteorologists, researchers at the United States Geological Survey and National Weather Service, members of the Georgia Environmental Protection Division staff as well as water utilities managers and cooperative extension agents. These professionals have training and expertise in monitoring and analyzing critical factors and indicators associated with drought.

Scientists study a great deal of data to analyze drought conditions and to make decisions. A sophisticated system for measuring drought was developed by meteorologist Wayne Palmer for the National Weather Service in 1965. Now known as the Palmer Drought Severity Index (PDSI), it uses temperature and rainfall to determine dryness and has become a semi-official drought index. The Georgia Automated Environmental Monitoring Network (AEMN) was established in 1991 by the College of Agriculture and Environmental Sciences of the University of Georgia to assist the monitoring of conditions such as drought. In addition, officials at the Environmental Protection Division of the Georgia Department of Natural Resources look at many indicators of moisture in the state, including groundwater levels, streamflows, reservoir levels, rainfall for the last 90 days, expected precipitation in the next 90 days, and water use patterns across the state. Scientists also use simple tools such as rain gauges and soil moisture probes to analyze various drought conditions.

In late June 2006, the Director of the Georgia Environmental Protection Division declared a Level One drought across the state and across all nine climate divisions in Georgia. There are four levels of drought in Georgia, with Level One being the least severe. Each level requires a drought response. The State Drought Response Committee, which includes representatives from state, federal and local agencies along with university and non-governmental agencies, advises the Director of the Environmental Protection Division to make such decisions. A decision is made after monitoring streamflows, lake levels, precipitation, groundwater levels, soil moisture and other climatic indicators. http://www.gaepd.org/Files_PDF/news/Georgia_EPD_News_Release_Drought_Declaration.pdf

Watering Schedule:
Monday, Wednesday, Saturday: Even addresses;
Tuesday, Thursday, Sunday: Odd addresses

Declared Drought Responses: Level One
Water on scheduled days – 12 midnight to 10 a.m. – and – 4 p.m. to 12 midnight.

Declared Drought Response: Level Two
Water on scheduled days – 12 midnight to 10 a.m.

Declared Drought Response: Level Three
Water on scheduled weekend day – 12 midnight to 10 a.m.

Declared Drought Response: Level Four
Complete outdoor water use ban

Researchers investigate drought and other natural phenomena through the process of scientific inquiry. This process is guided by observations, targeted questions and hypotheses, experimental procedures and investigational design, collection of valid and reliable data through appropriate tools, analysis of data to determine reasonable explanations, and communication of results for necessary action.

Language:

- **analyze** – to examine methodically by separating into parts and studying the interrelationships of those parts
- **climatologist** – a scientist who studies climate as the prevailing weather conditions of a place, including climate data, the analysis of causes of the differences in climate, and the application of climate data to the solution of specific problems
- **meteorologist** – a scientist who studies the atmosphere and atmospheric conditions
- **monitor** – to keep track of systematically with a view to collecting information; to test or sample on a regular basis
- **scientific inquiry/processes** – investigation done through a step-by-step, logical method; a body of techniques for investigating phenomena and acquiring new knowledge or correcting or integrating previous knowledge; generally includes the steps of observing, hypothesizing, testing, concluding, and reporting and discussing results

NOTE: Web sites cited in this document were accessible as of February 2007.

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Key Words: analyze, climatologist, meteorologist, monitor, scientific inquiry/processes

Desired Outcomes

Goals:

S6E3. Students will recognize the significant role of water in earth processes.

b. Relate various atmospheric conditions to stages of the water cycle.

S6CS4. Students will use tools and instruments for observing, measuring, and manipulating equipment and materials in scientific activities.

c. Read analog and digital meters on instruments used to make direct measurements of length, volume, weight, elapsed time, rates, and temperature, and choose appropriate units for reporting various quantities.

S6CS6. Students will communicate scientific ideas and activities clearly.

a. Write clear, step-by-step instructions for conducting scientific investigations, operating a piece of equipment, or following a procedure.
b. Understand and describe how writing for scientific purposes is different than writing for literary purposes.
c. Organize scientific information using appropriate tables, charts, and graphs, and identify relationships they reveal.

S6CS9. Students will investigate the features of the process of scientific inquiry.

a. Scientific investigations are conducted for different reasons. They usually involve collecting evidence, reasoning, devising hypotheses, and formulating explanations.
b. Scientists often collaborate to design research. To prevent bias, scientists conduct independent studies of the same questions.
c. Accurate record keeping, data sharing, and replication of results are essential for maintaining an investigator's credibility with other scientists and society.
d. Scientists use technology and mathematics to enhance the process of scientific inquiry.

Understandings:
Students will understand that…

- drought and water use impact the availability of water resources
- scientists and other professionals engage in drought research utilizing appropriate skills and training
- scientists use specialized tools and techniques to collect and analyze data about drought conditions
- scientists look at a variety of

Essential Questions:

- What interests, education, and training do scientists need to study drought?
- What tools do scientists use to study drought?
- How do scientists determine if we are in a drought situation?
- What skills are involved in scientific inquiry concerning drought?

indicators and references to determine drought conditions • scientific inquiry is a process for questioning, investigating, gathering data, explaining, and communicating.	
Students will know… • that scientists utilize training, knowledge, and inquiry methods to investigate drought • that scientists collect and analyze drought data by means of specialized tools and resources • that scientists constantly monitor and evaluate drought conditions in Georgia • that scientific inquiry is an organized series of logical, methodical steps.	**Students will be able to…** • describe the job of a scientist who studies drought • list tools and resources that scientists use to study drought. • perform simple soil moisture and rainfall measures • discuss ways that scientists determine if a drought situation exists • outline and plan a method of scientific inquiry.

Lesson Hook: Students review introductory letters from professional scientists who are directly involved in studying drought and soil conditions in Georgia. (See attached scientists' letters.)

Assessment

Performance Tasks:

- Written plan for collecting, analyzing, and communicating information to determine if Georgia is in a drought situation

Using a scientifically sound inquiry process, students work in groups to develop a written plan. Groups present their plans to the class, as teachers note the inclusion of the following scientific inquiry/scientific process components in each plan:

- Statement of the problem
- Research question or hypothesis
- A research plan or design
- Measurements or tests to collect data under controlled conditions
- Analysis and interpretation of the data
- Communication of conclusions based on the data

The National Science Education Standards (National Academy of Sciences,1996) provide an explanatory note: Scientific method abilities "do not imply a rigid approach to scientific inquiry. On the contrary, they imply codevelopment of the skills of students in acquiring science knowledge, in using high-level reasoning, in applying their existing understanding of scientific ideas, and in communicating scientific information" (pp. 144-145).

- Demonstration of appropriate application, accuracy of measurement, and skillful and careful use of a rain gauge and/or a soil moisture probe.

Students will use rain gauges and/or soil moisture probes or other appropriate instrumentation to make observations and collect local data associated with drought conditions.

Other Evidence:
Students summarize how the Environmental Protection Division actually determines if Georgia is in a drought and subsequent actions. (Review the attachment on how EPD monitors drought conditions.)

Plan of Action

Tasks:

Part A: Thinking Scientifically About Drought: 120 minutes

1. Following students' reading of the scientists' letters designated in the Lesson Hook, teachers review vocabulary (found at the end of the Teacher Background Information section) and the scientific processes (outlined in the Assessment section above).
2. Teachers then ask students to think like scientists to develop a process for collecting and analyzing information to answer the research question: *How do we determine if Georgia is in a drought situation?*
3. Teachers pose the following additional questions*: What evidence or observations do we need to determine if there is a drought? How could we collect data? What could we measure? How could we best measure it? What tools would we need? How do we analyze, interpret and communicate our findings and results? Where could we find information to help answer questions about drought?*
4. Teachers facilitate the process of investigating drought with appropriate inquiry worksheets (http://trackstar.4teachers.org Search scientific method for model worksheets) to guide the planning effort and allow time for students to work in groups to create a plan that should include use of rain gauges/soil probes (See Lesson 3 below) and all of the following steps of scientific inquiry: statement of the problem, research question or hypothesis, a research plan/design, collection of data, analysis and interpretation of data, communication of conclusions. Guidelines for science fair projects are also helpful for outlining the scientific processes, as provided in the Web site below:
http://school.discovery.com/sciencefaircentral/scifairstudio/handbook/scientificmethod.html

Part B: Determining A Drought Situation: 60 minutes

1. Teachers explain how the Director of the Environmental Protection Division determines if the state is in a drought (Review the attachment on how EPD monitors drought conditions.)

2. Students present their plans to determine Georgia's drought situation and compare their plans from Lesson 1 to the state's overall plan.

Part C: Using Scientific Tools To Investigate Drought: Time varies depending on student investigations

1. Students use rain gauges and soil probes as part of executing their drought investigation plan from Lesson 1. (Teachers may choose to use these tools for demonstration purposes rather than active student participation if necessary.)

2. Instruments are available at the Web sites listed in Additional Resources. Instructions for making a rain gauge and for a "tool-less" means of soil moisture measurement are included as attachments.

Additional Resources:

General Drought Information Web sites:
- http://earthobservatory.nasa.gov/Library/DroughtFacts/drought_facts_2.html
- http://www.georgiaweather.net
- http://www.griffin.peachnet.edu/bae/
- http://www.caes.uga.edu/topics/disasters/drought/restrictions/faq.html
- http://www.conservewatergeorgia.net/Documents/georgia_drought.html
- http://www.ga.water.usgs.gov/drought.html

Scientific Inquiry Worksheet: http://trackstar.4teachers.org (search: scientific method)
Also refer to various science fair project guidelines such as
http://school.discovery.com/sciencefaircentral/scifairstudio/handbook/scientificmethod.html

Environmental Protection Division Steps to Determine Drought: http://www.gaepd.org/Files_PDF/gaenviron/drought/drought_mgmtplan_2003.pdf

Rain Gauge and Soil Moisture Probe Information:
- http://www.globe.gov (a comprehensive program on data collection protocols for soil, etc.)
- http://globeassessment.sri.com/soils/moistureProtocol.html
- http://www.hwr.arizona.edu/globe/globe3/SMSite.html
- http://www.miamisci.org/hurricane/rainmeasure.html
- http://www.fi.edu/weather/todo/r-gauge.html
- http://school.discovery.com/lessonplans/activities/weatherstation/
- http://www.ars.usda.gov/is/AR/archive/mar04/planet0304.htm
- http://www.ext.colostate.edu/pubs/crops/04700.html

Options for Purchasing Rain Gauges or Soil Probes:
- http://www.KidsGardeningStore.com
- http://www.acornnaturalists.com

- http://www2.carolina.com
- http://www.forestry-suppliers.com
- http://www.ambientweather.com

Lesson Plan Template

Wiggins, G., & McTighe, J. (2004). *Understanding by design professional development workbook*. Alexandria, VA: Association for Supervision and Curriculum Development.

Dear Students,

My name is Jim Lathem and I am a soil scientist with the USDA Natural Resources Conservation Service (NRCS). Let me tell you a little about my career background and current job.

My area of professional expertise is a field of science called “Pedology”. Pedology is the study of soil in its natural environment. Pedology deals with soil formation (the process by which soil is created), soil morphology (the structure and make-up of natural soils), and soil classification (a system of taxonomy used to categorize soils based on morphology).

I graduated college in 1980 with a bachelor’s degree in Agronomy. My major field of study was soil science. In January of 1981, I went to work with NRCS as a field soil scientist.

I have spent most of my career studying and mapping soils throughout Georgia for the National Cooperative Soil Survey Program. Also, I studied and mapped soils near the Canadian border in North Dakota. The soil survey maps that I made are utilized to assist farmers, foresters, developers and others in understanding soils and helping land users to make wise land use decisions. You can look for soils maps in your area by visiting the Web Soil Survey online at http://websoilsurvey.nrcs.usda.gov/app/ or by contacting your local USDA NRCS office.

This is a photo of taken in the mid-1980s with a team consisting of me, 2 plant scientists and a biologist working on a comprehensive natural resource assessment in a river swamp in middle Georgia. *(I’m the second one from the right in the photo. I’m holding a soils auger which is a coring device capable of boring holes 5 feet or more into the ground)*

(continued)

The last few years, I have been employed as a resource soil scientist. The resource soil scientist position is one that involves a variety of work such as soils education assistance, maintaining soil information in computer databases, providing training, and technical support for USDA programs. This job includes many different assignments and involves making recommendations about many resource areas.

In the photo on the left, I am demonstrating to college students how to observe seasonal water table levels using soil properties such as soil color. In the photo on the right, I am performing a wetland delineation. The instrument in my backpack is a global positioning system (GPS) receiver. Using this device, I can log my field data for computer download into a mapping database. In other words, a GPS can record my position and help me to make an accurate, computerized map later at my office. Being a soil scientist can be a fun, outdoor job, but you sure can get dirty sometimes!

One of the features that pedologists study in the field is the depth to the seasonal high water table (SHWT). SHWT levels can be estimated during the drier times of the year by observing soil features such as patterns of soil colors, presence of thick organic layers, or the presence of layers of certain minerals in the soil such as manganese. During the wet seasons, SHWT can be directly observed through boreholes or can be directly recorded using special devices such as piezometers. Piezometers are tools that read water pressures and groundwater elevations within a borehole. Data loggers are used along with piezometers to record and store the data until it can be downloaded for processing.

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Steve Lawrence and Ken Monroe, USDA NRCS soil scientists, download data from a piezometer – data logger into a PDA (personal digital assistant). This data will be transferred to a computer database later.

The information that soil scientists collect and publish is vital to helping people understand soils and make wise use of this important resource. Studying seasonal high water tables is an important part of the work that a soil scientist does. For more information on soils and/or the Natural Resources Conservation Service, visit our Web site at http://soils.usda.gov/ . For more information on the job of NRCS soil scientists, click on "Teachers and Students" – "Soil facts" – "Careers".

Jim Lathem
USDA Natural Resources Conservation Service

Hello, students!

My name is Carmen Westerfield. I grew up on a small farm in southeast Georgia near Waycross. This is the same farm my dad grew up on. I spent a lot of time with Dad in the garden, doing farm chores and fishing in the Satilla River.   I have always been fascinated with looking at plants and different animals and the different colors of soils and rocks.

I have always liked the outdoors and nature, too. While I was in high school, I attended the Natural Resources Conservation Workshop where I had the opportunity to meet different professionals who worked in natural resources and forestry. This is where I learned about agronomy as a major. I attended Waycross Junior College as a science major and then transferred to the University of Georgia where I studied agronomy – crop and soil science.

One of my main reasons for selecting agronomy as my major was it offered flexibility when I graduated from college in looking for a job. During college, I interned as a soil conservationist. During this time, I learned about the work and how enjoyable it was to be able to work outdoors. I get a great deal of satisfaction in seeing practices I have designed installed on farms in my area.

Science and math are the basis of everything I do. As a district conservationist with the United States Department of Agriculture (see the attachment box about my job), I take knowledge developed in laboratories, universities, and prior field activities and apply them to solve problems on farms such as erosion, low productivity, and water quality concerns.

Studying about drought in Georgia is very important in solving problems today and preventing new ones tomorrow. We should all continue to learn more about the impacts of drought and what we can do to help conserve water. If you have any questions for me about my job or about soil science, please contact me at Carmen .Westerfield@ga.usday.gov.

Carmen Westerfield
USDA Natural Resources Conservation Service

The Job of a District Conservationist…

I am a District Conservationist with the United States Department of Agriculture, Natural Resources Conservation Service. I am a graduate from the University of Georgia with a Bachelors of Science in Agriculture, majoring in Agronomy – soil science. The Natural Resources Conservation Service (NRCS) works with people to conserve natural resources on private lands. We help land users and communities approach conservation planning and implementation with an understanding of how natural resources, such as soil and water and plants, relate to each other and to all of us – and how our activities affect those resources.

NRCS is structured across the nation as local field offices. As District Conservationist, I oversee the Barnesville field office,which encompasses Lamar, Monroe, Pike and Upson counties covering 826,300 acres including the Lamar County Soil & Water Conservation District and the Towaliga Soil & Water Conservation District. These counties are located in the Piedmont Major Land Resource Area, and the field office is located in two major river basins with half the area flowing to the Flint River and the other half flowing to the Ocmulgee River.

Conservation Planning has always been the foundation of our work. We provide technical assistance to landowners interested in managing their land to protect their natural resources. Based on an inventory of the producer's resources as well as needs and desires, we give them information and develop management alternatives. We evaluate a number of resources such as soil erosion rates, type of wildlife habitat, quality of forage and grasses, cropping systems and water sources. From this information we help them develop a conservation management plan, with a time line for implementation, which addresses as many aspects of their operation as possible. We use a variety of tools such as aerial photography using computer generated maps, topographical maps, and soils maps. As the producer's needs and resources change over time,the written plan is revised to meet the owner's new objectives.

The assistance ranges from pasture renovation to watering facilities, to setting up rotational grazing systems. Because most water sources are dependent on surface water, technical assistance on pond construction, maintenance and renovation is still requested. There is also a growing interest in water quality concerning stream and pond protection requesting such practices as stream crossings, fencing, livestock exclusion, watering ramps, gravity flow troughs, and other forms of alternative livestock water. We design the practices specific to the farm to protect and conserve the resource, water and soil.

NRCS assists landowners within conservation districts to develop and apply resource conservation systems to solve erosion, water quality, water conservation and other resource condition problems on cropland, pastureland, woodland, rangeland, mined land, and other disturbed areas. It also helps landowners and operators conserve, manage, improve, and increase habitat for fish and wildlife.

NRCS provides technical assistance to units of government on urban erosion, flooding, and on the protection of prime, important, and unique lands. We provide technical guidance on conservation, soils interpretations and other land and water resource information to both public and private concerns, rural and urban, and assists them in making sound land use plans and decisions.

As a conservationist I am required to maintain a working knowledge of a wide range of professional soil and water conservation principles, methods, and techniques sufficient to skillfully assess, analyze, and evaluate complex environmental conditions including severely eroded land, land vulnerable to flooding, and areas used for agricultural, residential, and commercial purposes. Short- and long-term conservation plans are developed using this knowledge, which is described in detail below:

--knowledge of agronomy, animal science, water quality (as related to consumption), horticulture, plant materials, economics, recreation, range conservation, hydrology, biology, forestry, and practical engineering techniques sufficient to advise and recommend on natural resource development and treatment alternatives for conservation plans involving a variety of land uses, soils, and conservation practices

--knowledge and skill in communication methods and procedures sufficient to discuss, explain, and advocate soil and water conservation measures, plans and objectives at meetings involving diverse groups of rural and community landowners, conservation leaders, agribusiness representatives, engineering firms, urban planners and developers and representatives from state and federal agencies; skill in clearly presenting supporting facts and data justifying the rationale for specific measures and alternatives.

Utilizing this knowledge, conservation practices are also designed to conserve water. Practices such as good pasture management, rotational grazing, and conservation tillage improve soil health by slowing runoff, improving infiltration, and increasing soil moisture while reducing downstream sediment.

All of these responsibilities make the job of a district conservationist very interesting!

--Carmen Westerfield

Carmen Westerfield and Leesa Woodall looking at planted trees in a wetland area.

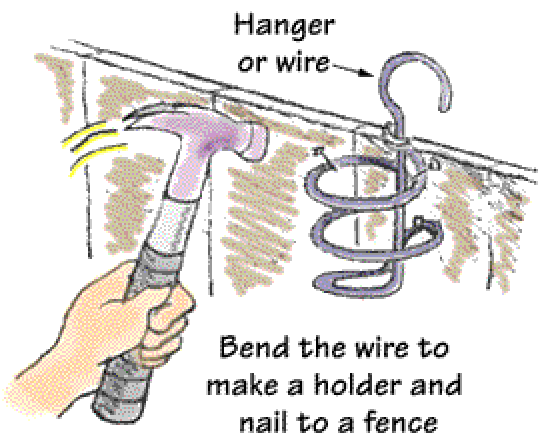
Carmen and local farmer Jack Walters discussing tree planting.

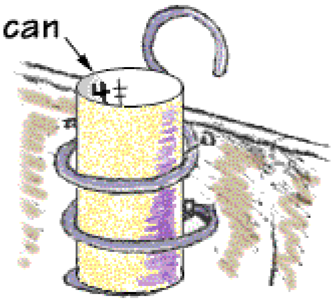
Carmen Westerfield takes clip samples to evaluate forages in a pasture.

How does the EPD monitor drought conditions?

Officials at EPD look at many indicators of moisture in the state, including groundwater levels, streamflows, reservoir levels, rainfall in the last 3, 6, and 12 months and expected precipitation in the next 90 days, and water use patterns across the state (all that comes from the state climatologist, United States Geological Survey, United States Army Corps of Engineers, National Weather Service, etc.) to monitor drought conditions. Depending on the extent of dryness, these indicators are said to be on different numerical levels reflecting the severity of a drought. Based on the severity of drought reflected by these indicators, EPD makes a decision to (or not to) put water-use restrictions in place. It's not done lightly — there's a lot of scientific data that goes into the decision and they realize the effect it has on day-to-day life for the people of Georgia(http://www.caes.uga.edu/topics/disasters/drought/restrictions/faq.html).

Make Your Own Rain Gauge





You'll need these materials:

- a glass beaker (or any straight-sided glass that can be marked with a measuring scale)
- a coat hanger or wire (bent to make a holding rack -- see picture)
- hammer and nails (to secure the rack)

Basically, any measuring glass left outside can serve as a rain gauge. However, since most rain showers are usually quite windy, you'll want to fasten your rain gauge somewhere so that it doesn't blow over.

Locate a good place for your gauge. There should be nothing overhead, like trees, electric wires, or the edge of a roof. These obstructions can direct rainwater into or away from your gauge, creating a false reading. The edge of a fence, away from the building, is often a good place for your gauge.

Once you have found the spot, attach the holding rack (refer to picture). Then, slip your measuring glass into position. Wait for rain, then record your measurement and empty the glass (http://www.fi.edu/weather/todo/r-gauge.html).

Table 1: Soil moisture interpretation chart			
Soil moisture deficiency	**Moderately coarse texture**	**Medium texture**	**Fine and very fine texture**
0% (field capacity)	Upon squeezing, no free water appears on soil but wet outline of ball is left on hand.		
0-25%	Forms weak ball, breaks easily when bounced in hand.*	Forms ball, very pliable, slicks readily.*	Easily ribbons out between thumb and forefinger.*
25-50%	Will form ball, but falls apart when bounced in hand.*	Forms ball, slicks under pressure.*	Forms ball, will ribbon out between thumb and forefinger.*
50-75%	Appears dry, will not form ball with pressure.*	Crumbly, holds together from pressure.*	Somewhat pliable, will ball under pressure.*
75-100%	Dry, loose, flows through fingers.	Powdery, crumbles easily.	Hard, difficult to break into powder.
*Squeeze a handful of soil firmly to make ball test.			

The feel and appearance of soil indicate soil moisture status. Use an auger or spade to sample soils to determine moisture content. Take soil samples throughout the depth of active plant root zones. Make an estimate of soil moisture status by firmly squeezing a handful of soil and comparing it with Table 1 above.

Table 1, excerpted from http://www.ext.colostate.edu/pubs/crops/04700.html*, may be used to provide a method of soil moisture evaluation if tools such as soil probes are unavailable to students.*