National Wildlife Federation Presents Eco-Schools USA Climate Change Connections

Integrating Climate Change Science and Applications Within the Eco-Schools USA Framework Utilizing NASA Data and Educational Resources

In Collaboration with the Following Partners

POWER
Prediction Of World Energy Resources
Langley Research Center

Eco-Schools USA Climate Change Connections

NWF's Eco-Schools USA Program Management

Principal Investigator	Senior Director, Laura Hickey
Co-Principal Investigator	Associate Director, Elizabeth Soper
Co-Principal Investigator/ Science Program Manager	Amanda Staudt, Ph.D.
Program Manager	Jennifer Murck

NASA Collaborators

SAIC, Hydrospheric and Cryospheric E/PO Specialist and ICESat Mission Education Lead	Brian Campbell
LandSat Mission E/PO Specialist	Anita Davis
AQUA Mission E/PO Specialist	Steve Graham
Terra Mission E/PO Specialist	Holli Riebeek

Consultants

NASA LaRC Science Directorate	Paul Stackhouse, Ph.D.
Chicago Botanic Garden	Jennifer Schwarz-Ballard, Ph.D.
University of New Hampshire	Mary Martin, Ph.D.
PEER Evaluators	Rachel Becker-Klein

Eco-Schools USA Staff:

Curriculum Writer	Amanda Staudt, Ph.D.
Curriculum Writer	Jennifer Hammonds, M.Ed.
Alaska Regional Contact	Courtney Sullivan
Atlanta Regional Contact	Na'Taki Osborne-Jelks
Tribal Schools Contact	Carole Palmer
International Contact	Laura Hickey

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Eco-Schools USA

National Wildlife Federation and its Eco-Schools USA program believe educators play a key role in developing a climate literate citizenry. With climate change being one of the most significant environmental issues of our time, young adults need to fully understand the essential principles of Earth's systems and the impact of climate change on them. Students also need opportunities to be exposed to "real science" that is experiential, engaging, and when understood and applied, provides them with the ability to communicate about climate change and make informed decisions with regard to individual actions. At the same time it is our desire that educators utilize this curriculum to attract and retain students in STEM disciplines and inspire the next generation of Earth Scientists.

NWF and NASA Collaboration

Eco-Schools USA Climate Change Connections is designed to build upon and utilize the many NASA mission resources, programs, and associated interfaces to enhance educator and student authentic learning experiences, and develop an integrated systems thinking approach to understanding and acting upon the issue of climate change. In collaboration with mission education specialists from ICESat, LandSat, Terra, AQUA, and AURA, a cross-programmatic curriculum was developed to provide a unified or systems thinking approach to addressing real-world Earth systems problems. Together we worked to meet the following goals and objectives:

Goals

1. Improve teacher competency for global climate change education
2. Utilize NASA Earth system data, models, and resources to strengthen teaching and learning about global climate change
3. Understand the connection to STEM standards and application

Objectives

1. Utilize NASA data and programs to provide authentic climate change data and learning experiences for educators and students to improve student learning and engagement and the ability to apply their knowledge through innovative climate change solutions for their schools and local communities.
2. Utilize National Wildlife Federation's educational framework of Eco-Schools USA to enhance teachers' and students' literacy about global climate change.
3. Enhance students' science, technology, engineering, analytical and math skills, and inspire the next generation of scientists.
4. Create an integrated, systems thinking climate change education model that will reach thousands of educators and millions of students around the world through the international Eco-Schools network.

The State of Climate Change Today

Amanda Staudt, Ph.D., NWF Climate Scientist

No longer is global warming something only facing future generations. Changes to our climate are being documented all across the planet today. People, animals, and plants are already feeling the heat.

Temperatures are increasing

The most striking evidence of a global warming trend is closely scrutinized data that show a relatively rapid and widespread increase in temperature during the past century. The 10 warmest years on record occurred during 1997-2008, according to NASA's Goddard Institute for Space Studies. The rising temperatures observed since 1978 are particularly noteworthy because the rate of increase is so high and because, during the same period, the energy reaching the Earth from the Sun had been measured precisely enough to conclude that Earth's warming was not due to changes in the Sun.

Sea levels are rising

Global sea level has increased by roughly 8 inches over the past century, and the rate of increase is accelerating. Global warming causes sea-level rise in two ways: (1) Ocean water is expanding as it warms. (2) Land-based ice in glaciers and ice sheets is melting. Sea-level rise has been happening even faster than scientists anticipated a few years ago. If recent projections are accurate, 2-3°F warming could bring about 3 feet of global sea-level rise by 2100, displacing approximately 56 million people in 84 developing countries around the world. Coastal habitats also face major changes as low-lying areas are inundated with saltwater.

Sea ice is melting

Declining sea ice is one of the most visible signs of global warming on our planet. Since 1979, Arctic sea ice extent in September (when the annual minimum is reached) has declined by over 30 percent, according to the National Snow and Ice Data Center. The ice extent has been declining in other seasons, too. Despite slightly larger ice extents in 2009, recent observations indicated that the ice is thinner and much younger (less multiyear ice) than it used to be. Covering an average of 9.6 million square miles, these areas of ice floating on ocean waters play an important role in regulating our climate, by reflecting some sunlight back to space, and in the life cycles of many polar species, such as polar bears, seals, and walruses.

Precipitation patterns are changing

Some places are getting more rainfall and others are getting less. Nearly everywhere is experiencing more heavy rainfall events, as warmer air is able to hold more water vapor. Right here in the United States, we are already seeing some important trends in precipitation. The Southwest appears to be shifting to a more arid climate, in which Dust Bowl conditions will become the new norm. Annual precipitation totals in the Northeast, Midwest, and Plains have increased by 5 to 20 percent during the last 50 years. The southeastern United States is having both more drought and more floods.

Oceans are acidifying

The ocean has absorbed a large fraction of the carbon dioxide fossil fuel burning has pumped into the atmosphere, slowing the rate of global warming. But, all this extra carbon dioxide is impacting the ocean, too. The pH of surface seawater has decreased by 0.1 units since 1750, and is projected to drop another

0.5 units by 2100 if no action is taken to curb fossil fuel emissions. These changes would take tens of thousands of years to reverse.

Earth as a System

Excerpts from Dr. Art Sussman Ph.D., *Dr. Art's Guide to Planet Earth*

"Earth is Whole" means that all the planet's physical features and living organisms are interconnected. They work together in important and meaningful ways. The clouds, oceans, mountains, volcanoes, plants, bacteria and animals all play important roles in determining how our planet works. Earth systems scientists combine the tools and ideas from many scientific disciplines including geology, biology, chemistry, physics, and computer science. In addition, they use modern technologies to measure key features of our planet, such as the concentration of gases in the atmosphere and the temperature of the ocean in many locations. Satellites orbiting our planet provide enormous amounts of data that Earth system scientists use to try to understand how our planet works and what kinds of changes are happening. To understand how the Earth works you must become a systems thinker.

Knowing that a system is made up of different parts that join together to form an interconnected whole we must also remember

- each part of a system can itself be described as a system, and
- a system can be very different from its parts.

Many of us can feel overwhelmed by the environmental issues that we encounter in newspapers and magazines, or television, radio, and internet regarding climate change. How can we understand complicated environmental issues? Compounding the complexity we must also understand that within the whole system there are systems within systems within systems.

Subsequently, no matter the complexity of the system we can always understand it better by asking three systems questions.

- What are the parts of the system?
- How does the system function as a whole?
- How is the system itself part of larger systems?

In examining the Earth as a whole, you can focus on Earth's matter, the stuff or matter that exists on our planet, Earth's energy that makes things happen on our planet, and Earth's life, the organisms that make our planet unique.

II. Climate Change Curriculum Overview

Student Goals and Objectives

Goals

1. Improve student competency for global climate change problems and solutions
2. Utilize NASA Earth system data, models, and resources to strengthen learning about global climate change
3. Increase student interest in STEM disciplines

Objectives

1. Students will understand the difference between weather and climate and their role in climate change.
2. Students will understand the importance of NASA's Earth Observing Satellites as a tool for understanding how Earth has changed and continues to change over time.
3. Students will understand how to utilize NASA data to make predictions and inferences about how the Earth's systems are changing as well as be able to collect, analyze and discuss the data collected.
4. As students utilize the data from NASA's Earth Observing Satellites they will understand how collaboration among scientists is a key component to predicting the effects of climate change on a global, national, regional, and local level.
5. Students will understand that climate change is due to natural cycles and anthropogenic impacts on Earth's systems.
6. Students will understand the potential results of human impact on climate change and understand that local concerns become global concerns.
7. Students will learn about the Eco-Schools USA framework, the 8 pathways to sustainability, and have access to a variety of tools and resources to apply to helpful solutions that will positively impact not only their local area, but the global Earth system.

Climate Literacy Principles[1]

Climate literacy is an ongoing process and is an understanding of your influence on climate and climate's influence on you and society. A climate-literate person

- understands the essential principles of Earth's climate system,
- knows how to assess scientifically credible information about climate,
- communicates about climate and climate change in a meaningful way, and
- is able to make informed and responsible decisions with regard to actions that may affect climate.

Using the seven Climate Literacy Principles as a guide

- The sun is the primary source of energy for Earth's climate system.
- Climate is regulated by complex interactions among components of the Earth system.
- Life on Earth depends on, is shaped by, and affects climate.
- Climate varies over space and time through both natural and man-made processes.

[1] "Climate Literacy Principles, Mar. 2009, 20 Oct. 2010 < http://www.climatescience.gov/Library/Literacy/ >.

- Our understanding of the climate system is improved through observations, theoretical studies, and modeling.
- Human activities are impacting the climate system.
- Climate change will have consequences for the Earth system and human lives.

Energy Awareness Principles[2]

Energy awareness is a complex topic. There are many ways to approach energy depending on the grade level, course topics, and instructional methods. Yet no matter the pedagogic setting, using a literacy based approach can provide a sound foundation to build learners' understanding surrounding the topic. The energy awareness principles set out a broad framework from which to teach about energy topics. Energy is an inherent driving force throughout the universe and the Earth system. Humans use energy from various sources, and there are environmental, political, and social consequences related to our use of energy. Sustainable energy use can only occur when there is balance between the amount of energy available and the rate at which it is consumed.

- Energy drives the Earth system.
- The primary sources of energy used by society are non-renewable stores sources, such as fossil fuels and nuclear and renewable sources, such as solar, wind, hydro, and biomass.
- Humans' use of energy has consequences on the environment that sustains them.
- The distribution of stored non-renewable and renewable energy sources varies around the planet, resulting in distribution and transmission costs.
- There are significant social, political, and equity issues associated with the human use of and access to energy.
- Developing a sustainable energy supply that minimizes impacts on the environment will require informed decision-making, technological and societal innovation, and improved efficiency.

Eco-Schools USA in association with NASA has developed a cross-programmatic curriculum designed to increase the numbers of climate literate and energy aware citizens who will be the future decision makers in a delicate and growing global economy.

Key Concepts

- Data Collection, Analysis, and Dissemination
- Interpretation and Comparison of Time Series Data
- Change Over Time
- Earth's Systems and Human and Societal Impacts
- Taking Action in the Form of:
  - Citizen Science
  - Community Service
  - Service Learning

[2] CLEAN – Climate Literacy & Energy Awareness Network, June 2011. http://cleanet.org/clean/literacy/energy.html

Within Each Lesson

Each lesson includes the following elements.

- Purpose
- Grade Level
- Time to Complete
- Link To Standards
- Student Objectives
- Teacher Background
- Prerequisite Knowledge
- Materials and Tools
- Vocabulary
- Lesson Links
- Procedure
- Websites for Further Learning
- Student Reading Resources
- Assessment Tools

At the conclusion of each lesson is an appendix. The appendix for each lesson includes the following elements.

- National Standards
- Climate Literacy Principles
- Energy Awareness Principles
- Essential Questions Answer Key
- Concept Quiz
- Essay

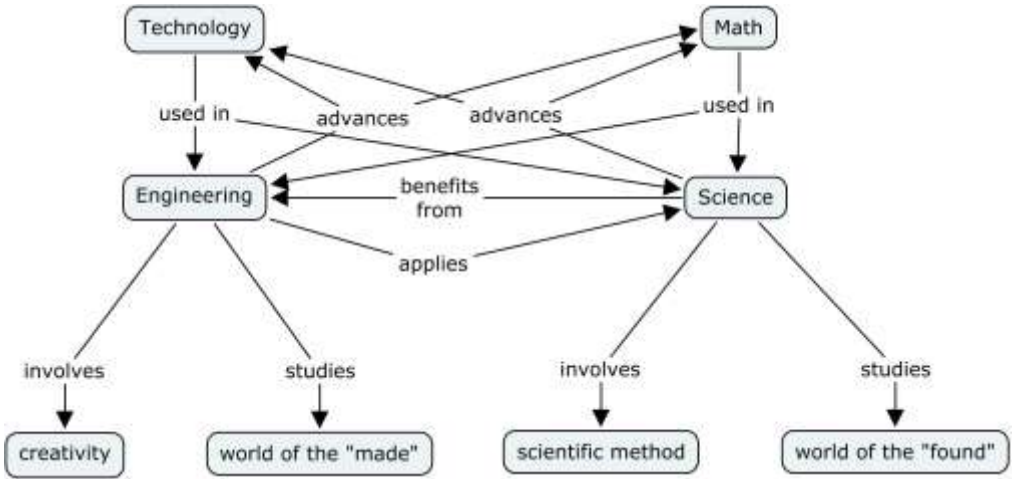
III. Teaching the Whole Student

Inquiry in the Classroom

Is true inquiry taking place in my class? Reading, An Inquiry Primer, http://www.experientiallearning.ucdavis.edu/module2/el2-60-primer.pdf by Alan Colburn will supply you with the nuts and bolts of scientific inquiry. To better understand what inquiry should look like in your classroom along with advice for implementation, video clips of inquiry taking place in the classroom, and assessment's place in the inquiry driven classroom, go to, http://www.justsciencenow.com/index.htm .

A Focus on STEM Education

"STEM literacy is an interdisciplinary area of study that *bridges* the four areas of science, technology, engineering, and mathematics. STEM literacy does not simply mean achieving literacy in these four strands or silos. Consequently, a STEM classroom shifts students away from learning discrete bits and pieces of phenomenon and rote procedures and toward investigating and questioning the interrelated facets of the world. One hallmark of a STEM classroom is an emphasis on design and problem-solving in "intellectually messy" learning situations that weave together the disciplines." (Washington STEM Initiative, 2009)



Thornburg, 2009

STEM is a key component to our future's success in a competitive global economy. According to the National Environmental Education Foundation, 80% of all students decide to opt out of science and math careers before entering high school. Environmental education, which opens its doors to a myriad of opportunities in STEM careers, is a heuristic tool for making science more relevant and engaging, and provides an appealing entry point for students thinking about future careers.

Did you know the most recent ten year employment projections by the U.S. Labor Department show that of the twenty fastest growing occupations projected for 2014, fifteen of them require significant mathematics or science preparation to successfully compete for a job[3]? Even the requirements for occupations that historically did not require a high school education have dramatically shifted. In the last thirty years, the share of factory workers without a high school degree fell from more than half to just one in five (21%). At the same time, those with a post-secondary education had reached 31 percent. If current trends continue, over 40 percent of factory jobs will require post-secondary education by 2012[4].

"We must prepare students so they have a strong foundation in STEM subjects and are able to use this knowledge in their personal and professional lives. And we must inspire students so that all are motivated to study STEM subjects in school and many are excited about the prospect of having careers in STEM fields."

Knowing these facts lends itself to anxiety over the fact that our students are falling behind their peers around the world, especially in math and science. According to the National Center for Education Statistics, about one-third of the fourth-graders and one-fifth of eighth-graders cannot perform basic mathematical computations, and U.S. high school seniors recently tested below the international average for 21 countries in mathematics and science.[5] As a result, fewer American students than ever are graduating from college with math and science degrees. When compared with our international competitors, we are not performing well. In 1995, U.S. fourth graders ranked 12th against

[3] Bureau of Labor and Statistics, Fastest growing occupations, 2004-14, http://www.bls.gov/emp/emptab21.htm
[4] Standards for What? Educational Testing Service, 2003
[5] National Center for Education Statistics

other nations when it came to mathematics competency[6]. By the 8th grade their ranking dropped to 19th, below not only Asian students in countries such as Korea, Japan and Taiwan, but also below students in many Eastern European nations such as Bulgaria, the Czech Republic and Slovenia. A similar deterioration has occurred in science. In 1995, U.S. fourth graders ranked 6th in science competency. By the 8th grade their ranking dropped to 18th, below many of the same countries cited above. More recent rankings of U.S. students relative to their counterparts around the globe have been no more encouraging with respect to America's future ability to compete. [5]

A call to action by the President's Council of Advisors on Science and Technology report, "The success of the United States in the 21st century – its wealth and welfare – will depend on the ideas and skills of its population. These have always been the Nation's most important assets. As the world becomes increasingly technological, the value of these national assets will be determined in no small measure by the effectiveness of science, technology, engineering, and mathematics (STEM) education in the United States. STEM education will determine whether the United States will remain a leader among nations and whether we will be able to solve immense challenges in such areas as energy, health, environmental protection, and national security. It will help produce the capable and flexible workforce needed to compete in a global marketplace. It will ensure our society continues to make fundamental discoveries and to advance our understanding of ourselves, our planet, and the universe. It will generate the scientists, technologists, engineers, and mathematicians who will create the new ideas, new products, and entirely new industries of the 21st century. It will provide the technical skills and quantitative literacy needed for individuals to earn livable wages and make better decisions for themselves, their families, and their communities. And it will strengthen our democracy by preparing all citizens to make informed choices in an increasing technological world. The council is asking the president to transform K-12 Education using a two-pronged approach. We must prepare students so they have a strong foundation in STEM subjects and are able to use this knowledge in their personal and professional lives. And we must inspire students so that all are motivated to study STEM subjects in school and many are excited about the prospect of having careers in STEM fields." (Holdren, John P., et. al.)

A Focus on Process Skills

Excerpt from *Science and Children* "Editor's Note Inquiry-Process Skills"

We take for granted that students have some abilities in questioning, observing, predicting, planning an investigation, collecting data, interpreting information, and communicating their ideas. But, this is more than likely not the case. We must be deliberate in how we instruct students and encourage their development of these skills. For example, we can't simply say "observe this leaf" and expect them to be able to clearly see the intricacies of the vein and margin patterns. We must be specific in how we direct them and teach them how to critically look at a phenomenon and question it. Learning in isolation of content does not maximize the ability to learn these skills in such a way that they can be easily transferred to other situations. The National Science Education Standards integrate process skills into the broader abilities of scientific inquiry. "Students at all grade levels and in every domain of science should have the opportunity to use scientific inquiry and develop the ability to think and act in ways associated with inquiry, including asking questions, planning and conducting investigations, using appropriate tools and techniques to gather data, thinking critically and logically about relationships between evidence and explanations, constructing and analyzing alternative explanations, and communicating scientific

[6] International Association for the Evaluation of Educational Achievement
[5] STEM Education Caucus

arguments" (NRC 1996, p. 105). If you search, you will find a variety of lists identifying process skills. Basically, they are the tools and skills students need to investigate phenomenon. But don't assume students develop these skills without your careful guidance. They must be prompted to investigate in such a way that they can develop increasingly more sophisticated skills and attitudes. We should not underestimate the capabilities of young students and they should be urged to reach a high bar. They are capable of engaging in all of the process skills when provided with guidance and encouragement. Don't simply hand them a ruler and ask them to measure. (Froshchauer, 2010)

Process Skills utilized within the Eco-Schools USA curriculum

- Observation
- Prediction
- Inference
- Formulating Hypotheses
- Making and Making Sense of Models
- Measurement
- Identifying and Manipulating Variables
- Investigation
- Drawing Conclusions
- Communication

Interdisciplinary Connections

"By their very nature, reading and writing activities can play a vital role in achieving a minds-on emphasis in the learning of science. Reading and writing activities can serve as conceptual tools for helping students to analyze, interpret, and communicate scientific ideas." (Holliday, Yore, and Alvermann 1994, p.877)

"These activities can help engage in students' minds the complex reasoning and problem solving processes that scientist use in the course of their work. Meaningful learning is the process of actively constructing conceptual relations between new knowledge and existing knowledge…" (Glynn 1999, p.222)

Reading

"In investigating the natural convergences between science and literacy, we found a great deal of evidence for mutual support, and none was more central than our understanding of the way in which text can support rather than supplant inquiry-based science learning." (Cervetti et. al., 2006) Students are assigned articles to read specific to topics covered. They must be able to read, comprehend, and discuss their understanding to a partner, small group, and whole group. Students will have the opportunity to participate in an environmental book club as a part of an extension and action project; opening their eyes to the foundations of environmental awareness, stewardship, activism, and education.

Writing

"There is probably no better way to assess students understanding than to look at what students write in their conclusions." (DeFronzo, 2006) Students are actively engaged in writing throughout the unit as they are asked to write all observations, predictions, questions, vocabulary, and all other parts of the scientific method in their science notebook. Also students will be asked to write a summary of articles read including questions they would like to have answered or topics for further research. Writing in response to video segments and lessons completed will be an additional opportunity to write in the science notebook.

Geography

As students work to gather NASA data sets they will have opportunities to gather data from different parts of the world. They will be able to see how climate varies by region and throughout the season. Students will also be able to see the differences in elevation, vegetation, temperature, population.

Vocabulary Instruction

The Power of Good Vocabulary Instruction in the Science Classroom

Helping students to develop a strong reading vocabulary requires more than having them look up words in a dictionary. Rather, students need instruction that will help them acquire new word knowledge and develop strategies to enable them to increase the depth of that knowledge over time. To help students develop word knowledge in breadth and depth, we must first recognize four fundamental obstacles, and then develop teaching practices to address those obstacles:

- **The size of the task.**
  The number of words that students need to learn is exceedingly large.
- **The differences between spoken English and written or "literate" English.**
  The vocabulary of written English, particularly the "literate" English that students encounter in textbooks and other school materials, differs greatly from that of spoken, especially conversational, English. Students—both English language learners and those for whom English is the first language—may have limited exposure to literate English outside of school.
- **The limitations of sources of information about words.**
  The sources of information about words that are readily available to students—dictionaries, word parts, and context—pose their own problems. Each can be difficult to use, uninformative, or even misleading.
- **The complexity of word knowledge.**
  Knowing a word involves much more than knowing its dictionary definition, and simply memorizing a dictionary definition does not guarantee the ability to use a word in reading or writing. Adding to the complexity is the fact that different kinds of words place different demands on learners.

The Texas Education Agency

"Teaching specific terms in a specific way are probably the strongest action a teacher can take to ensure that students have the academic background knowledge they need to understand the content they will encounter in school. When all the teachers in a school focus on the same academic vocabulary and teach it in the same way, the school has a powerful comprehensive approach. When all the teachers in a district embrace and use the approach, it becomes even more powerful." Marzano, 2005

IV. National Standards

National Science Education Standards (NSES)

Content Standards for Grades 9-12, "None of the eight categories of content standards should be eliminated…No standards should be eliminated from a category" (NSES, 1996)

Unifying Concepts & Processes -Systems, Order, and Organization -Evidence, Models, and Explanations -Change, Constancy, and Measurement -Equilibrium	**Earth and Space Science** -Energy in the Earth System -Geochemical Cycles
Science As Inquiry -Abilities necessary to do Scientific Inquiry -Understanding about Scientific Inquiry	**Science and Technology** - Abilities of Technological Design -Understandings about Science and Technology
Physical Science -Chemical Reactions -Conservation of Energy -Interactions of Energy and Matter	**Science In Personal & Social Perspectives** - Personal and Community Health -Population Growth -Natural Resources - Environmental Quality -Natural and Human Induced Hazards -Science and Technology in Local, National, and Global Challenges
Life Science -Interdependence of Organisms -Matter, Energy, and Organization in Living Systems	**History & Nature Of Science** - Science as a Human Endeavor -Nature of Scientific Knowledge -Historical Perspectives

NSES, http://www.nap.edu/openbook.php?record_id=4962

National Council of Teachers of Mathematics (NCTM)

Numbers and Operations -Compute fluently and make reasonable estimates.	**Problem Solving** -Build new mathematical knowledge through problem solving. -Solve problems that arise in mathematics and in other contexts.
Algebra -Analyze change in various contexts.	**Communication** -Communicate their mathematical thinking coherently and clearly to peers, teachers, and others -Analyze and evaluate the mathematical thinking and strategies of others.
Measurement -Understand measurable attributes of objects and the units, systems, and processes of measurement.	**Connections** -Recognize and use connections among mathematical ideas. -Understand how mathematical ideas interconnect and build on one another to produce a coherent whole. -Recognize and apply mathematics in contexts outside of mathematics.
Data Analysis & Probability -Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them. -Develop and evaluate inferences and predictions that are based on data.	**Representation** -Use representations to model and interpret physical, social, and mathematical phenomena.

NCTM, http://www.nctm.org/standards/default.aspx?id=58

National Educational Technology Standards (NETS)

Creativity and Innovation -Use models and simulations to explore complex systems and issues. -Identify trends and forecast possibilities	**Critical Thinking, Problem Solving, & Decision Making** -Students use critical thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources.
Communication & Collaboration -Students use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others.	**Digital Citizenship** -Practice safe, legal, and responsible use of information and technology. -Exhibit a positive attitude toward using technology that supports collaboration, learning, and productivity.
Research & Information Fluency -Students apply digital tools to gather, evaluate, and use information.	**Technology Operations & Concepts** -Understand and use technology systems. -Select and use applications effectively and productively.

NETS, http://www.iste.org/standards.aspx

V. CURRICULUM SUMMARY

Module I: Introduction to Eco-Schools USA and NASA Data

Lesson 1: Green, Green Revolution
An Introduction to Eco-Schools USA
Students will be introduced to the Eco-Schools framework and pathways to sustainability. Utilizing Eco-Schools USA Environmental Audits teachers will guide students through the energy audit in preparation for Lesson 19: I Got the POWER: Solar Energy Potential on Your Campus. Students will have the option to be a part of their school's Eco-Action team.

Lesson 2: Get Your Techno On!
An Introduction to My NASA Data
Students will learn how to use the My NASA Data LAS (Live Access Server) to access, collect, and analyze data from Earth observing satellites. Utilizing the near-surface air temperature data, students will become comfortable with plotting maps and time series, comparing two data sets, and bringing data into Excel to do further analysis.

Lesson 3: It's A Bird…It's A Plane…It's…CARBON!
A Carbon Cycle Adventure Story
Carbon's is one of the most important and abundant elements on Earth. Having a strong understanding of the atom and element, Carbon, and its role in the Earth system will be critical foundation piece as students work on other lessons. This is not your traditional from beginning to end story. This story of Carbon takes students on a roller coaster of a ride through a carbon atoms journey through the Earth system.

Module II: Factors Influencing Temperature

Lesson 4: Is It Getting Hot in Here, Or Is It Just Me?
Exploring Land Surface Temperature and Long-wave Radiation
Digging deeper into the near-surface air temperature data, students will examine how temperature has been changing globally and where they live. The analysis is supplemented with the daily downward longwave surface radiation data, to provide finer time resolution.

Lesson 5: Why All the Wiggling On the Way Up?
Investigating CO_2 Trends
Students will examine the monthly carbon dioxide (CO_2) in the troposphere observations from the AIRS instrument to learn about how carbon dioxide varies in time and space. The satellite data will be considered in the context of long-term observations from Mauna Loa (the Keeling curve).

Lesson 6: Wherefore art thou, Albedo?
Ice-Albedo Feedback
After learning about the components of the Earth's energy budget, students will focus on how the reflectivity of the Earth's surface affects how much solar energy is absorbed. Satellite-based observations of downward and upward short-wave fluxes will be used in combination with monthly snow-ice amount to examine how these quantities may be changing over time.

Lesson 7: Quantifying Land Changes Over Time Using Landsat
Our Nation is so vast! How do scientist measure changes over time? Students will examine Landsat images of Phoenix, Arizonia, identify land cover types, and calculate percent change from the first image to the second image. Students will also begin to consider the impacts these changes could have on residents and the local ecology.

Lesson 8: Quantifying Land Changes Over Time
Investigating the Affects of Deforestation and Urbanization
By examining images from the LandSat mission, students will explore how deforestation and urbanization have changed the landscape over the past decades. These changes will be related to the extent to which they have contributed to climate change.

Lesson 9: Conceptualizing Module II
To complete this unit, students will complete a comparative analysis between the preceding lessons, confirm or deny evidence of a relationship, and finally predict future trends based on collected data. These factors influencing temperature will be put in the context of all the various radiative forcing agents, as presented in the Intergovernmental Panel on Climate Change (IPCC) reports and of model projections of future climate.

Module III: How Climate Change Affects Natural and Human Systems

Lesson 10: I Speak for the Polar Bears!
The Relationship Between Arctic Sea-Ice and Polar Bear Habitat
Students will use satellite-based observations of near-surface air temperature and monthly snow and ice amount to examine how polar bear habitat has been changing. They will be provided with maps of polar bear denning locations to compare to sea-ice distributions in different years.

Lesson 11: Ghost Town
Sea Surface Temperature and Coral Bleaching
Students will map sea-surface temperature and identify places where temperatures exceed the threshold for coral bleaching.

Lesson 12: Citizen Scientist to the Rescue!
Trends in Spring Arrival Using Project Bud Burst
Students will learn how to observe seasonal shifts in nature and contribute data to the national Project Bud Burst. Next, students will use satellite observations of the leaf area index track the arrival date of spring, and compare to the Bud Burst database.

Lesson 13: How Do Scientists Measure Trees?
What is DBH?
By observing the physical characteristics and measuring the circumference and diameter of tree cookies and trees in the field, students will learn how scientists measure trees to understand the potential to sequester carbon from the atmosphere.

Lesson 14: Branching Out
The Relationship between Dendrochronology and Biospheric Data
Using satellite models and tree rings students will look for a correlation between biospheric models and tree ring growth analysis. Students will also develop a hypothesis relating seasonal and annual growth to environmental conditions.

Lesson 15: Stifling, Oppressive, Sweltering, Oh My!
The Science Behind Heat Waves and their Effect on Human Health
Students will do a more in-depth analysis of the temperature and outgoing long-wave radiation data to identify heat waves. Their analysis will be supplemented with surface-based observations of ground-level ozone, to explore the human health dimensions of heat waves. In addition, students will consider the role that other social factors play in the vulnerability to heat waves, especially poverty, access to air conditioning, and public health interventions.

Lesson 16: Now You See It, Now You Don't
Exploring Patterns in Precipitation
Using observations of monthly precipitation students will investigate changing rainfall patterns. Investigations may be supplemented with surface-based observations of precipitation.

Lesson 17: The Tide is High, but I'm Holding On…
Investigating Sea-Level Rise and Coastal Habitats
Students will use observations from the ICESat mission to investigate how ice mass has changed and implications for sea-level change in recent years. Students will examine the impacts of continued sea-level rise on coastal habitats and communities in the Chesapeake Bay region, using results from NWF modeling.

Lesson 18: Conceptualizing Module III
To complete this unit, students will identify relationships in the data sets collected and implement a citizen science approach that will help real world scientists monitor and make predictions about climate change's effect on our botanical systems.

Module IV: Energy and Tools Of The Trade

Lesson 19: I've Got the POWER!
Solar Energy Potential at Your School
Solar panels can be a cost-effective way to offset some energy expenditures and significantly reduce the carbon footprint of a school. Students will use NASA data to investigate how much solar energy their location is exposed to each year, an important step in determining whether solar panels might be a good investment for their school. They will use data from both My NASA Data and from the Prediction of Worldwide Energy Resource Project (POWER) dataset.

Lesson 20: I've Got the POWER!
Wind Energy Potential at Your School
Wind turbines are an important source of renewable energy, and are increasingly available for small scale implementation. Using observations of wind speeds from the POWER data set along with estimations of local surface roughness, students will determine whether their school might be a good location for a wind turbine.

Lesson 21: Climate Solutions: A Call to Action!
Eco-Schools USA Climate Change and Energy Pathways
As students begin to work through Eco-Schools seven step framework and complete the Energy Pathway they will develop an action plan based on the results of their energy audit, their EOS investigations, and their research reading, to make measurable changes to their school's energy consumption.

Time Needed To Complete Eco-Schools USA Climate Change Curriculum

The curriculum is designed in a way such that you, the educator, can select lessons from each module that best meet the needs of your students and local educational timelines, to that end we want to remind you of the goals and objectives of the Eco-Schools USA Climate Change curriculum, CCC, please refer back to page 1.

In order for students to understand how the Earth system is affected by climate change it is important that students have lessons from each module. Below is the **recommended minimum** for the CCC curriculum.

Module I	**Two lessons from Module I – Eco-Schools USA and technology introduction**
Module II	**Two lessons from Module II – Outside affects on temperature**
Module III	**Three lessons from Module III – Select human and natural systems that will meet your students interest or relevant to your location**
Module IV	**Two lessons from Module IV – Lesson 21 is a must as it is the planning and action that will be a transformative experience for your students. Please choose from one of the other lessons to more directly address energy.**
Total	**Nine lessons**

Technology Accessibility Solutions

Although technology is an integral component of most lessons within each module, we understand there are many schools who are either not equipped or do not have ongoing access to computers and related technologies. To assist those of you who do not have access to technology, we have developed a set of guidelines. These guidelines will allow you to utilize and implement the Eco-Schools USA Climate Change Connections curriculum to the fullest extent possible.

1. In each lesson that requires students to collect data you will find a "Student" and "Teacher" Excel document within the lesson folder. The "Teacher Excel" document serves as an answer key; an example of what your student's work should look like when complete. **Locate the "Teacher Excel" document for the lesson you want your students to complete.**

2. Make copies of the "Teacher Excel" document based on how you would like to group your students, (i.e. for every student, each pair of students, classroom set, one to display for entire class)., Only make copies of the charts and/or graphs within the Excel document. **DO NOT copy the entire Excel document.** This will print a multitude of pages that are not necessary for your students to be successful. **NOTE: If color is used in the graphic you must print in color for students to understand what they are looking at.**

3. The charts and/or graphs from your desired lesson will allow your students to work through the "Essential Questions" and will allow them to successfully meet most of the learning outcomes and objectives associated with the lesson.

4. Using this method, students will also be able to complete all forms of assessment, reflection, and evaluation.

VI. Bibliography and Web Resources

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Marzano, Robert J. *Building Academic Vocabulary: Teacher's Manual*. Alexandria, VA: Association for Supervision and Curriculum Development, 2005. Print.

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Sussman, Art, and Emiko Koike. *Dr. Art's Guide to Planet Earth: for Earthlings Ages 12 to 120*. White River Junction, VT: Chelsea Green Pub., 2000. Print.

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Earth Observatory
http://earthobservatory.nasa.gov/

Fossil Fuels
http://www.darvill.clara.net/altenerg/fossil.htm

Global Coral Reef Alliance
http://www.globalcoral.org/CORAL%20REEF%20BLEACHING%20AND%20SEA%20SURFACE%20TEMPERATURE.html

Heating Imbalances
http://earthobservatory.nasa.gov/Features/EnergyBalance/page3.php

Incoming Sun
http://earthobservatory.nasa.gov/Features/EnergyBalance/page2.php

On Thin Ice: Already struggling with pollution, oil drilling and other threats, can polar bears survive global warming's devastating effects? National Wildlife Magazine, 12-01-2006, Daniel Glick
http://www.nwf.org/News-and-Magazines/National-Wildlife/Animals/Archives/2007/On-Thin-Ice.aspx

Relationship between Snow Cover and Net Radiation
http://earthobservatory.nasa.gov/GlobalMaps/view.php?d1=CERES_NETFLUX_M&d2=MOD10C1_M_SNOW

Renewable and Nonrenewable Resources
http://www.bbc.co.uk/schools/gcsebitesize/geography/managing_resources/energyrev1.shtml

Solar Surprise for Climate Science
http://www.bbc.co.uk/news/science-environment-11480916

STEMEd Caucus Steering Committee
http://www.stemedcaucus.org/Default.aspx

Stephan-Boltzman Law
http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/stefan.html

The President's Council of Advisors on Science and Technology, Executive Report
Prepare and Inspire: K-12 Science, Technology, Engineering, and Math (STEM) Education for America's Future
http://science.nsta.org/sciencematters/PCASTSTEMEdReport.pdf

Why Are Corals So Important?
http://celebrating200years.noaa.gov/foundations/coral/side.html

Web Page Creation
http://www.make-website.com/netkids/kids-make-a-free-website.php

Wiki's
http://www.teachersfirst.com/content/wiki/

Foldables
1. http://www.dinah.com/index.php