Middle School Earth and Space Sciences

Students in middle school develop understanding of a wide range of topics in Earth and space science (ESS) that build upon science concepts from elementary school through more advanced content, practice, and crosscutting themes. There are six ESS standard topics in middle school: Space Systems, History of Earth, Earth’s Interior Systems, Earth’s Surface Systems, Weather and Climate, and Human Impacts. The content of the performance expectations are based on current community-based geoscience literacy efforts such as the Earth Science Literacy Principles (Wysession et al., 2012), and is presented with a greater emphasis on an Earth Systems Science approach. The performance expectations strongly reflect the many societally relevant aspects of ESS (resources, hazards, environmental impacts) as well as related connections to engineering and technology.

The National Wildlife Federation’s Eco-Schools USA programs has aligned three of the six middle school earth and space science topics that meet our learning objectives and outcomes, Earth’s Systems, Weather and Climate and Human Impacts.

Earth’s Systems: Students understand how Earth’s geosystems operate by modeling the flow of energy and cycling of matter within and among different systems. Students can investigate the controlling properties of important materials and construct explanations based on the analysis of real geoscience data. Of special importance in both topics are the ways that geoscience processes provide resources needed by society but also cause natural hazards that present risks to society; both involve technological challenges, for the identification and development of resources and for the mitigation of hazards.

Weather and Climate: Students can analyze data, including maps, and construct and use models to develop understanding of the factors that control weather and climate. A systems approach is also important here, examining the feedbacks between systems as energy from the sun is transferred between systems and circulates through the ocean and atmosphere.

Human Impacts: Students understand the ways that human activities impacts Earth’s other systems. Students can use many different practices to understand the significant and complex issues surrounding human uses of land, energy, mineral, and water resources and the resulting impacts of their development.
The National Wildlife Federation’s Eco-Schools USA program has aligned their program pathways of sustainability to the Next Generation Science Standards, NGSS. As a part of the Eco-Schools 7-Step Framework, linking to the curriculum, is a priority. This alignment is designed to highlight the natural connections between the NGSS and the Eco-Schools USA program.

Our program icons are used to denote pathway connections to the NGSS Performance Expectations. Not every topic, with its set of Performance Expectations are a fit with the Eco-Schools USA program and in that case an alignment will not be present.

Also present within this alignment document are connections to the Common Core State Standards, CCSS, English Language Arts, ELA, and Mathematics, 21st Century Skills, Environmental Ladder of Responsibility, and Connections to Music, Physical Education, and Art.

Green STEM is an initiative of the National Wildlife Federation’s Eco-Schools USA program and is focused on identifying best practice in the STEM fields as it relates to environment-based learning. These elements include:

- Problem-based learning
- Utilizing the school, both inside and out, as a learning laboratory
- The incorporation of two or more STEM disciplines within a single lesson, whole curricula, a set of standards, etc.
- A Maker mentality – design/create/solve
- A commitment to service learning
- An inclusive culture – where all students can learn and all students can participate
MS. Earth’s Systems

Students who demonstrate understanding can:

**MS-ESS2-4. Develop a model to describe the cycling of water through Earth’s systems driven by energy from the sun and the force of gravity.** [Clarification Statement: Emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical.] [Assessment Boundary: A quantitative understanding of the latent heats of vaporization and fusion is not assessed.]

**MS-ESS3-1. Construct a scientific explanation based on evidence for how the uneven distributions of Earth’s mineral, energy, and groundwater resources are the result of past and current geoscience processes.** [Clarification Statement: Emphasis is on how these resources are limited and typically non-renewable, and how their distributions are significantly changing as a result of removal by humans. Examples of uneven distributions of resources as a result of past processes include but are not limited to petroleum (locations of the burial of organic marine sediments and subsequent geologic traps), metal ores (locations of past volcanic and hydrothermal activity associated with subduction zones), and soil (locations of active weathering and/or deposition of rock).]

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### Developing and Using Models

**Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.**

- Develop a model to describe unobservable mechanisms.  
- (MS-ESS2-4)

#### Constructing Explanations and Designing Solutions

**Constructing and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.**

- Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students’ own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.  
- (MS-ESS3-1)

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### ESS2.C: The Roles of Water in Earth’s Surface Processes

- Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. (MS-ESS2-4)

- Global movements of water and its changes in form are propelled by sunlight and gravity. (MS-ESS2-4)

### ESS3.A: Natural Resources

- Humans depend on Earth’s land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. (MS-ESS3-1)

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### Cause and Effect

- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-ESS3-1)

### Energy and Matter

- Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. (MS-ESS2-4)

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### Connections to Engineering, Technology and Applications of Science

### Influence of Science, Engineering, and Technology on Society and the Natural World

- All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. (MS-ESS3-1)

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### Connections to other DCIs in this grade-band: MS.PS1.A (MS-ESS2-4), (MS-ESS3-1); MS.PS1.B (MS-ESS3-1); MS.PS2.A (MS-ESS2-4); MS.PS3.B (MS-ESS2-4); MS.PS3.A (MS-ESS2-4); MS.PS3.D (MS-ESS2-4); MS.PS4.B (MS-ESS2-4); MS.LS1.C (MS-ESS3-1); MS.ESS2.D (MS-ESS3-1)

### Articulation across grade-bands: MS.PS1.A (MS-ESS2-4), (MS-ESS3-1); MS.PS1.B (MS-ESS3-1); MS.PS2.A (MS-ESS2-4); MS.PS3.B (MS-ESS2-4), MS.PS3.A (MS-ESS2-4); MS.PS3.D (MS-ESS2-4); MS.PS4.B (MS-ESS2-4); MS.LS1.C (MS-ESS3-1); MS.ESS2.D (MS-ESS3-1)

### COMMON CORE STATE STANDARDS

**Connections: ELA/Literacy – RST.6-8.1**

- Cite specific textual evidence to support analysis of science and technical texts. (MS-ESS3-1)

**RST.6-8.2**

- Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-ESS3-1)

**WHST.6-8.9**

- Draw evidence from informational texts to support analysis, reflection, and research. (MS-ESS3-1)

**Mathematics – 6.EE.B.6**

- Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. (MS-ESS3-1)

**6.EE.B.4**

- Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. (MS-ESS3-1)
ECO-SCHOOLS USA PATHWAYS ALIGNMENT
MS-ESS2-4, MS-ESS3-1

Each Performance Expectation is more successfully accomplished by students who have numerous opportunities to engage in inquiry based learning experiences and using the school as a learning laboratory, provides students with these opportunities. Students will be able to develop and use models with greater precision and understanding and have the ability to communicate understanding with fact-based evidence.

Students who have played an integral role in making meaningful changes on their campus have the conceptual understanding needed to build new learning around these performance expectation’s overarching concepts, cause and effect relationships and the flow of energy into and out of systems.

LADDER OF RESPONSIBILITY

Connecting to Home
- Share gardening and habitat building at home on a smaller scale. Potted plants, square foot gardens, hydroponic and/or vertical gardens, insect houses, frog habitats, bird feeders, butterfly habitats
- Talk about current events related to energy. How does state and national energy issues affect the family budget?
- Volunteer at your local community garden, nature center, and/or local, state, and/or national park.
- Consider how changes (big and small) and commitments made at the family level can impact the local environment; discuss local, state, national and global environmental issues.
- Environmental and scientific literacy are important no matter your age or profession.

The Four R’s
- **Reduce:** Using less and investing in long-lasting products that can be re-used means less waste.
- **Refuse:** You have the right as a consumer to refuse products like Styrofoam cups and take out containers, plastic dinnerware, straws, etc. If you need a to-go container, bring one from home. Straws are not necessary when enjoying your favorite drink. Plastic water bottle – no thank you, I brought my own reusable bottle.
- **Reuse:** Cut back on disposable and single serve items. Buy a big bag of veggie straws and bring them to school or work in a reusable eco-friendly container. Use both sides of the paper, better yet try going completely digital!
- **Recycle:** **This is the last step in the cycle.** Once you have exhausted the other 3 R’s then it’s time to properly dispose of the item. Make sure you understand the recycling policies in your community. Where can you dispose of hazardous waste? Have you started a compost bin?

Wildlife and Habitat Stewardship
Wildlife depend on us to speak on their behalf; to protect and conserve the natural resources they depend on. Being a wildlife and habitat steward requires us to care for the planet and those who call it home.

Learn to use various outdoor spaces as the backdrop for mindful practices that holistically benefit students.
- Reading and writing outside
- Listening to sounds in nature
- Relieving stress through outside physical activity (running, organized sports, gardening, walking, hiking, swimming, climbing, playing, etc.)
- Fostering an appreciation for nature as a space to be cherished, conserved, and protected.

21st CENTURY SKILLS

Learning and Innovation
- Creativity and Innovation
- Critical Thinking and Problem Solving
- Communication and Collaboration

Information, Media, and Technology
- Information Literacy
- ICT Literacy (Information, Communications, Technology)

Life and Career
- Flexibility and Adaptability
- Initiative and Self-Direction
- Productivity and Accountability
- Leadership and Responsibility

Music/PE/Art
Work with teachers on campus that have the ability and expertise to extend student learning beyond their core academic classes, ELA, science, math, and the social studies.
Examples include:
- Playing period pieces inspired by history-making events.
- Advocate for walk and bike to school days.
- Make art inspired by Earth’s systems, using recycled materials to make collages or photographs documenting water flows in and out of systems.

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MS. Weather and Climate

**MS. Weather and Climate**

**Students who demonstrate understanding can:**

**MS-ESS3-5.** Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century. [Clarification Statement: Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities. Emphasis is on the major role that human activities play in causing the rise in global temperatures.]

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**Science and Engineering Practices**

**Disciplinary Core Ideas**

**Crosscutting Concepts**

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**Connections to other DCIs in this grade-band:** **MS.PS3.A** (MS-ESS3-5)

**Articulation across grade-bands:** **HS.PS3.B** (MS-ESS3-5); **HS.PS4.B** (MS-ESS3-5); **HS.ESS2.A** (MS-ESS3-5); **HS.ESS2.D** (MS-ESS3-5); **HS.ESS3.C** (MS-ESS3-5); **HS.ESS3.D** (MS-ESS3-5)

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**COMMON CORE STATE STANDARDS**

**ELA/Literacy – RST.6-8.1**

Cite specific textual evidence to support analysis of science and technical texts. (MS-ESS3-5)

**Mathematics – MP.2**

6.EE.B.6

Reason abstractly and quantitatively. (MS-ESS2-5),(MS-ESS3-5)

Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. (MS-ESS3-5)

6.EE.B.4

Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. (MS-ESS3-5)
### Ladder of Responsibility

#### Connecting to Home
- Share gardening for wildlife at home on a smaller scale. Potted plants, square foot gardens, hydroponic and/or vertical gardens, insect houses, frog habitats, bird feeders, butterfly habitats
- Talk about current events related to changing global temperatures. What impacts have there been to the family budget and/or to the environment?
- Volunteer at your local community garden, nature center, and/or local, state, and/or national park.
- Consider how changes (big and small) and commitments made at the family level can impact the local environment; discuss local, state, national and global environmental issues.
- Environmental and scientific literacy are important no matter your age or profession.

#### The Four R’s
- **Reduce:** Using less and investing in long-lasting products that can be re-used means less waste.
- **Refuse:** You have the right as a consumer to refuse products like Styrofoam cups and take out containers, plastic dinnerware, straws, etc. If you need a to-go container, bring one from home. Straws are not necessary when enjoying your favorite drink. Plastic water bottle – no thank you, I brought my own reusable bottle.
- **Reuse:** Cut back on disposable and single serve items. Buy a big bag of veggie straws and bring them to school or work in a reusable eco-friendly container. Use both sides of the paper, better yet try going completely digital!
- **Recycle:** This is the last step in the cycle. Once you have exhausted the other 3 R’s then it’s time to properly dispose of the item. Make sure you understand the recycling policies in your community. Where can you dispose of hazardous waste? Have you started a compost bin?

### Wildlife and Habitat Stewardship

Wildlife depend on us to speak on their behalf; to protect and conserve the natural resources they depend on. Being a wildlife and habitat steward requires us to care for the planet and those who call it home.

Learn to use various outdoor spaces as the backdrop for mindful practices that holistically benefit students.
- Reading and writing outside
- Listening to sounds in nature
- Relieving stress through outside physical activity (running, organized sports, gardening, walking, hiking, swimming, climbing, playing, etc.)
- Fostering an appreciation for nature as a space to be cherished, conserved, and protected.

### 21st Century Skills

#### Learning and Innovation
- Creativity and Innovation
- Critical Thinking and Problem Solving
- Communication and Collaboration

#### Information, Media, and Technology
- Information Literacy
- ICT Literacy (Information, Communications, Technology)

#### Life and Career
- Flexibility and Adaptability
- Initiative and Self-Direction
- Social and Cross-Cultural Skills
- Productivity and Accountability
- Leadership and Responsibility

#### Music/PE/Art

Work with teachers on campus that have the ability and expertise to extend student learning beyond their core academic classes, ELA, science, math, and the social studies.

Examples include:
- Playing period pieces inspired by history-making events.
- Advocate for walk and bike to school days.
- Make art inspired by Earth’s systems, using recycled materials to make collages or photographs documenting impacts from the rises in global temperature.
MS. Human Impacts

Students who demonstrate understanding can:

**MS-ESS3-2.** Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. [Clarification Statement: Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as the eruption of volcanoes), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems monitoring hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts).]

**MS-ESS3-3.** Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.* [Clarification Statement: Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as pollution of the air, water, or land).]

**MS-ESS3-4.** Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth’s systems. [Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth’s systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.]

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**Analyzing and Interpreting Data**
- Analyzing data in 5–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.
- Analyze and interpret data to determine similarities and differences in findings. (MS-ESS3-2)

**Constructing Explanations and Designing Solutions**
- Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.
  - Apply scientific principles to design an object, tool, process or system. (MS-ESS3-3)

**Engaging in Argument from Evidence**
- Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).
  - Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (MS-ESS3-4)

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**ESS3.B: Natural Hazards**
- Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events. (MS-ESS3-2)

**ESS3.C: Human Impacts on Earth Systems**
- Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth’s environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3)
- Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS-ESS3-3),(MS-ESS3-4)

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**Patterns**
- Graphs, charts, and images can be used to identify patterns in data. (MS-ESS3-2)

**Cause and Effect**
- Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. (MS-ESS3-3)
- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-ESS3-4)

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**Connections to Engineering, Technology, and Applications of Science**

**Influence of Science, Engineering, and Technology on Society and the Natural World**
- All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. (MS-ESS3-4)
- The uses of technologies and limitations on their use are driven by people’s needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. (MS-ESS3-2),(MS-ESS3-3)

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**Connections to Nature of Science**

**Science Addresses Questions About the Natural and Material World**
- Science knowledge can describe consequences of actions but does not make the decisions that society takes. (MS-ESS3-4)

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Middle School Earth and Space Science

**ECO-SCHOOLS USA PATHWAYS ALIGNMENT: INTERDEPENDENT RELATIONSHIPS IN ECOSYSTEMS**

**MS-ESS3-2, MS-ESS3-3, MS-ESS3-4**

Each Performance Expectation is more successfully accomplished by students who have numerous opportunities to engage in inquiry-based learning experiences and using the school as a learning laboratory, provides students with these opportunities. Students will be able to develop and use models with greater precision and understanding and have the ability to communicate understanding with fact-based evidence. Students who have played an integral role in making meaningful changes on their campus have the conceptual understanding needed to build new learning around these performance expectation’s overarching concepts, of understanding patterns and cause and effect relationships.

**LADDER OF RESPONSIBILITY**

**Connecting to Home**
- Share gardening for wildlife at home on a smaller scale. Potted plants, square foot gardens, hydroponic and/or vertical gardens, insect houses, frog habitats, bird feeders, butterfly habitats
- Talk about current events related to human impacts on the environment. What impacts have there been to the family budget and/or to the local environment, for example, increases in food costs or loss of green spaces or once common species?
- Find and support local farmer’s markets, participate in farm co-op programs and try growing your own herbs, fruits, and vegetables that will grow in your area.
- Volunteer at your local community garden, nature center, and/or local, state, and/or national park.
- Consider how changes (big and small) and commitments made at the family level can impact the local environment; discuss local, state, national and global environmental issues.
- Discuss family transportation habits. Can you increase how often you walk, ride your bike, and/or carpool?
- What’s the family’s consumption and waste habits? What little changes can you make now?
- Environmental and scientific literacy are important no matter your age or profession.

**Using Tools Outside**
- Demonstrate and teach proper use and safety of equipment – lab safety applies outside as well as inside. Never assume students know how to use the tool for its intended purpose.
- Proper care and maintenance of tools used to design, create, and maintain gardens and wildlife habitats – i.e. carpentry, electric, and battery powered tools, shovels, rakes, sheers, etc.
- Needs analysis – what tools are required to complete a project or task? I.e. microscopes, saws, drills, soil testing kits, etc.
- Applied use of tools as a way to design, create, and maintain gardens and habitats
- An understanding that tools are technology too. Innovation is born from necessity to make a project or task easier.

**The Four R’s**

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**21st CENTURY SKILLS**

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- Critical Thinking and Problem Solving
- Communication and Collaboration

**Information, Media, and Technology**
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**Life and Career**
- Flexibility and Adaptability
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- Productivity and Accountability
- Leadership and Responsibility

**Music/PE/Art**

Work with teachers on campus that have the added expertise to extend student learning beyond their core academic classes, ELA, science, math, and the social studies.

Examples include:
- Playing music or learning about music that was written/composed to convey an environmental message, such as is heard in Pete Seeger and Jack Johnson’s music.
- Advocate for walk and bike to school days.
- Make art inspired by Earth’s systems, using recycled materials to make collages or photographs documenting both positive and negative human impacts.

Middle School Earth and Space Science

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