Iowa 8th grade Science Bundles

Iowa 8th grade Science Bundles

Applying Science to Iowa

TED NEAL

Contents

Bundle 5: Iowa's Changing Land Use

Bundle 6: Climate

Foreward

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ABOUT THE CURRICULUM

Several years ago, the University of Iowa Center for Global and Regional Environmental Research and College of Education teamed up to develop free eighth grade science curricula on land use and climate science, in response to Iowa's grade level alignment of the middle school Next Generation Science Standards.

Encouraged by their early progress, the collaborators decided to keep going and develop material for the full eighth grade school year. *Their complete online textbook is now ready for the classroom, a year ahead of full* NGSS *implementation in fall* 2019.

Primary author Dr. Ted Neal, clinical associate professor of science education, led a team of graduate and pre-service teaching students and CGRER scientists to develop the material. They grouped standards, resources and lesson material into six bundles, each designed to engage Iowa's middle schoolers with local data and information on relevant topics like athletic concussions and agriculture.

"It's very place-based," said Nathan Quarderer, a phD student in Neal's science education group. "It's our thinking that if you can focus on these issues in your own backyard, you can inspire kids to be lifelong learners."

These lessons are built on NGSS principles and put learning in the students' hands with hands-on activities for groups and individuals. Kids will have ample opportunity to get curious, generate questions and lead themselves to answers.

From a teachers who's done it before

Several science teachers around the state have already begun to pilot this curriculum. Mandy Dunphy of Solon Middle School tried bundles four, five and six last spring, and is using the full book this year.

Dunphy said her kids have been interested and engaged in the material. For her classes last spring, the land use bundle was an especially big hit. It focuses on agricultural practices and impacts, something Solon's students see every day.

"For me, it was a really easy decision to get my kids involved in the science that's actually happening around them," she said.

Using anything new the first time can create challenges, though. Dunphy said she did not finish Bundle Six before school let out for the summer and struggled to adapt the material for the full spectrum of student needs.

But still, she said she sees the curriculum's value and recommends it to others.

Dunphy said she feels much more prepared the second time around and has three pieces of advice for other teachers considering using this book.

1. *Bounce ideas off of other science teachers.* Everyone in the state will transition to full NGSS soon, whether they use this curriculum or another. Teachers can be resources for each other as they work through new methods and material.
2. *Contact local experts.* As the material is all local and relevant, there are bound to be people nearby willing to come share their experiences with real-life science with the students. Dunphy brought in someone from the Johnson County Conservation Department to talk about how prairie plants affect soil
3. *Keep an open mind.* Giving the kids more control can be scary. Know that you're not going to be 100% successful, but don't give up when it gets hard.

Teaching climate science

Focused on climate science, the newest piece of Iowa's middle school science standards, Bundle Six, took a lot of careful planning and consideration. Input from University of Iowa climate experts has proven especially valuable in its development.

Drs. Charles Stanier and Scott Spak, associate professors of chemical engineering and urban planning respectively, identified the climate change impacts most important to Iowa and the average eighth grader. They carefully considered an appropriate geographical scale and analysis level for each impact, including increased precipitation and delayed timing of spring.

In light of common misconceptions and skepticism about climate science, the curriculum aims to help students identify trustworthy information, guiding teachers and students through a variety of reliable data sources.

"In a perfect world, they'd develop some appreciation for the process," Stanier said of his hopes for students who use the book.

To make sure the brand new material works, phD candidate Quarderer is leading an assessment on Bundle Six. Using a 20 question survey, he and his team are measuring learning outcomes for 75 students in pilot classrooms like Dunphy's.

So far, the results show statistically significant improvement for students using this curriculum. Soon, the results will be compared to those from a control group in Waterloo. Quarderer said the survey is available to any teacher interested in measuring learning in their own classroom.

For more information on the Eighth Grade Science Phenomena Bundles, contact ted-neal@uiowa.edu

Introduction

Welcome to our pressbook, our attempt to provide 8th grade science teachers in Iowa a free curriculum targeted at the new Iowa Science Standards based on real-world, evidence-based, Iowa-based science. Teachers and students are presented with interesting phenomena, like cell phone usage, concussions in sports, and how Iowa's land has changed over time. Students will be guided through an introductory lesson on the topic, then are encouraged to explore deeper into areas of their own interest. Additionally, these lessons are designed to allow students to gather their own data, use place-based education, local and real sources of data and aren't cookie cutter, guess what's in my teachers head games. This is designed with the learner first!

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These new Iowa Standards were adopted in August 2015, but don't exactly follow the Next Generation Science Standards. This was fueled by public feedback; a team of people listened to and determined that Iowa would be better served by aligning the middle school portion of NGSS into grade specific areas instead of a broad band. A primary reason for this was the transient nature of students today. Here is Standard Review Team Report that takes you through the process of how this was determined (particularly pages 21 – 32: Appendix 2).

The official rollout date was a four year adoption with implementation starting fall 2019. We have put this together as a live, active document, open to feedback and improvement, as a tool for you to use. In addition to being free, we are also interested in assessing how it truly impacts student learning. If you'd be interested in having your students learning assessed, please let us know. Currently, we are looking to pilot bundle 5 and 6 in classrooms to measure their impact.

Now, lets talk about the framework of the book. It is divided into 6 "bundles". Each unit utilizes multiple standards through the usage of a real-world phenomena. In essence, you can view each bundle as a new chapter, or, in teacher speak, a new topic to teach. Each topic/chapter consists of a standard outline that may adjust slightly by the unique challenges of each unit. In general they go like this:

Tier 1: This is the start of each unit that is done by the whole group. It typically includes an introductory video from a real-world scientist and is designed to get kids engaged in the topic at hand. These initial tiers are set up for the whole class to get into a new phenomena, and so spark their interest in the topic.

Tier 2: This section is a more focused exploration into a topic. In most chapters there are multiple tier 2 options available, giving teachers and students a lot of flexibility. In essence, a teacher could choose to have the whole class work together on any tier 2 bundle. However, teachers may also differentiate and allow students to explore areas of interest.

Tier 3: Get out of the way and let your kids learn – that's what this bundle is all about. By the time you've gotten to tier 3, students have generated a lot of questions/topics they may be interested in pursuing. We encourage kids to ask relevant questions, use real data and communicate their findings via collaborative work, just like in the real world. Creativity and originality is the name of the game. Let them create videos, write to the local paper, or present to the city council. Sky is the limit! Additionally, we would LOVE to see the learning that occurs, and are trying to find a way to house that information.

Finally, the book has an appendix for additional resources.

We realize that many students may initially struggle with not being given direct answers, words to memorize or doing school how it has always been done. Below is a short interview on inquiry from Dr. Kate Tierney. We really like how she explains that data is critical, that students need to practice using it and understanding it. This little video could be used by you or even viewed by your students, a gateway to having kids talk about how to do real science.

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We view this book as your book, with a desire to incorporate feedback into the book to grow into the future. No profit is being made by anyone on this book and it will remain a free resource for you, use it as you will.

Feedback, input, recommendations, new lessons (tiers), ideas and others can be sent to ted-neal@uiowa.edu.

Finally, we would like to thank CGRER (Center for Global and Regional Environmental Research) for their expertise, financial support, and access to world-class scientists. Without them, this would have always remained a dream. The College of Education, who is always pushing us to strive to improve learning for students. To the team: you are amazing and such wonderful colleagues, truly honored to work with you every day.

Standards Addressed

Formatting idea one:

* = Standard is covered thoroughly

+ = Standard is touched on

Bundle 1:

+**MS-PS1-3**	Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.
***MS-PS3-3**	Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.
+**MS-ETS1-1**	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
+**MS-ETS1-2**	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
***MS-ETS1-3**	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
***MS-ETS1-4**	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Bundle 2:

***MS-PS2-1**	Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.
***MS-PS2-2**	Plan an investigation to provide evidence that the change in an object's motion depends on the sum o the forces on the object and the mass of the object.
***MS-PS3-1**	Construct and interpret graphical displays of data to describe the relationships of kinetic energy to th mass of an object and to the speed of an object.
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***MS-ETS1-4**	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Bundle 3:

+**MS-PS4-1**	Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.
***MS-PS4-2**	Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.
+**MS-PS4-3**	Integrate qualitative scientific and technical information to support the claim that digitized signals ar a more reliable way to encode and transmit information than analog signals.

Bundle 4:

+**MS-LS4-1**	Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption tha natural laws operate today as in the past.
+**MS-LS4-2**	Apply scientific ideas to construct an explanation for the anatomical similarities and differences amo modern organisms and between modern and fossil organisms to infer evolutionary relationships.
+**MS-LS4-3**	Analyze displays of pictorial data to compare patterns of similarities in the embryological developmen across multiple species to identify relationships not evident in the fully formed anatomy.
***MS-LS4-4**	Construct an explanation based on evidence that describes how genetic variations of traits in a population increases some individuals' probability of surviving and reproducing in a specific environment.
***MS-LS4-6**	Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.
***MS-ESS3-4**	Construct an argument supported by evidence for how increases in human population and per-capit consumption of natural resources impact Earth's systems.

Bundle 5:

***MS-ESS3-3**	Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
***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.
+**MS-LS2-5**	Evaluate competing design solutions for maintaining biodiversity and ecosystem services.
+**MS-LS4-4**	Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.
+**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.
+**MS-PS1-3**	Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.
+**MS-ETS1-1**	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
+**MS-ETS1-2**	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
+**MS-ETS1-3**	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

Bundle 6:

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.
MS-ESS2-5	Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.
MS-ESS2-6	Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.
***MS-ESS3-5**	Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

BUNDLE 1: STORY OF THINGS

Welcome to Bundle 1- Story of Things

A YouTube element has been excluded from this version of the text. You can view it online here: https://pressbooks.uiowa.edu/8thgradescience/?p=3

Overview:

This investigation contains three components. Tier 1 is designed to engage the learner in exploration of thermal transfer in a variety of materials with regard to kinetic energy of molecules. Tier 2 involves students comparing commercially produced insulating products and engineering their own product to lengthen the solid state of ice. Tier 3 allows students to build on their prior learning to create a device to cool air temperature, while gaining a greater understanding of the impacts of the materials on society.

Big ideas:

1. Energy as heat will be transferred from a warmer object to a cooler object until both objects are at the same temperature.
2. Heat flow is an inevitable consequence of contact between objects of different temperature.
3. Insulators help minimize thermal transfer, but cannot stop it.
4. Natural and synthetic materials come from natural resources and impact the environment and society.

Standards addressed:

MS-PS1-3	Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.
MS-PS3-3	Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.
MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
MS-ETS1-4	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.
Science and Engineering	Analyze and interpret data to determine similarities and differences in findings.
Crosscutting Concepts	Patterns: Graphs, charts, and images can be used to identify patterns in data.

Tiers in depth:

Tier 1:

Students will engage in the exploration of thermal transfer in a variety of materials with regard to kinetic energy of molecules. Students will be measuring the rate at which ice will melt on a wide variety of materials (both synthetic and natural). Examples of these materials can be, but should not be limited to: variety of metals, wood, plastic, styrofoam, paper, cardboard, desk surface, bubble wrap, aluminum foil, drinking straws, paper towel, books, magazines, and glass. Students should be encouraged to brainstorm a minimum of five surfaces for their testing phase.

Tier 2:

Students will bring in commercially produced insulating products, and will do a “virtual dissection” where they research and determine the resources (synthetic and natural) that were used to create their cup. They will then engineer their own product to lengthen the time ice is in its solid state. They will collect data and compare/contrast to other students’ work, as well as already manufactured products that were brought in. Students will take this data to re-design/ re-build their cup, so the optimal design process can be achieved.

Tier 3:

Students will build on their prior learning to create a device to cool air temperature, while gaining a greater understanding of the impacts of the materials on society. Students will plan, build, test, and argue their results with their peers. Student will then select one component of their “air cooling device” and determine where (geographically) the parts of that component came from. Students will share out quantitative and qualitative data regarding their device to determine the success or challenges of their device, as well as participating in a discussion on the impact to society.

Time:

We expect this unit would take a minimum of three weeks and as long as five weeks. Teachers would guide the initial investigations with the whole group in Part 1. Next, the students start asking questions and are allowed to explore the answers to their questions on Thermal Energies in Part 2. The teacher provides students with an engineering challenge using all that was learned in the prior parts in Part 3.

Tier 1: Melting Ice Using Different Materials

Tier 1: Melting Ice Using Different Materials

Objective:

Students will engage in the exploration of thermal transfer in a variety of materials with regard to kinetic energy of molecules. Students will create a diagram model to describe the connection between the materials and thermal conductivity.

Overview:

Students will engage in the exploration of thermal transfer in a variety of materials with regard to kinetic energy of molecules. Students will be measuring the rate at which ice will melt on a wide variety of materials (both synthetic and natural). Examples of these materials can be, but should not be limited to: variety of metals, wood, plastic, styrofoam, paper, cardboard, desk surface, bubble wrap, aluminum foil, drinking straws, paper towel, books, magazines, and glass. Students should be encouraged to brainstorm a minimum of five surfaces for their testing phase.

Big questions:

As a class and in small groups, they will explore, compare and contrast various insulating materials, asking some of the following big questions along the way:

- Why do some materials help us insulate ice better than others?
- How could two things have the same temperature, but one *feels* warmer than the other?

Standards addressed:

MS-PS3-3	Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.

Tier in depth:

Part I:

MS-PS3-3: Examples of these materials can be, but should not be limited to: variety of metals, wood, plastic, styrofoam, paper, cardboard, desk surface, bubble wrap, aluminum foil, drinking straws, paper towel, books, magazines, and glass. Students should be encouraged to brainstorm a minimum of 5 surfaces for their testing phase.

Allow students to touch a piece of aluminum metal (or other metal) and piece of wood. Ask “Which one FEELS colder?” and “Which do you think would melt an ice cube the fastest?” Either allow them to conduct that investigation, or watch this video. Use the procedure described in this video to transition from the phenomena into an investigation.

Students should create a diagram model to describe the connection between the materials and thermal conductivity. Model information should include the surface, information on molecular kinetic energy, direction and flow of the thermal energy, and information on the effect on the ice cube.

Part II-Discussion of Results:

Students should share models and findings with their peers and teacher. Class discussions can occur to clear up any misconceptions and allow for class agreement on how the thermal energy is transferring in/out of the various materials. Evidence for student findings should emphasize molecular kinetic motion as well as quantitative data from temperature results.

Experts:

Solutions:

Tier 2: Engineering to Minimize Melting

Tier: Engineering to Minimize Melting

Objective:

Students will design their own model or prototype of an insulated cup. After testing, they will re-design this cup until the optimal design process is achieved.

Overview:

Students will bring in commercially produced insulating products, and will do a "virtual dissection" where they research and determine the resources (synthetic and natural) that were used to create their cup. They will then engineer their own product to lengthen the time ice is in its solid state. They will collect data and compare/contrast to other student work, as well as already manufactured products that were brought in. Students will take this data to re-design/ re-build their cup, so the optimal design process can be achieved.

Big questions:

1. What materials make good insulators?
2. How do data inform material choices in engineering?

Standards addressed:

MS-PS1-3	Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.
MS-PS3-3	Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.
MS-ETS1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
MS-ETS1-4	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.
Science and Engineering	Analyze and interpret data to determine similarities and differences in findings.
Crosscutting Concepts	Patterns: Graphs, charts, and images can be used to identify patterns in data.

Tier in depth:

Part 1: Engineering to Minimize Melting

Overview of activity 1:

Each student group will bring in some already manufactured thermos-product (i.e. – styrofoam Starbucks cup, Yeti, RTIC, insulated mug, McDonald's coffee cup, etc.) Student groups will do a "virtual dissection" where they research and determine the resources (synthetic and natural) that were used to create their cup. Research should include information to allow a conclusion and "impact statement" sharing how this product has impacted society. Students should share their learning with their peers and focus should be placed on structure and function of the insulated cup components.

Students will design their own model or prototype of an insulated cup. They will test and compare/contrast to other student work, as well as already manufactured products that were brought in. Testing could be based on how long the cup keeps ice in a solid state.

Students will take this data to re-design/ re-build their cup so the optimal design process can be achieved.

Experts:

Solutions:

Tier 3: Cooling The Room

Tier 3: Cooling The Room

Objective:

Students will create a device that will cool surrounding air by planning, building, and testing the device.

Overview:

Students will build on their prior learning to create a device to cool air temperature, while gaining a greater understanding of the impacts of the materials on society. Students will plan, build, test, and argue their results with their peers. Student will then select one component of their "air cooling device" and determine where (geographically) the parts of that component came from. Students will share out quantitative and qualitative data regarding their device to determine the success or challenges of their device, as well as participating in a discussion on the impact to society.

Big questions:

1. How do devices cool air?
2. How do synthetic materials, coming from natural resources, impact the environment and society?

Standards addressed:

MS-PS1-3	Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.
MS-PS3-3	Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.
MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

Tier in depth:

Part I: Students will create a device that will cool surrounding air ("air conditioner"). They will plan, build, test, and argue their results with their peers.

Disclaimer: Teachers can determine the appropriate constraints (time, cost, materials, etc) for this activity.

Part II: Students will share out quantitative and qualitative data regarding their device to determine the success or challenges of their device as well as participating in a discussion on the impact to society.

Part III: Students will select one component of their "air cooling device" and determine where (geographically) the parts of that component came from. Students can report this out through the use of a video they create, a schematic flow chart, etc. An example can be shown to the students through this video regarding the "Story of a Pencil." Additional information regarding components might be found here: https://mrdata.usgs.gov/

Extension:

Students could also extend into a discussion of the environmental impact of their "air conditioner" by considering all components of their device. Students could construct a "cradle to grave" analysis that details all aspects of the manufacturing and products that are utilized in their device.

Possible ideas can be found at the following websites:

Cleverly website

Homemade Air Conditioner ideas

Swamp Cooler

Experts:

Solutions:

BUNDLE 2: COLLISIONS

Welcome to Bundle 2- Collisions

Overview:

This investigation contains three components. Tier 1 is designed to engage the learner in exploration of concussions and CTE. Tier 2 includes investigating safety equipment, treatment for concussions, and has students engineering their own product to improve the protection of athletes at risk. The final component, Tier 3, allows the students to build on their prior learning to apply their understanding of and experience with collisions to improve the outcomes of these inevitable collisions.

Big ideas:

1. A concussion is a brain injury that affects brain function.
2. Safety equipment can help lessen the impacts of concussions.

Standards addressed:

MS-PS2-1	Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.
MS-PS2-2	Plan an investigation to provide evidence that the change in an object's motion depends on the sum o the forces on the object and the mass of the object.
MS-PS3-1	Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.
MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successfu solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
MS-ETS1-4	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Tiers in depth:

Tier 1:

Students learn about the story of Zac Easter, a young man from Indianola, Iowa, who committed suicide at 24 years old, after suffering from symptoms of CTE (chronic traumatic encephalopathy) as a result of multiple concussions. Students spend time doing brief research to better understand CTE and will then report to the class. As a class and in small groups, students investigate the likelihood and occurrence of concussions in high school athletics.

Tier 2:

Students investigate safety equipment and treatment for concussions and engineer their own product to improve the protection of athletes at risk.

Tier 3:

Students build on their prior learning to apply their understanding of and experience with collisions to improve the outcomes of these inevitable collisions

Time: We expect this unit would take a minimum of 3 weeks and as long as 5 weeks. Teachers would guide the initial investigations with the whole group in Tier 1. Next, the students start asking questions and are allowed to explore the possible responses to their questions in Tier 2. The teacher provides students with an application of knowledge using all that was learned in the prior parts in Tier 3.

Tier 1: What do concussions have to do with physics?

Tier 1: What do concussion have to do with physics?

Objective:

The learner will engage in exploration of concussions and CTE.

Overview:

Student will learn about the story of Zak Easter, who committed suicide at 24 years old after suffering from symptoms of CTE (chronic traumatic encephalopathy) as a result of multiple concussions. Students will spend time doing research to better understand CTE. The teacher should use their discretion if/what should be covered by the students in their research, as well as possibly splitting classes into groups to cover certain parts of the research about CTE. The groups or individuals then come back together as a class to share what they found about CTE as a way to bring together the problem as a whole: concussions occurring in athletes.

Big questions:

Students then investigate the following questions:

- In high school sports (or athletics in general), when are concussions happening most often and what is the cause?

Standards addressed:

MS-PS2-2	Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.
MS-PS3-1	Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.

Tier in depth:

Phenomena: Share with students the story of Zac Easter, as told by his family using the video and article in documentary format by the Des Moines Register. Zac Easter was from Indianola, Iowa and committed suicide at 24 years old after suffering from symptoms of CTE (chronic traumatic encephalopathy) as a result of multiple concussions. Allow students to do some reflection after understanding Zac's story, then discuss two other well-known stories of CTE victims – Tyler Sash (University of Iowa football player and from Oskaloosa, Iowa, and Mike Webster (former NFL player for the Pittsburgh Steelers and story made famous in the Will Smith movie, Concussion).

Students should do some whole class research first, to determine when concussions happen and in which sports most often. From there, students could be split into groups based on interest (football, cycling, soccer, etc.). Students can create a display of "what we know" about how and why concussions happen, perhaps specifically in the sport they are studying, and support these claims with evidence and reasoning.

MS-PS2-2: Students develop questions based on their prior research that lead them towards developing an investigation of why concussions are happening, using Newton's first and second laws. These investigations should be designed to determine the relationship between the motion of an object (dependent variable – most likely the athlete) and the sum of the forces acting on it (independent variable). These investigations allow students to develop an explanation of a cause and effect relationship used to predict the motion of the object (dependent variable) and the sum of the forces acting on it (independent variable).

MS-PS3-1: To further expand their investigations, students should construct and interpret graphical displays of data to describe the relationship of kinetic energy to the mass of an object and to the speed of an object. Students would want to create or gather data based on their sport of study. Data can be simulated and collected using the PhET Collision Lab. Students should include in their explanation of their investigation how the kinetic energy of an object is proportional to the mass of the moving object and grows with the square of its speed.

Discussion of Results: Students should share findings and graphs with their peers and teacher. Class discussions can occur to clear up any misconceptions and allow for class agreement on why concussions occur, according to Newton's first and second laws, as well as the relationship between kinetic energy and the mass and speed of an object. Evidence for student findings should emphasize Newton's laws, as well as quantitative data from graphs of simulation results.

Nature of Science: Before moving on, the teacher should take time to discuss with students how the examples of Sir Isaac Newton and the scientists studying CTE, as well as their own investigations demonstrate how science is a human endeavor. Scientists and engineers are guided by habits of mind such as intellectual honesty, tolerance of ambiguity, skepticism and openness to new ideas. Students read about how Sir Isaac Newton was guided by habits of mind that supported him in discovering the motion of an object is determined by the sum of the forces acting on it. Furthermore, students then can use the same discussion from Newton and apply it to today's scientists studying CTE. How are they models of or not of intellectual honesty, tolerance of ambiguity, skepticism and openness to new ideas?

Optional- Primary vs. Secondary Sources: Students could examine the differences in primary vs. secondary sources of information and data when doing research for an investigation. An example of this is the KCCI news story on July 26, 2017 about a new study about CTE being released. The primary source is the actual study of CTE from Boston University's CTE Center by neuropathologist Dr. Ann McKee.

Resources:

Included in Part 1, 2, or 3

- Middle School Phenomenon Model Course 1 – Bundle 4 Energy, Force, and Motion: When Objects Collide
- PhET Collision Lab
- Des Moines Register Documentary: Zac Easter and CTE
- Reading and Discussion Questions about Sir Isaac Newton

Supplemental to Part 1, 2, or 3

- KCCI News Story about CTE Study
- Boston University's CTE Study published in the Journal of American Medical Association
- New York Times article about Boston University's CTE Study
- CNN article about Boston University's CTE Study
- ABC News: Heads Up Youth Sports Concussions Video
- Article: Simpleware working with ANSYS on Simulating Head Injuries in American Football
- New York Times article: Really? Cycling is the Top Sport for Head Injuries
- News Leader article: Football causes most concussions? Think again.
- Forbes article: Football Physics: The Forces Behind Those Big Hits
- CBS News article: The real doctors behind movie "Concussion" speak out
- National Highway Traffic Safety Administration on Bicycle Safety and Helmets
- Law of Inertia and Head Injuries
- University of Nebraska: The New Normal: A Brain After Concussion

Experts:

Solutions:

Prepared By Hallie Edgerly (ADM Middle School) and Courtney Van Wyk (Pella Christian Middle School)

Tier 2: Engineering to Minimize Impact

Tier 2: Engineering to Minimize Impact

Objective:

Student should investigate safety equipment and treatment for concussions and will engineer their own product to improve the protection of athletes at risk.

Overview:

In this Tier 2 activity, students apply Newton's third law to design a solution to the problem of concussions occurring that involves two colliding objects (depending on what sport the students are studying, most likely one of these objects will be the athlete).

Big questions:

While researching and investigating current concussion safety equipment, students will work to answer this big question along the way:

- How can sports be more safe when it comes to preventing, being aware of, and treating concussions?

Standards addressed:

MS-PS2-1	Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.
MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
MS-ETS1-4	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Tier in depth:

Part I: MS-PS2-1: First, students investigate what equipment is already out there designed specifically for concussion safety. This might be equipment the athlete wears or tests the athlete has to complete. Students find out how the equipment is tested, find existing data of the equipment from tests, or gather data using the PhET Collision Lab simulation. Next, students design an improved version or new version of the equipment. This design should eventually include a model created by the students. Again, data is gathered using the simulation and then analyzed and interpreted for optimal operational range for the proposed object (the model students have designed) to meet the criteria of providing a safer environment for the athlete. Through analysis and interpretation of the data, the students will determine what parts of their model will need to be re-designed/re-built to achieve optimization and provide evidence of why their design is considered optimal.

Part II: MS-PS3-1: To again further expand their investigations, students can use their data to create graphical displays demonstrating the relationship of kinetic energy to the mass of an object and to the speed of an object. Students should include in their explanation of their investigation how the kinetic energy of an object is proportional to the mass of the moving object and grows with the square of its speed.

Experts:

Solutions:

Tier 3: Application to Inevitable Collisions

Tier 3: Application to Inevitable Collisions

Objective:

Students will build on their prior learning from Tier 1 and 2, and will apply their understanding of and experience with collisions to improve the outcomes of these inevitable collisions.

Overview:

Students will use their prior knowledge and past experience from Tier 1 and 2 of this Bundle, as well as outside experience to pick a collision of their own interest. Many suggestions are included in the list below. Students will plan, build, test, and argue their results with their peers. Disclaimer: Teacher can determine the appropriate constraints (time, cost, materials, etc) for this activity.

Big questions:

- How might collisions happen?
- How can the results of a collision be explained?
- How does our understanding of Newton's Laws apply to other inevitable collisions that the outcomes can be improved?

Standards addressed:

MS-PS2-1	Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.
MS-PS2-2	Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.
MS-PS3-1	Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.
MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
MS-ETS1-4	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Tier in depth:

Application Challenge Presented to Students: Students will use their prior knowledge and past experience from Part 1 and 2 of this bundle, as well as outside experience to pick a collision of their own interest. Many suggestions are included in the list below. Students will plan, build, test, and argue their results with their peers. Disclaimer: Teacher can determine the appropriate constraints (time, cost, materials, etc) for this activity.

Discussion of Results: Students will share out quantitative and qualitative data regarding their investigation to determine the success or limitations of their investigation as well as participating in a discussion on the impact to society and moral/ethical concerns.

Examples of Collisions, etc.

- Concussions: Technology being used for head injuries – prevention, awareness, or treatment
    - Stakeholders: athletic trainers, parents, coaches
    - Importance of fit of helmet, amount of air pressure
    - Rules/Regulations of NCAA, IHSAA, or IGHSAU

    - When are females at the highest risk of concussions since most football players are males?
- Vehicles
    - Safety features: improvements, child car seats, adult seats in cars,
    - Driverless cars
    - Stakeholders: police officers, insurance agencies, car accident specialists, emergency workers
    - Car vs. Train accidents
    - Motorcycles
    - Speed cameras
- Baseball Bats
- Sledding
- Football
    - Running backs vs. linebackers
- Soccer
    - Why don't soccer players wear helmets?
- Race Cars
    - Fastest cars, acceleration, crashes on the track
- Cycling
    - Wearing helmets, types of helmets, programming to encourage helmet use
- Engineering design challenge: egg drop – must protect the egg

Experts:

Solutions:

BUNDLE 3: COMMUNICATIONS

Welcome to Bundle 3- Communications

Overview:

We are awash in a sea of waves. In this bundle, we're not referring to the waves associated with earthquakes or the ocean, but, rather, the electromagnetic waves used for communication. Wireless internet, television, radio, and cellphones all operate by transmitting and receiving signals that travel through space as waves. The familiar concepts of frequency, wavelength, and amplitude covered in elementary science will all be built upon here. Students will begin by looking at one application of waves, the concept of WiFi (wireless internet), to better understand how they're able to communicate with friends and family over large distances without being physically connected. From there, further investigations that look at how waves interact with different materials will be explored, followed by a deeper look at the effects that waves can have on living organisms. This interdisciplinary bundle links together concepts from the life, physical, and earth/environmental sciences.

Big ideas:

- Waves are reflected, absorbed, or transmitted through various materials.
- We depend on waves for communication.

Standards addressed:

MS-PS4-1	Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.
MS-PS4-2	Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.
MS-PS4-3	Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.

MS-LS1-5	Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.
MS-ESS3-3	Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
MS-ETS1-4	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Tiers in depth:

Tier 1:

Students will explore the concept of waves through the application of the wireless internet signal (Wi-Fi). To meet this objective students should first review the concept of waves, including basic properties such as wavelength and amplitude. Emphasis here is on electromagnetic waves, and students should be reminded that waves have a wide range of use in the field of communications, including radio and television. To help develop a better sense of how we make use of waves to communicate and transmit information, this set of activities gives students the opportunity to design experiments that investigate waves through the application of wireless internet. Students are then asked to come up with a method that allows them to map the strength of the Wi-Fi signal in their school or neighborhood.

Tier 2:

Part A

The purpose of this project is for students to develop some understanding of radio waves using their experience with something they interact with on a day-to-day basis: Wi-Fi. Students should use their experience from Tier I of this bundle to help draw them into the investigation. Students will begin by brainstorming about different kinds of signals, and how to generate, send, and receive signals. This initial engagement activity should lead to a discussion about Wi-Fi and how they could possibly improve the wireless Internet signal in parts of the school. A potential end goal could include designing and engineering a solution to boost the Wi-Fi signal in their classroom. If access to a wireless router is not available, a television or other device that can be turned on and off with a remote control could be used as a substitute to investigate the behavior of waves and radio signals.

Part B

This is an opportunity for students to develop a deeper understanding of the relationships between waves (cellular & WiFi) and living organisms. Through this investigation, students are able to determine whether or not WiFi or cell phone signals have any impact on living organisms, specifically plants. Students can explore different variables including type and strength of signal, plant species, or distance between signal source and living organism. This activity could be used as a starting point for looking more closely at the claims made in newspapers and other media sources about the health effects associated with cellphones and WiFi.

Tier 3:

Here is the chance for students to investigate further those questions and ideas about waves and communication that most interest them. During the course of Tiers 1 & 2 questions will likely come up that you (the teacher) hadn't thought of. Now is the time to let students dig deeper. There are countless communication applications that depend on our understanding of the behavior of waves. Astronomers, HAM radio operators, military and emergency personnel, radio disc-jockeys, and meteorologists all make great local experts that students could connect with during Tier 3.

Tier 1: How Does Wi-Fi Work?

Tier 1: How does Wi-Fi work?

Objective:

Students will explore the concept of waves through the application of the wireless internet signal (Wi-Fi).

Overview:

To meet this objective students should first review the concept of waves, including basic properties such as wavelength and amplitude. Emphasis here is on electromagnetic waves, and students should be reminded that waves have a wide range of use in the field of communications, including radio and television. To help develop a better sense of how we make use of waves to communicate and transmit information, this set of activities gives students the opportunity to design experiments that investigate waves through the application of wireless internet. Students are then asked to come up with a method that allows them to map the strength of the Wi-Fi signal in their school or neighborhood.

Big Questions:

- What are waves?
- How do we use waves for communication?
- What is Wi-Fi and how does Wi-Fi work?
- What can I learn about the strength of the Wi-Fi signal(s) in my school or neighborhood?

Standards addressed:

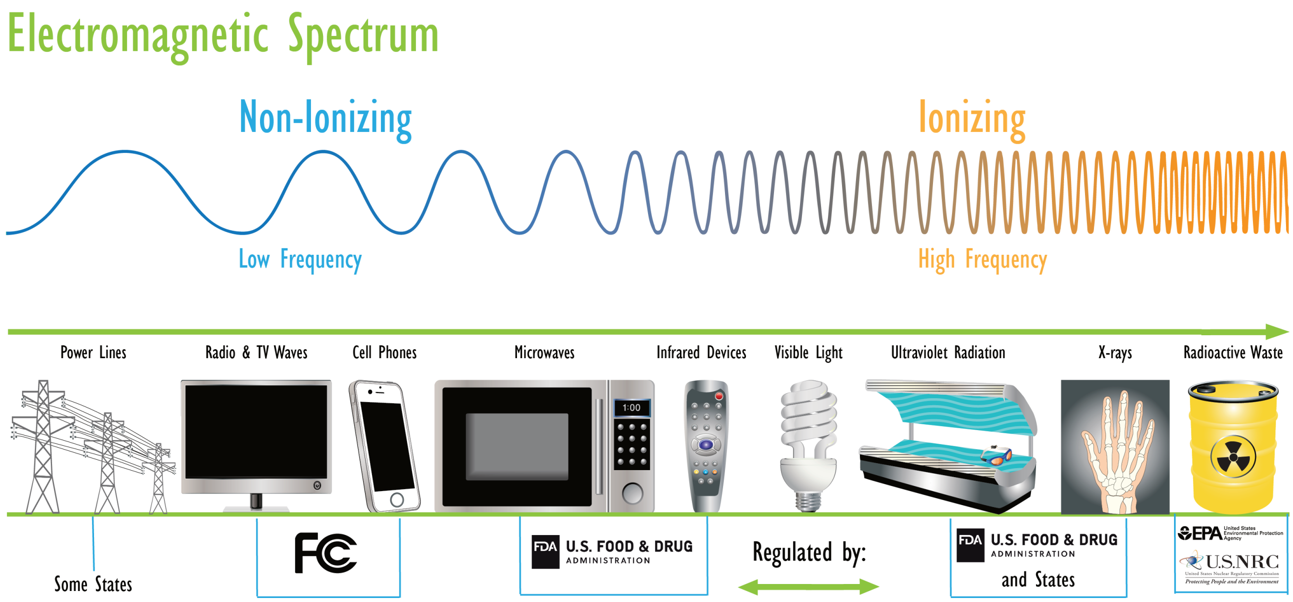
MS-PS4-1	Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.
MS-PS4-2	Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.
MS-PS4-3	Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.

Tier in depth:

https://computer.howstuffworks.com/wireless-network.htm

Have you ever wondered how we are able to transmit information and communicate over large distances, without the use of wires or cables? You may recall that digital information can be sent over great distances without being degraded significantly. Devices like tablets, cell phones and computers are capable of turning these digital signals into text, voice, or video that we can read, listen to, and watch. But when these devices are not connected through a cord or plug, how are they able to transmit and receive information? These digital messages can be sent using electromagnetic waves, or wave pulses, of different frequency and wavelength.

https://www.epa.gov/radiation/radiation-resources-outside-



You're probably familiar with Wi-Fi, and may even have experience using it in your school or home. When you're within range of a wireless router that's transmitting a Wi-Fi signal, you may possibly be able to connect to the internet via that network using your smartphone or tablet. Wi-Fi networks operate using radio waves with frequencies in the range of 2.4 – 5 GHz (gigahertz), landing somewhere between cell phone and microwave signals on the electromagnetic spectrum pictured above. These waves are capable of transferring bits of information typically coded as a series of 0's or 1's that can then be translated back into images, sound, or text through our smart devices.

Tier 1A – Mapping the strength of the Wi-Fi signal in your school

One application of these ideas presents itself when we try joining a Wi-Fi network at school, the library, a restaurant, or at home. You may have noticed that depending on where you're located with respect to the source of the Wi-Fi signal, you may have an easier time accessing the internet, or may even observe faster or slower download speeds based on the strength of your Wi-Fi signal. One way to investigate how the Wi-Fi signal in your school varies with location, would be to create a map of the Wi-Fi signal strength for different rooms in your school. This can be achieved using a number of different techniques, or apps that will run on your smart device, several of which are listed below:

http://appshopper.com/productivity/ar-signal-master

https://itunes.apple.com/us/app/ar-signal-master/id1281825606?mt=8

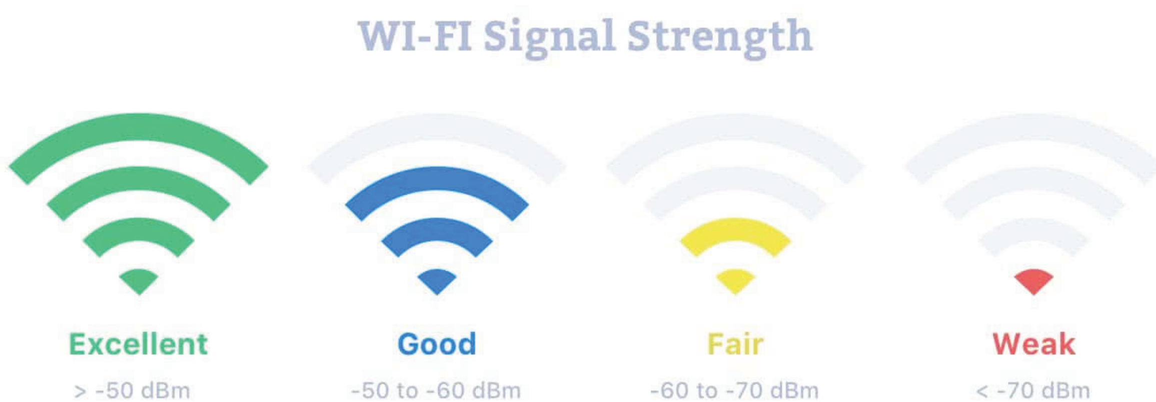
https://itunes.apple.com/us/app/dr-wifi-speed-signal-test/id1188167907?mt=8 https://play.google.com/store/apps/details?id=esso.App.wifiDoctor&hl=en

https://play.google.com/store/apps/details?id=com.farproc.wifi.analyzer&hl=en

https://play.google.com/store/apps/details?id=ua.com.wifisolutions.wifiheatmap

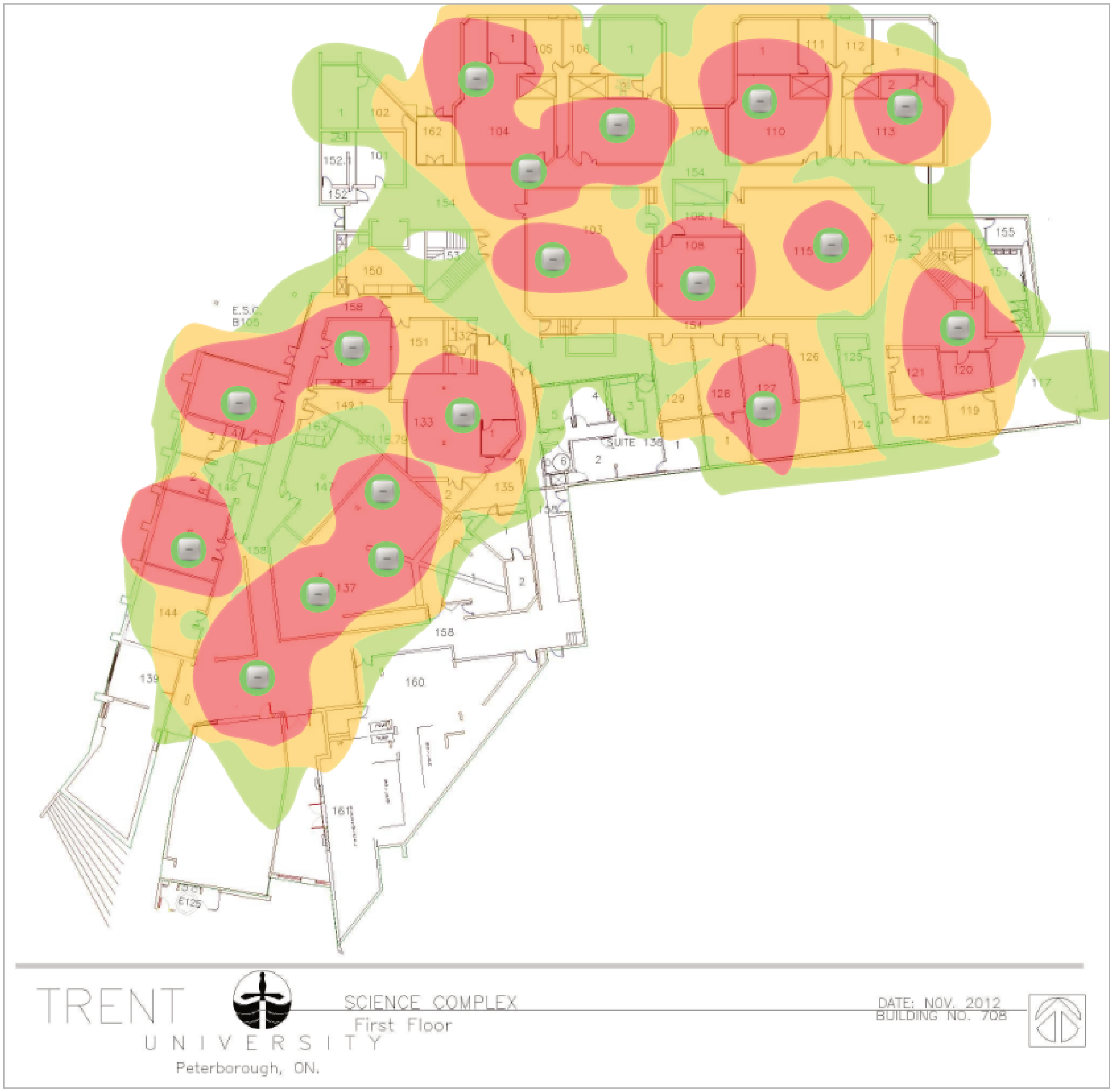
Once you have obtained or created a floor plan of your school, visit the different areas and see if you notice how the strength of the local Wi-Fi signal changes from room to room. If you're unable to download applications to your phone or tablet, you maybe be able to get a sense of how the Wi-Fi signal is changing, simply by observing the Wi-Fi icon on your smart device, an example of which is pictured below. Generally when there are more bars or lines lit up, the Wi-Fi signal, measured in decibel-milliwatts (dBm), is stronger.

https://www.netspotapp.com/what-is-rssi-level.html



The final product of your map may take on any number of different forms, but you might consider including things like numbers to demonstrate the Wi-Fi signal strength in each room. Similarly, you could try developing some sort of color-coding scheme that could communicate how the Wi-Fi signal in your school varies from room to room, based on strength of signal. This could result in what some refer to as a Wi-Fi 'heat map' with different colors representing different Wi-Fi signal strengths (see below).

https://www.trentu.ca/it/wifi-heat-maps-non-residence-areas



Tier 1B – Mapping the Wi-Fi networks of your neighborhood.

Now that you've had a chance to explore the Wi-Fi network at your school, you might be ready to get outside to explore the other Wi-Fi networks that exist around your school or home. Identifying the location of these Wi-Fi 'hotspots' can be helpful when you're traveling and need to be able to access the internet. Oftentimes, these kinds of maps are provided by local internet providers, or can be created using apps that will run on your tablet or smartphone like those listed here:

https://itunes.apple.com/us/app/wifi-finder-map/id946365975?mt=8 https://itunes.apple.com/us/app/wifi-map-get-free-internet/id548925969?mt=8

https://play.google.com/store/apps/details?id=io.wifimap.wifimap&hl=en

https://play.google.com/store/apps/details?id=org.speedspot.wififinder

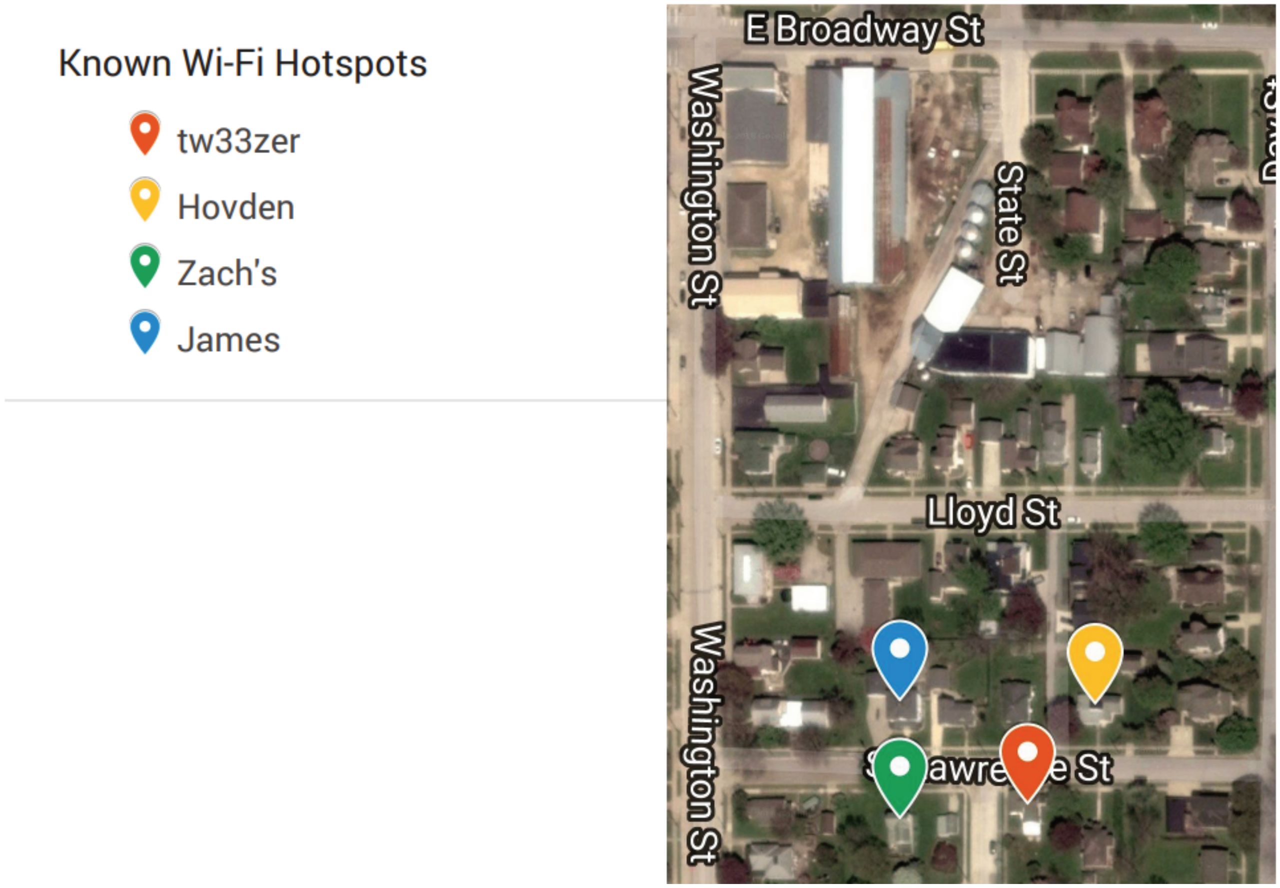
You can also monitor the available networks directly from the Wi-Fi settings on your smart device. Take some time to walk around your local community and see what you can do to create a map of the nearby Wi-Fi networks. You could do this by creating a table of Wi-Fi network names, along with the latitude and longitude of each corresponding location (something you can also determine with your phone or tablet), which could then be translated into a two-dimensional map. You might also benefit from using online mapping tools such as Google My Maps, to create a representation of the Wi-Fi networks in your neighborhood like the one shown below.

https://www.google.com/mymaps/

https://www.scribblemaps.com/

https://learn.arcgis.com/en/projects/get-started-with-arcgis-online/lessons/create-a-map.htm

Wi-Fi In My Neighborhood



Follow-Up Questions:

Based on your investigation, what claims are you able to make about the Wi-Fi signal in your school?

Are you able to make any well-informed estimates about where the source(s) of the Wi-Fi signal in your school are located?

Can you create a model to help explain why the Wi-Fi signal strength at your school changes in the way that it does based on your investigation?

Based on your map, what claims can you make about the Wi-Fi networks in your local community?

Does the model you created above help explain any of the observations you made while mapping the other Wi-Fi networks in your community? If not, what changes could you make to your model?

References:

https://iowacore.gov/iowa-core/subject/science/8/physical-science/waves-and-their-applications-in-technologies-for-information-transfer

http://ngss.nsta.org/DisciplinaryCoreIdeas.aspx?id=13&detailid=79

http://ngss.nsta.org/DisplayStandard.aspx?view=topic&id=16

http://ngss.nsta.org/DisplayStandard.aspx?view=pe&id=172

https://nextgenscience.org/pe/ms-ps4-3-waves-and-their-applications-technologies-information-transfer

https://www.scientificamerican.com/article/how-does-wi-fi-work/

Experts:

Solutions:

Tier 2, Part A: WiFi & Living Organisms

Tier 1: How Does WiFi Work?

Objective:

It has been reported that students have decreased attention in classes when they've slept with their cell phones on, and that WiFi may be harmful to our health. This led individuals to wonder about the effects of cell phone signal, and WiFi on living organisms.

Overview:

Students will continue to develop the ideas established in *Tier 1* of this bundle, by investigating the impact that cellular and radio waves have on living things. This interdisciplinary activity ties together standards from life, physical, and earth/environmental science.

Big Questions:

- What are the effects of WiFi and cellular signal on seed germination and growth?
- Do all plants respond to WiFi and cellular signal the same?
- Is there a minimum "safe" distance?
- Does it matter what stage of growth the plant is in?

Standards addressed:

MS-LS1-5	Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.
MS-PS4-2	Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.
MS-ESS3-3	Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Tier in depth:

Part 1 –

This is an opportunity for students to develop a deeper understanding of the relationships between waves (cellular & WiFi) and living organisms. Through this investigation, students are able to determine whether or not WiFi or cell phone signals have any impact on living organisms, specifically plants. Students can explore different variables including type and strength of signal, plant species, or distance between signal source and living organism. This activity could be used as a starting point for looking more closely at the claims made in newspapers and other media sources about the health effects associated with cellphones and WiFi.

Part 2 –

What follows is a list of articles that students could consider as they begin to collect evidence to support their claims, based on the results of their experiments. One possible direction that students may want to consider for this part of the bundle would be to engage in argument from evidence to support or refute claims about the impacts of waves (cellular/WiFi) on human health. Consideration should be given to the credibility of sources.

- https://www.niehs.nih.gov/health/topics/agents/emf/index.cfm
- http://time.com/4508432/what-is-wifi-radiation-cancer/
- http://www.earthcalm.com/wi-fi-health-risks-and-children
- https://naturalon.com/the-top-10-health-risks-of-wi-fi/view-all/#
- http://www.telegraph.co.uk/women/mother-tongue/11599311/Wi-Fi-is-not-harming-our-chidren-heres-the-evidence.html
- https://www.buzzfeed.com/tomchivers/a-study-claiming-wifi-is-linked-to-autism-has-been-accused?utm_term=.rynx3ZWGv#.db3d9pymG
- https://www.forbes.com/sites/quora/2016/05/19/a-radiation-oncologist-says-everything-you-need-to-hear-about-wifi-and-cancer-risk/#3ec766e27267

As students design experiments to answer their Big Questions, they should begin putting together a list of necessary resources, some of which may appear below.

Student Resources:

- Cress, or other plant seeds
- Wi-Fi routers/hotpots
- Cellular devices
- Potting materials as requested by students

Experts:

Solutions:

Tier 2, Part B: Wireless Dead Zones

Tier 1: How does WiFi work?

Objective:

Students will continue with the investigation they began in Tier I of this bundle. Now that they have a sense of *how* the Wi-Fi signal strength can vary throughout the building, the next step is to begin to try to understand *why*.

Overview:

The purpose of this project is for students to develop some understanding of radio waves using their experience with something they interact with on a day-to-day basis: Wi-Fi. Students should use their experience from Tier I of this bundle to help draw them into the investigation. Students will begin by brainstorming about different kinds of signals, and how to generate, send, and receive signals. This initial engagement activity should lead to a discussion about Wi-Fi and how they could possibly improve the wireless Internet signal in parts of the school. A potential end goal could include designing and engineering a solution to boost the Wi-Fi signal in their classroom. If access to a wireless router is not available, a projector, television, or other device that can be turned on and off with a remote control could be used as a substitute to investigate the behavior of waves and radio signals.

Big Questions:

- How could we improve buildings to prevent "dead zones" ?
- We know now what materials hamper wireless signals. Are there any materials that can amplify them?
- What is a signal and how are signals generated, sent and received?
- What are some examples of signals?
- How can we impede or enhance a signal?
- What common materials contribute to blockage or amplification of Wi-Fi signals?
- How can we construct a device that will help amplify the wireless signal in our classroom or other places on the schoolyard?

Standards addressed:

MS-PS4-2	Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.
MS-PS4-3	Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.
MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
MS-ETS1-4	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Tier in depth:

Considering how many of us have experienced a Wi-Fi 'dead zone' before, the students should have some reference from the Tier I activity that they can use to come up with ideas to answer the investigation questions (see **Big Questions** above). They should share these ideas as a class and then come up with an initial question for everyone to work off of later. The teacher and students should begin coming up with a list of necessary resources, as the students devise their investigative plan in groups of 2-4. Like other Tier II activities in this book, this investigation should be largely student-driven with less guidance from the teacher. Let students come up with their own questions and ideas about how to design and carry out their experiments, and engineering design. The Big Questions above are only there as potential questions that students might come up with. If something else comes up during their planning, be flexible and let them explore their curiosities.

Like most experiments, they should have a control to compare their variable cases to. Ensure the students have a proper data collection process as well as a place to log their data. The teacher may want to approve of the plan before the experiment begins. As a teacher, you should monitor the students' progress and act as a source of guidance to help lead them to the answer without telling them. After running through the experiments and collecting data, students should analyze the data and draw conclusions, particularly those that students feel are relevant to society. Once all groups have finished, the teacher should ask the class questions concerning what further questions or experiments could be made as a result of this first experiment, and the teacher should encourage the students to do further investigations.

Student Resources:

- Wifi routers/hotspots
- Wireless device
- Cardboard
- Aluminum Foil
- Mirrors
- Additional as needed (Building Materials)
- Experts:

Solutions:

BUNDLE 4: CHANGING LIFE

Welcome to Bundle 4- Changing Life

A YouTube element has been excluded from this version of the text. You can view it online here: https://pressbooks.uiowa.edu/8thgradescience/?p=44

Overview:

This unit covers topics such as adaptation, evolution through natural selection, artificial selection, human impact on ecological systems, embryological development, genetic variation, diversity, and extinction.

Big ideas:

1. Life in Iowa (as in the rest of the world) has changed over time in response to environment

and other biotic interactions.
2. Living things have many developmental similarities that indicate a common ancestor.
3. Adaptations are possible due to the existence of natural variation and changing environment (note: mutation also plays a role but is not the focus).
4. Human beings act as an extreme environmental impact and changes can be observed in ecological systems as a result.

Standards addressed:

MS-LS4-1	Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.
MS-LS4-2	Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.
MS-LS4-3	Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy.
MS-LS4-4	Construct an explanation based on evidence that describes how genetic variations of traits in a population increases some individuals' probability of surviving and reproducing in a specific environment.
MS-LS4-6	Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.
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.

Tiers in depth:

Tier 1:

The entire class will consider a specific geographical location (near the school, preferably – but somewhere in Iowa). As a class and in small groups, they will explore, compare, and contrast the current and historic living inhabitants of the area. Students will ultimately describe how an environment and its species are related, and use their data to look for patterns and consider how a local ecosystem has changed over time.

Tier 2:

Students will have a chance to look more closely at an organism of their choice. In small groups or individuals, they will analyze and interpret data from those organisms' life histories, compare living and historic individuals, and construct evidence-based arguments to explain how and why they have changed over time. This is also the tier in which other labs or activities to explore mechanisms (such as natural selection) may be utilized.

Tier 3:

Students will hone in on one species population (or system), and use the skills and data analysis techniques they have learned in this unit to construct a scientific solution for mitigating human impacts. Their audience for this written, oral, or filmed presentation will be a local governing body.

Tier 1: How have living things and their environments changed?

Tier 1: How have living things and their environments changed?

Objective:

Students can describe how an environment and its species are related, and use their data to look for patterns and consider how a local ecosystem has changed over time.

Overview:

In this Tier 1 activity, the entire class will consider a specific geographical location (near the school, preferably – but somewhere in Iowa). As a class and in small groups, they will explore, compare, and contrast the current and historic living inhabitants of the area.

Big questions:

- What is the relationship between an animal or plant, and its environment?
- How have living things changed over time?
- How have their environments changed over time?
- What patterns arise from our data?

Standards addressed:

MS-LS4-1	Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.
MS-LS4-2	Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.
Science and Engineering	Analyze and interpret data to determine similarities and differences in findings.
Crosscutting Concepts	Patterns: Graphs, charts, and images can be used to identify patterns in data.

Tier in depth:

Field Option: Students bring a journal with them to observe a local ecosystem (e.g. park, wetland, urban forest, location at the school, etc).

1. Each learner picks their own living organism, and describes it using observations. "What does the animal look like?" "What is it doing?" They may also describe it using inferences. "What are the animal's predators likely to be?" "How is this season different for the animal than other seasons?" (Students will compile this data so that comparisons can be made to look for themes).

2. Students then make a list of the environmental conditions, and consider which of those which might pose a threat to the animal's survival (e.g. predators, weather patterns, food sources, competition, terrain, humans, etc.).

3. Next, students and teacher go and make observations of exposed fossils. Ideally, there may be exposed fossils within traveling distance; if not, a good substitute would be handheld fossil specimens native to the surrounding area, or greater Iowa area.

4. A brief explanation and discussion will follow, of how that rock formation and the fossils within came to be. Students conclude by working with a small group to talk about what kinds of strategies or features those living things needed to survive, and how it was different than the conditions that exist now in Iowa. Finally, the entire class documents their observations in a google form (or other group accessible document) and summarizes their experience with one or two emerging questions and/or big ideas.

Resources for understanding the development of landforms, fossils, and geology in Iowa:

Map of Landforms (click on your area to learn more about its development)

Fossils in Iowa

Intro to Iowa Geology

Modified (Campus option): Students make observations around their school, whether wildlife or urban. Detailed overhead maps can also be used. Students are shown a geological map of Iowa to pinpoint their location and surrounding geology and/or environment. Devonian fossils or other fossils from differing time periods are shared (see resources above), and students make comparisons similar to those described in the first option.

Experts:

Solutions:

Tier 2: What makes living things change?

Tier 2: What makes living things change?

Objective:

Students will examine data describing a native population over time, and construct an explanation for its change in genetic and physical characteristics. By the end of Tier 2, they will be able to engage in scientific dialogue about how and why organisms change over time, utilizing explanations based in genetics, embryology, and mechanisms of evolution.

Overview:

In this tier, students will have a chance to look more closely at an organism (or group of organisms) of their choice. In small groups or as individuals, they will analyze and interpret data from those organisms' life histories, compare living and historic individuals, and construct evidence-based arguments to explain how and why they have changed over time.

Big questions:

- How do living things change? What are the driving factors for that change?
- How do population traits and genetics change over time?
- What is the relationship between an individual and a population? How are they different or the same?
- How have humans impacted changing life?

Standards addressed:

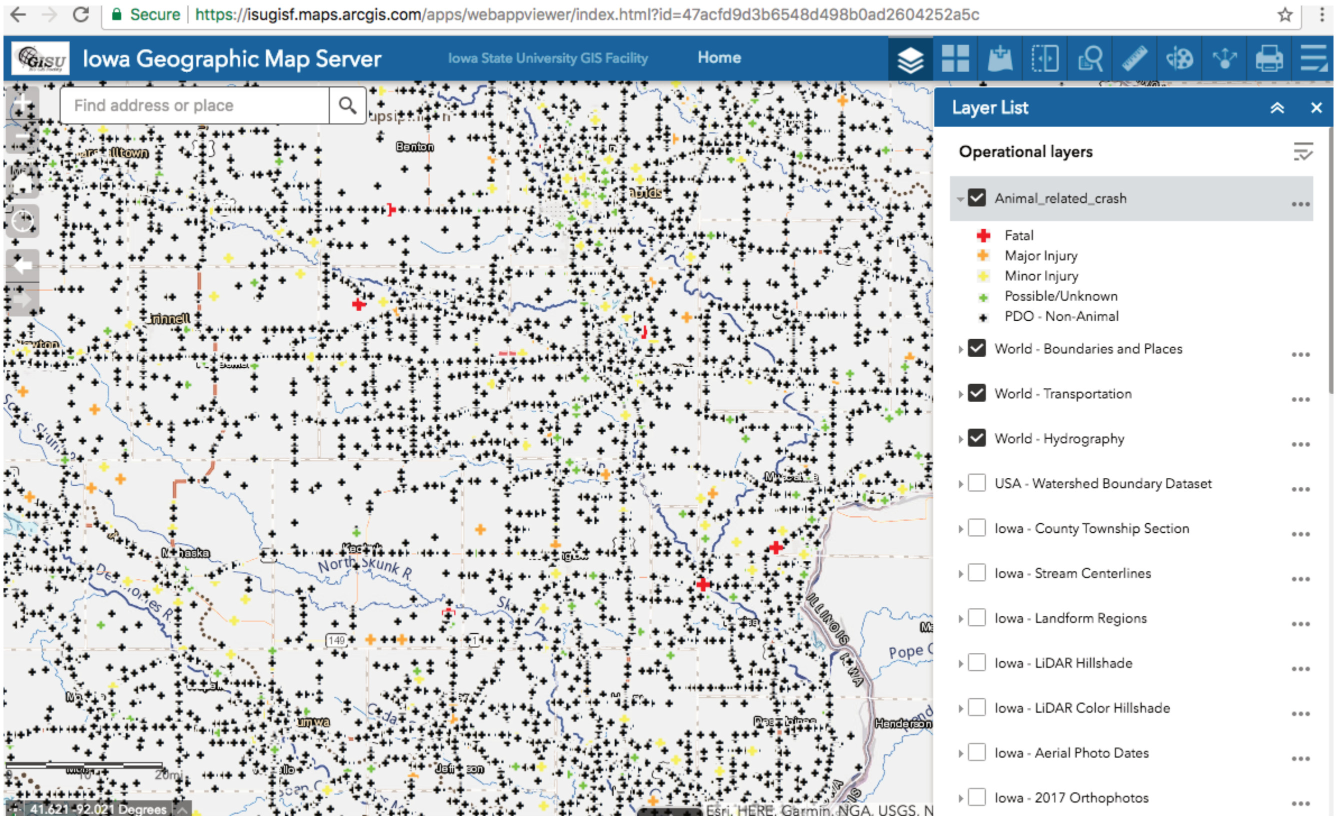
MS-LS4-4	Construct an explanation based on evidence that describes how genetic variations of traits in a population increases some individuals' probability of surviving and reproducing in a specific environment.
MS-LS4-6	Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.
MS-LS4-3	Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy.
Science and Engineering	Apply scientific ideas to construct an explanation for real-world phenomena, examples, or events. 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. Use mathematical representations to support scientific conclusions and design solutions.
Crosscutting Concepts	Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

Tier in depth:

Part I: Introduction to Genetic Change

As a class, students listen to a story about deer populations living in Iowa. They then examine data collected from the DNR or Iowa State that document how different traits have emerged over time. Students mathematically analyze these changes over time. Resources on deer populations:

- Fact sheet on history of white-tailed deer in Iowa (students could create historical maps of deer populations in Iowa over time – where did they live, in what numbers, and for how long?)
- History of Deer Hunting in Iowa
- Cladogram of deer populations across North America (and corresponding traits)
- Map of Car-Deer Crashes in Iowa (example below – red is fatal, orange and yellow are injuries, green is unknown):



During this period, the teacher will be documenting their emerging ideas on a whiteboard, and drawing out their ideas about what creates certain phenotypes. To gain a shared vocabulary and review concepts from elementary, the teacher will need to help them come to an introductory understanding about the following topics: What are genes? What is a phenotype? How do we get our genes? Students do not yet need to be told about the more complex details such as mutation, punnet squares, or the importance of survival to reproduction. The following are some basic resources for students to try out their ideas and compare them with scientists':

- Stalking the Genetic Basis of a Trait from HHMI BioInteractives
- What are DNA and genes? From Learn.Genetics
- 23 and Me What are Genes? (the popular self-testing genetic ancestry company)
- Conclusion of this cycle is a class argument where students use evidence to support their ideas about which environmental factors were most influential in the deer's genetic change.

Part II. Student groups choose their own organism groups.

Students will choose an organism (or organismal groups) on their own, or from a list of pre-selected organisms. Some ideas are below:

- Eastern Screech Owl (two color morphs exist in Iowa, in a gradient from North to South).
- Great Blue Heron (some Herons have adapted to humans by developing new hunting behaviors, such as taking goldfish from human-made ponds)
- Peregrine Falcon (These birds are known to roost and hunt in cities with skyscrapers, and have adjusted to life in the city. What genetic features have changed in these populations?)
- Squirrel species of Iowa: Eastern gray tree and red/pine squirrels
- Bobcats of Iowa (much research on genetic change over time)
- Emerald Ash Bore (an insect posing a conservation problem for Ash trees)

Student groups will be responsible for researching their organisms, and identifying the following aspects:

- What genetic changes have occurred in the population over time?
- What environmental, biotic, climate, event-based, or other changes may have affected those genetic changes?
- Students must create a physical representation **model** that shows how the population changed in response to some cause. They must also include mathematical or graphical **data** that supports their conclusions.

Other activities for students to play engage with the mechanism of natural selection and related evidence:

- Developing an Explanation for Mouse Fur Color
- Evolution Collection from HHMI BioInteractive (includes the popular Rock Pocket Mouse lab, as well as films and interactives on the transition fossil Tiktaalik)
- Genetics Collection from HHMI BioInteractive

Experts:

Solutions:

Tier 3: How have humans impacted changing life?

Tier: How have humans impacted changing life?

Objective:

Students will collect/compile and interpret data to understand the human impact on a selected organism. They will design a solution to mitigate that impact, and use scientific argument to present their idea to a governing body.

Overview:

From the beginning of the unit, students have encountered many changes in living organisms, and potential causes for such changes. Some of these causes have been related to human impact, including human impacts that have been detrimental or even lethal to the plant or animal populations. Now, students will hone in on one species population (or system), and use the skills and data analysis techniques they have learned in this unit to construct a scientific solution for mitigating human impacts. Their audience for this written, oral, or filmed presentation will be a local governing body. Big ideas considered by students will be:

Big questions:

- How have living things adapted over a long period of time in response to their environment?
- How does the environment influence which organisms, and traits in organisms, continue in a population?
- What is common ancestry?
- How do humans influence the environment here in Iowa?

Standards addressed:

MS-LS4-1	Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.
MS-LS4-2	Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.
MS-LS4-3	Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy.
MS-LS4-4	Construct an explanation based on evidence that describes how genetic variations of traits in a population increases some individuals' probability of surviving and reproducing in a specific environment.
MS-LS4-6	Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.
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.

Tier in depth:

Part I: Collecting Data and Seeking Solutions

1. Students will be asked to analyze a living organism or system of organisms in Iowa (or relating to Iowa – for example, gulf organisms affected by the dead zone), and to seek data describing their genetic and/or other changes in the population over time.
2. The student or student group will then be tasked with making a case to a governing body about whether or not the human impact on this living thing is significant, and what they argue is an appropriate response.

Part II: Presenting Data and Arguing from Evidence

1. In the students' presentation, they will explain how the environment relating to their chosen organism has changed through known history, how scientists think the organism has adapted with evidence in the fossil record, embryological development, anatomical similarities with other living things, and genetic analysis. They will explain what the ideal environmental conditions for the organism would be and how humans may alter that. They will explain what they think would be a likely change in the organism's future development based off the same evidence that helped scientists to explain how the living things already changed.
2. Students should have a plan for how human effects on the organism could be minimized in the future.

3. This plan, supported with evidence from step one, will be presented to a governing body (or other legitimate audience).

Experts:

Solutions:

BUNDLE 5: IOWA'S CHANGING LAND USE

Welcome to Bundle 5 – Land Use

A YouTube element has been excluded from this version of the text. You can view it online here: https://pressbooks.uiowa.edu/8thgradescience/?p=21

Overview:

This bundle provides resources for teachers and students to explore land use, and how it has changed and continues to change in Iowa. Many tools can be used to study land use change. Our bundle features extensive use of historical and current maps and aerial photography. Expect this bundle to take a minimum of 4 weeks, and as long as 8 weeks to complete. Students begin (Tier 1) by comparing current and historical maps/aerial photographs of where they live. In Tier 2, the concepts of watersheds, ecosystem services, and thermal properties of different landscapes, and the interaction between landscape and water cycle are introduced. The Tier 2 lessons (there are three of them) can be covered in any order, or some of the Tier 2 lessons can be omitted. For Tier 3, we encourage teachers to allow students or student teams to take on their own research projects based on questions or problems generated during Tiers 1 and 2.

Studying land use brings up a wide variety of issues including agriculture, fishing, ecosystems, economic development and jobs, water quality, flood management, animal habitat, food availability and quality, recreation, and soil erosion. Current, local events are encouraged for incorporation into Bundle 5 – especially for Tier 3. The key components are that students have a driving question, collect data, use this data to generate evidence, make a claim, and share their findings.

Big ideas:

1. Land use in Iowa has changed and continues to change over time.
2. Earth's systems benefit humans, but per-capita use and over consumption impacts those natural resources.
3. Urbanization of natural landscapes has large impacts on the environment.
4. Biotic and abiotic factors work together to sustain each other in a natural environment.

Standards addressed:

MS-ESS3-3	Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
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.
MS-LS2-5	Evaluate competing design solutions for maintaining biodiversity and ecosystem services.
MS-LS4-4	Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.
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.
MS-PS1-3	Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.
MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
Science and Engineering	
Crosscutting Concepts	

Tiers in depth:

Tier 1:

Teachers will guide the whole class in an initial investigation of current vs. historical land use using aerial photography. This section is designed to engage the learner in their local environment by having them determine, document, and share with their classmates the land use changes over time where they live. Students then set out to learn about watersheds and will investigate their local watershed. Later, students are encouraged to investigate their personal questions about land use in their local areas.

Tier 2:

Students study ecosystem services and benefits to better understand how earth's systems benefit humans, and how per-capita use and consumption impacts those natural resources. Students will begin by confronting one of two local phenomena, in which human consumption interacts with natural resources. In the first option, students examine the relationship between karst topography, land use, and the quality of drinking water. In the second option, a local development project is considered in terms of the impact it has on the benefits we receive from the site's natural resources. These options can both be considered sequentially, or one can be chosen over the other.

Tier 2:

Students will learn about heat absorption and reflection of light in different materials through hands on activities, articles, and websites. Students will perform investigations analyzing surfaces such as pavement in their surrounding community. One web option for data are pavement temperature sensors throughout Iowa and available on Iowa State's website. Using their data and new knowledge, students will then be asked to develop solutions to potential problems that may or may not affect them or others in their local area.

Tier 2:

This series of investigations is meant to expose students to the examination of Iowa's natural resources and ecosystems. Students will examine Iowa's climate and natural water cycle and how that influences habitats. Students will be introduced to natural resources as they examine how biotic and abiotic factors work together to sustain each other in a natural environment. These investigations work well as a reference point of comparison with how human beings have altered the natural landscape.

Tier 3:

This is the ultimate goal of the unit. Learning is for the learner – not for the teacher. To this end, students should investigate a question that they are interested in, related to the topic, that they could gather data, take a stance, and share their findings. As they explored Tier I & II, surely they had topics that piqued their interest. Let them run with it. Negotiate how they share what they have done, whether it be a YouTube video, a presentation, a paper, a website, fundraising for some community improvement….. the sky is the limit.

Tier 1: Changing Land Use

Tier 1: Changing Land Use

A YouTube element has been excluded from this version of the text. You can view it online here: https://pressbooks.uiowa.edu/8thgradescience/?p=129

Objective:

The first objective of the Tier 1 Land Use activity is to engage the learner. This is accomplished by focusing on local land use change at the student's home address or home town. In part two, the objective is to learn about watersheds. Finally, students are encouraged to investigate personal questions about land use.

Overview:

Teachers will guide the whole class in an initial investigation of current vs. historical land use using aerial photography. This section is designed to engage the learner in their local environment by having them ascertain the land use changes that have occurred in their home location. Students then set out to learn about watersheds and will investigate their local watershed. Later, students are set free to investigate their personal questions about land use in their local areas.

Big questions:

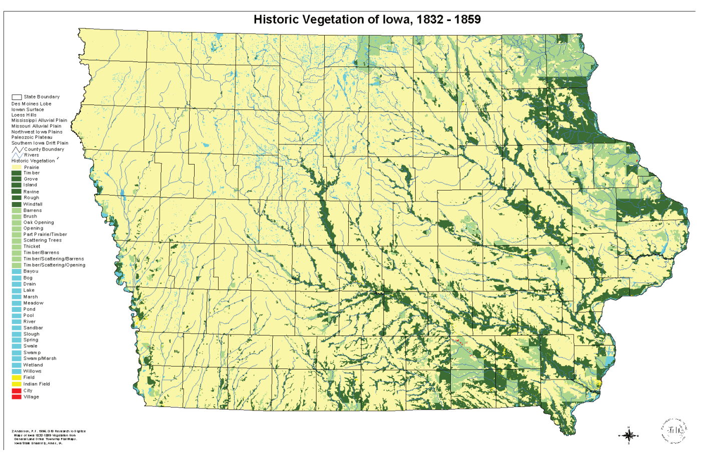
- What does it mean to develop land?
- What natural resources must a community use as their population grows?
- How does alteration of a landscape change the services associated with that land?
- What are the limitations on our consumption?
- What are our individual and societal needs, desires, and values? How do they manifest in natural resource use?
- How do humans benefit from ecosystem services?
- What are the scientific, economic, and social considerations for development?

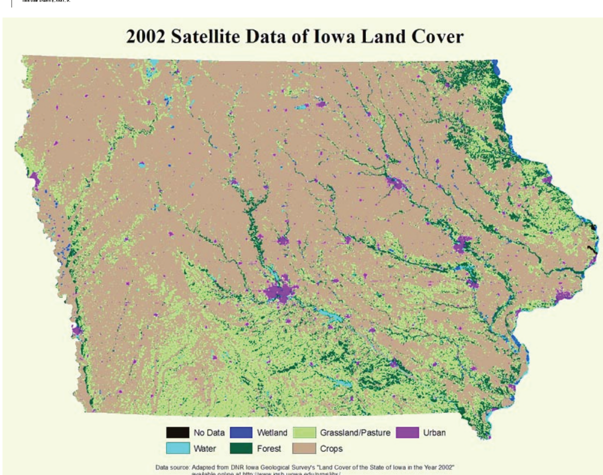
Standards addressed:

MS-ESS3-3	Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
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.
MS-LS2-5	Evaluate competing design solutions for maintaining biodiversity and ecosystem services.
MS-LS4-4	Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.
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.
MS-PS1-3	Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.
MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
Science and Engineering	
Crosscutting Concepts	

Tier in depth:

Tier 1 – Part I: Land Use: Iowa has a very extensively altered landscape, perhaps the most altered landscape of any state in the United States. Ninety-nine percent of native prairie and wetland is no longer present. These dramatic land use changes provide an exciting learning opportunity, where students can construct a history of local land use change. The initial engagement is accomplished by having students research this reality in the area they live in, or another Iowa location of interest to them (e.g., home neighborhood, park, town, county, family farm, where family members live or have lived). Students are encouraged to talk with parents, grandparents, historians, librarians, etc… to gain an understanding of how the area has been altered (soil, land surface, water, vegetation, other organisms, etc…) and why that alteration has taken place (social, economic, etc). Students are required to bring evidence, in the form of images, stories, graphs, tables, or other means to support their understanding. Students are encouraged to use sites such as: http://ortho.gis.iastate.edu/ (this site allows you to display photos as far back as far as 1836 and, using a slide tool, compare two images) and Google Earth to utilize aerial images of land use changes. Additionally, students will search for other resources that show how land use has changed over time. One starting point is: https://archaeology.uiowa.edu/government-land-office-survey-maps. However, students should be given space and freedom to determine what qualifies as a valuable resource, so further specific sources can be identified and utilized as a means of differentiation of instruction. (Maybe students even have historic pictures of the area, maybe taken by their parents, that could be shared). Students need to summarize how their selected area has changed over time, the reasons for the changes and the pros and cons of these changes.



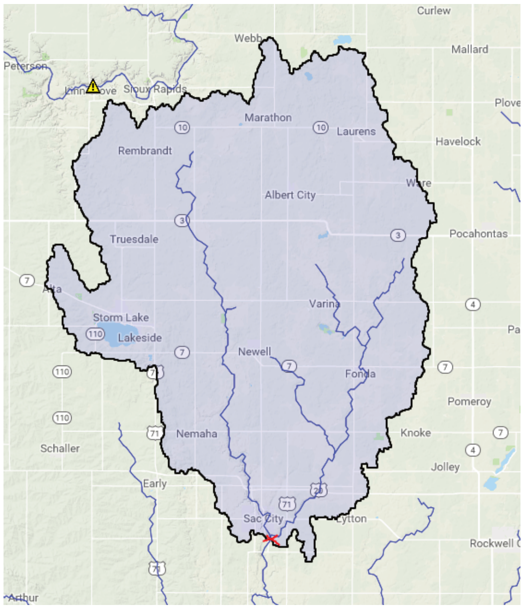


Tier 1 – Part II: Watershed: Now that students have an understanding of how their land has changed, it is important to understand their area's place in a watershed. There are many great ways to explore watersheds. One way is for students to utilize the website: http://ifis.iowafloodcenter.org/ifis/ to learn about watersheds, including what the definition of a watershed is, how defining a watershed boundary can be useful, and what the boundaries of their own watersheds are – specifically of the locations researched in Tier 1 – Part I.

USING IFIS for watersheds: Go to the website: http://ifis.iowafloodcenter.org/ifis/ and then click on the "IFIS" button to launch the Flood Information System. Two tools within IFIS are best for thinking about watersheds. First is the "Raindrop Flow Tracker" which traces the route of rain in creeks and rivers until it leaves Iowa. And the second is the "Watershed Boundary" tool (output shown in the Figure below). One tool shows where rain goes from a specific point on the map. The other shows the what areas supply water to a specific point on the map.

To use the "Raindrop Flow Tracker," zoom to your area of interest in Iowa. Then, on the right hand side, select the toolbox and select "Raindrop Flow Tracker". Click on any location on the map and it will display the route for rain hitting that location to reach the nearest river/stream. To display watershed boundaries, within the same "Toolbox" location within IFIS, use "Find Watershed Boundary" to display watershed boundaries. Have students click on several locations within the area of interest to understand how the watershed boundaries change. Showing the watershed boundaries for a large creek or river should generate a large area as the watershed boundary (for example see the figure below), but it may take several clicks to select the right pixel to show the full watershed area. Watershed areas within towns and cities that may have stormwater ditches and underground drainage systems can also be interesting, but a bit challenging using IFIS. Finally, explore the website and look at the rainfall data, flow and flood issues of your area. This should develop into more questions that could be further researched as an extension possibility for Tier 1 – Part III.

One teaching approach for Tier 1, Part II is to have students make a list of people that would need to be involved in a team to solve flooding or water quality problems at a specific location, for example (as shown in the map below) at the joining point of the North Racoon River and Cedar Creek near Sac City, Iowa. Have student select a point on the map relevant to them and identify 5 stakeholders that would be needed to solve flooding issues, or water quality issues. This reinforces the idea of a watershed. Answers might include cities, towns, sewage treatment plants, parks, quarry operators, planners/designers/builders of buildings in the watershed, farmers, road maintenance crews, foresters, and many other land owners, land managers, and developers. This approach of team-based solutions to floods and water quality is being successful put in place in Iowa and other locations. See for example the Iowa Watershed Approach http://www.iowawatershedapproach.org/



Watershed boundary example. Shown is the area influencing water quantity and quality for the location marked by the small red X – the North Racoon River just after where it joins Cedar Creek below Sac City, Iowa.

An alternate activity is to make it a detective problem: if a contaminant was located in a specific waterway, where would the water quality detectives need to search to find the cause of the contamination? A real-world example of this was the 2014 Elk River spill in West Virginia, where smelly drinking water was noticed by residents of Charleston, West Virginia. The drinking water source was a nearby river, and the contamination was from leaking tanks at a factory in the watershed.

Part III: Water Quality: At this point, students should be highly tuned into their personal area. They will now be pushed to research the quality of the water in their particular region. Students will focus on Nitrate, Nitrite, Temperature, pH, Dissolved Oxygen, Specific Conductance, and Turbidity by using the data from the website: http://iwqis.iowawis.org. Step 1: On the right hand side, select "information panel" from the bottom ICON and turn on the "information panel". This will provide students with a snapshot of information regarding the significance of each data item listed above. Step 2: Select the flask and determine what tests you'd like to run. In the sample shown here, we have selected Dissolved Oxygen. Students can then change the time scale, pull up other data, and even see images of the area where the testing station is located. Step 3: students will use the data, their understanding of watersheds, and their knowledge of how land use has changed to make a statement, supported by evidence, of their understanding of their local neighborhood. Collectively, they will gain an understanding of how people's actions, both current and historically, have impacted the region where they live and play. One note: these data collection tools are more spread out around the state and students might have to use an ever larger watershed to get a glimpse of their region. This is a limitation but also an opportunity for students to test their home environment.

*****EXTENSION POSSIBILITY:** Have students collect their own water samples and determine it's quality. Many of you have heard of or been trained in the IOWATER Program. The IOWATER program has gone through some changes due to “ongoing fiscal constraints” but there is a method to access the historical data for the state of Iowa.

The way to get to it (currently) is through the National Water Quality Portal Site: https://www.waterqualitydata.us/portal/

To get Iowa data, go to where it says “Location” and then “State”. Use the dropdown box to choose Iowa. Then scroll down to where it says “Data Source” and select “STORET”. Then, proceed to and select “Show Sites on Map”. From there, you can see what sites are “STORET”, which include both professional sites and IOWATER sites. You can zoom into the map and click on sites to download data. Anything with a IASNAPST (IOWATER snapshot or IOWATER) is volunteer collected data. Snapshot includes lab analysis.

For information on training, equipment and additional questions, contact Dr. Mary Skopec at Lakeside Lab.

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Tier 2: Human interactions with the land

Tier 2: Human interactions with the land

Objective:

The objective of Tier 2 is for students to learn about ecosystem services and benefits that come from land and landscapes. Furthermore, students need to learn about "how increases in human population and per-capita consumption of natural resources impact Earth's systems" (language is from MS-ESS3-4).

Overview:

To achieve this objective, we present two case studies that illustrate ecosystem services, and how those ecosystem services are changed by human development. Students will begin by confronting one of two local phenomena. The first phenomenon or case study involves the links between karst topography (shallow limestone and dolomite surface rock) and drinking water quality. Karst topography is common in northeast Iowa and occurs in conjunction with sinkholes, which capture media attention and student interest. In the second option, students consider the tradeoffs between local development of land, and the loss of ecosystem services or benefits provided by the land prior to development. These options can both be covered sequentially, or one can be chosen over the other.

Big questions:

- What does it mean to develop land?
- What natural resources must a community use as their population grows?
- What are the limitations on our consumption?
- What are our individual and societal needs, desires, and values? How do they manifest in natural resource use?
- How do humans benefit from ecosystem services?
- What are the scientific, economic, and social considerations for development?

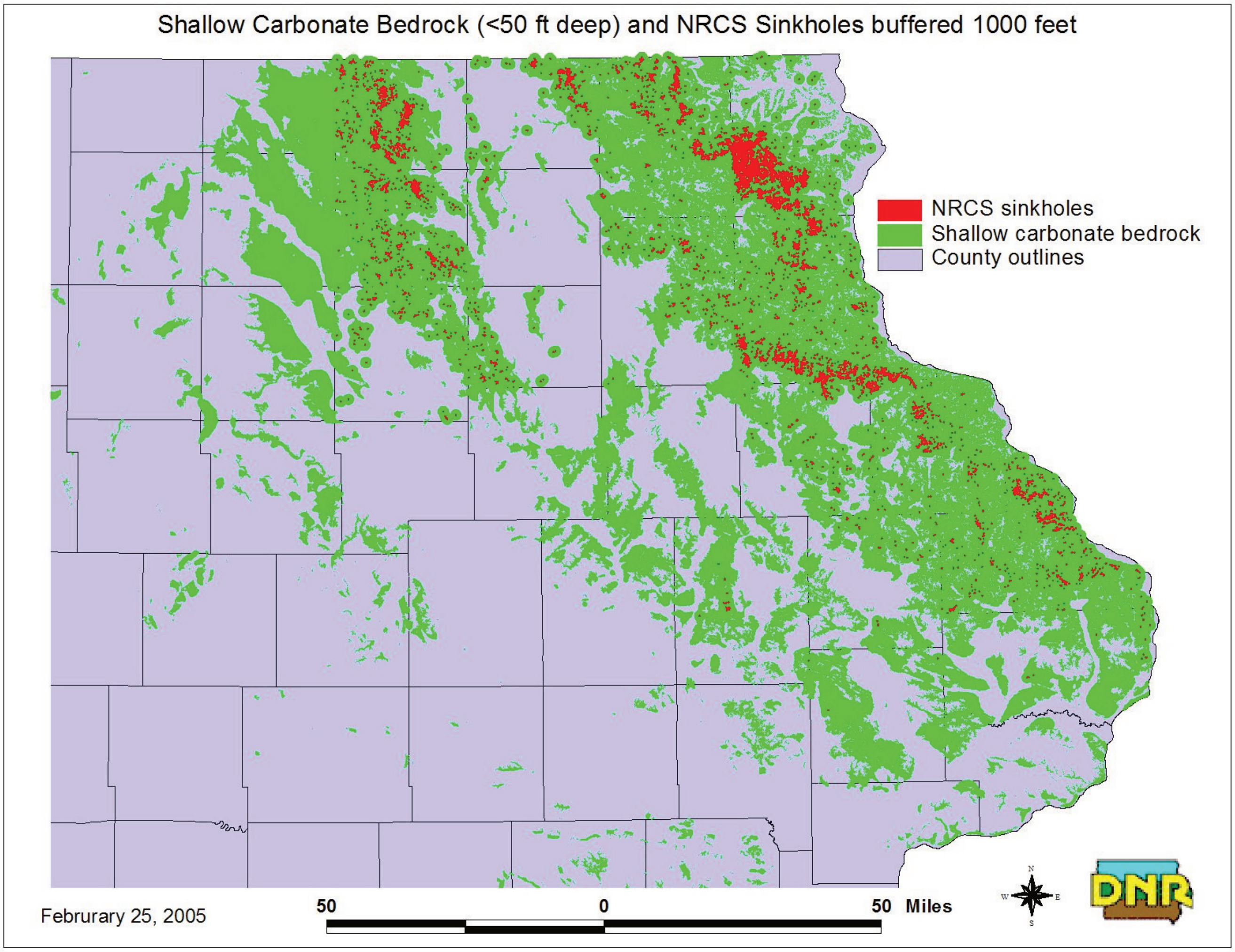
Standards addressed:

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.
MS-ESS3-3	Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
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.
MS-ESS3-5	Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.
MS-LS2-5	Evaluate competing design solutions for maintaining biodiversity and ecosystem services.
MS-LS4-4	Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.
MS-PS3-3	Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.
MS-PS4-3	Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.
Science and Engineering	
Crosscutting Concepts	

Tier in depth:

Option 1: Karst Topography, Drinking Water, and Sinkholes

Introduction: The composition of the ground impacts how society uses it – and vice versa. Karst topography (shallow limestone and dolomite surface rock) is common in northeast Iowa, and has important consequences for water quality. A map of the karst terrain is shown below.



Sinkholes are more common than students might expect, and even happen in Iowa. In karst terrain, because the surface bedrock is soluble, sinkholes are fairly common. Because of the solubility and porosity of the karst layers, water contamination problems can occur more easily in karst terrain. When water pollution sources (such as intensive livestock operations) are combined with karst terrain and private wells – problems with water quality and well pollution have been found. To confront and begin exploring these problem, have students view the following resources which describe various accounts of sinkholes, drinking water, mining shafts, and karst topography in Iowa (and surrounding area).

- "Brown water that smells like urine": http://www.thegazette.com/subject/sports/outdoors/forum-explores-relationship-between-karst-livestock-operations-and-water-quality-20170606
- Trouble with Hogs in Northeast Iowa: http://www.thegazette.com/subject/news/business/agriculture/trouble-with-hogs-in-northeast-iowa-20170422

- Karst Topography and Fishing: http://www.thegazette.com/subject/sports/outdoors/karst-can-aid-rivers-as-well-as-streams-20170602
- IPR Science of Sinkholes (Radio): http://iowapublicradio.org/post/science-sinkholes#stream/0
- I-80 Sinkhole: http://www.ketv.com/article/iowa-dot-investigates-interstate-80-sinkhole/7126434
- Illinois golfer plunges into sinkhole: https://usnews.newsvine.com/_news/2013/03/12/17285573-i-was-just-freefalling-golfer-plunges-into-illinois-sinkhole?lite
- Iowa Students save deer from sinkhole (profanity in last few seconds of video – preview first): http://www.kwwl.com/story/26728258/2014/10/Tuesday/video-winneshiek-county-men-save-deer-from-sinkhole
- Modeling karst topography (a lab activity): https://geomaps.wr.usgs.gov/parks/cave/karst.html

Data investigation: Using data sources, students learn more about karst topography, sinkholes, past mining systems, CAFO's, and their interrelations. Ask students: How is karst topography related to water quality? Is our water safe to drink? What are the "hot spots" in Iowa that have similar water issues (due to geology and surrounding land use)? How can we mitigate these problems with drinking water? How can we measure and predict our risk due to contaminants from animal feeding operations (AFOs) and other agriculture? Is it possible to predict our risk of sinkholes or water contamination? What are the variables involved, and how can they be measured and described? Use data sources below to predict outcomes and investigate your hometown or school. More maps are available from the DNR.

- Map of karst topography: https://programs.iowadnr.gov/maps//afo/
- Iowa DNR Map of Coal Mines: https://programs.iowadnr.gov/maps//coalmines/
- Info on karst topography from DNR: http://www.iowadnr.gov/Environmental-Protection/Land-Quality/Animal-Feeding-Operations/Mapping/Karst-Sinkholes

Option 2: Local Development

Choose a local development project in your town (preferably in the planning stages, although implementation also works). Ask students to list and discuss the environmental resources (i.e., ecosystem services) that tract of land provides (or provided), and to consider how the land development might change them. Students can contrast the ecosystem services with the benefits from the development, such as housing or recreation. Encourage students to argue from evidence – if the new development will provide recreation for community members, how many individuals are expected to utilize the space, and is there a precedent? If the development is slotted for land that currently holds pollinator habitat, what kind of importance do pollinators hold in the community, and what percentage of pollinator habitat does this slot of land take up? Help your students to use precise measurements and quantitative language by utilizing the following resources. Can the development be modified to maintain some of the ecosystem services? Or can enhancement of nearby landscape (i.e. plantings, management of habitat, soils or drainage, etc.) be done to make up for development-related losses in ecosystem services?

- Enviro-Atlas Interactive Map of services: https://www.epa.gov/enviroatlas/enviroatlas-interactive-map
- Eco-health relationship browser: https://www.epa.gov/enviroatlas/enviroatlas-eco-health-relationship-browser
- Eco-Wheel with environmental goods, services, and benefits: https://www.epa.gov/enviroatlas/ecosystem-services-enviroatlas
- USGS soil composition data: https://www.nrcs.usda.gov/wps/portal/nrcs/surveylist/soils/survey/state/?stateId=IA

Experts:

Solutions:

Created by Andrea Malek (andrea-malek@uiowa.edu) and edited by Charles Stanier (charles-stanier@uiowa.edu).

Tier 2: Impacts of Urbanization

Tier 2: Impacts of Urbanization

Objective:

Students will learn about temperatures of materials in outdoor environments, such as grass, light colored concrete, and blacktop. They will then work to engineer solutions that limit excessively high summertime temperatures, and produce public service announcements that educate the public about this phenomenon.

Overview:

Students will learn about heat absorption and reflection of light in different materials through hands on activities, articles, and websites. Students will perform investigations analyzing surfaces around their school or in the surrounding community, and how those surfaces change temperature during the day because of heat transfer, particularly through absorption of energy from sunlight. One particularly interesting dataset is from real-time pavement temperature sensors reported to the web by the Iowa Department of Transportation. Using their data and new knowledge, students are guided to understand the problems associated with excessive surface temperatures, air temperatures, and heat index levels and to develop solutions and public service announcements about them.

Big questions:

- What affects does the weather have on surface temperature (i.e., cloud cover versus clear skies)?
- What hazards could result from surfaces with elevated temperatures?
- What causes temperature differences in cities and rural areas?
- Why is it really hot in a corn field?
- Why do we build with certain building materials?

Standards addressed:

MS-ESS3-3	Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
MS-PS1-3	Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.
MS-PS3-3	Apply Scientific principles to design a method for monitoring and minimizing humans impact on the environment.
MS-PS4-2	Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.
Science and Engineering	
Crosscutting Concepts	

Tier in depth:

Engagement: Is it ever too hot for an airplane to fly? (see https://www.wired.com/story/phoenix-flights-canceled-heat/). What will happen in Iowa if Arizona-like temperatures occur here? Are the materials we use to build our infrastructure, or the crops we plant in our fields, causing our state to become hotter? Have students heard about any other examples similar to this one that affected people elsewhere? (If so, encourage them to investigate that phenomenon.)

NOTE: *For best mentoring of students, teachers should keep in mind whether student investigations can be approached by considering temperature only (such as heat transfer problems and deformation of blacktop pavement), or whether both temperature and humidity are involved (such as human comfort levels, water cycle issues and agricultural issues, need for air conditioning, and corrosion of materials). As needed, teachers should review the concepts of dew point, soil moisture, evaporation, and heat index, and determine how to incorporate these into student investigations, data collection, and problem solving. One Iowa-specific source on this is Iowa Climate Statement 2017: It's not just the heat, it's the humidity! (and the sources at the end too). Iowa Climate Statement 2017: It's not just the heat, it's the humidity!*

Part 1: Human infrastructure: All things absorb or reflect light in different amounts. This energy is then given off by objects as thermal energy. Over the course of time humans have altered their environment. Removing natural foliage and land cover and replacing it with buildings, blacktop roads, and concrete structures. The initial engagement activity for this lesson is to take students and have them carefully observe different environments. For example: take students into a grass field, to the school parking lot, and into the city where the students are surrounded by buildings and concrete sidewalks. At each location students are asked to make observations: What are their surroundings? What is the air temperature? What is the surface temperature of their surrounding? Etc. Students will then be directed to look at various data outlets, such as, https://mesonet.agron.iastate.edu/RWIS/?camid=IDOT-014 and any other sources that they may be able to find via Google search. The Iowa State Mesonet website will allow students to see the difference in air temperature and surface road temperature at the time of inquiry but also in the past.

The Environmental Protection Agency provides valuable data involving the areas classified as urban heat islands. Data and information that shows the impact that urban heat islands can have on infrastructure and people. https://www.epa.gov/heat-islands/heat-island-impacts Impacts that can be studied and used for problem solving exercises include elevated energy consumption, elevated emission of greenhouse gases and air pollutants, negative impacts on people's health and comfort, and adverse to drinking water supplies.

Part 2: Natural Land Cover vs. Crop Land: Another analysis that students would do is look at evidence that shows how human planted crop land and other foliage affect surface temperature. One resource that could be used is NASA's Earth Observatory Website https://earthobservatory.nasa.gov/GlobalMaps/view.php?d1=MOD13A2_M_NDVI&d2=MOD11C1_M_LSTDA. The areas with the densest vegetation (like the rain forests) always have a surface temperature lower than land that is striped or absent of vegetation. This article contains data that shows the difference in surface temperatures between agricultural fields and forests from locations around the Midwest including Iowa http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.449.821&rep=rep1&type=pdf. Besides using this article for the data it contains, it provides students the chance to analyze the data of real scientists who are working on investigating similar questions. During this section of the investigation students should be encouraged to perform their own investigations analyzing surface areas in their surrounding community. This can be accomplished with a basic thermometer.

Students should then be introduced to the concept of albedo. They should try and relate their findings from their independent studies of their temperature and materials study within their community, with NASA data on albedo. Does what they find support what scientists are saying about the correlation between albedo and surface temperature? Students should explain using data to support their claims. https://earthobservatory.nasa.gov/IOTD/view.php?id=84499

Part 3: Solutions: After investigation, data collection and interpretation, and understanding the issues – students should work to engineer solutions to specific temperature or heat index related problems. Another good student-centered capstone activity on these phenomena are public service announcements that either warn about hazardous conditions, or educate the public on problems and/or solutions. As always, students should use data and other evidence to support claims.

Students Question (Sample):

What affects does the weather have on surface temperature (i.e. cloud cover vs. clear skies)?

What hazards could result from surfaces with elevated temperatures?

What causes temperature differences in cities and rural areas?

Why is it really hot in a corn field?

Why do we build with certain building materials?

*Students should be allowed to investigate any of their interests so long as they form an investigatory question

Experts:

Solutions:

Created Zach Miller (ia.zachmiller@gmail.com) and edited by Charles Stanier (charles-stanier@uiowa.edu)

Tier 2: Iowa's Natural Resources and Ecosystems

Tier 2: Iowa's Natural Resources and Ecosystems

Objective:

Students will develop skills and knowledge regarding some of Iowa's natural resources and/or ecosystems. By researching a local landscape (ideally by traveling there, taking field observations, and interacting with knowledgeable guides, educators, or caretakers), students will learn about how the landscape and its relationship to humans has changed over time. If available, we recommend a nature preserve, natural area, or native landscape for this Tier 2 lesson. Using the data and observations recorded, students will make inferences about the landscape.

Overview:

This series of investigations is meant to expose students to the examination of Iowa's natural resources and ecosystems. Areas of focus can be the interactions of landscape with climate, water cycle, habitat (for mammals, amphibians, birds, fish, insects, etc.), or agriculuture. Students will be introduced to natural resources as they examine how biotic and abiotic factors work together to sustain each other in a natural environment. Student investigation of native, preserved, or natural landscapes can serve as a useful reference point when considering human landscape alteration.

Big questions:

- What was Iowa like when European settlers first arrived?
- What lived here before modern agriculture was established?
- How did the ecosystem in my local area look and work together?

Standards addressed:

MS-ESS3-3	Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
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.
MS-LS2-5	Evaluate competing design solutions for maintaining biodiversity and ecosystem services.
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.
Science and Engineering	
Crosscutting Concepts	

Tier in depth:

Option 1: What's the Story of _______?

*These represent sample questions that this investigation can address. Students should formulate their own research question as they acquaint themselves with a natural landscape:

- What was Iowa like when European settlers first arrived?
- What lived here before modern agriculture was established?
- How did the ecosystem in my local area look and work together?

Iowans have very little day-to-day exposure to their natural ecosystem. A majority of the state is now used for cropland; therefore, many Iowans have little knowledge of what a native tallgrass prairie, woodland, or wetland look like.

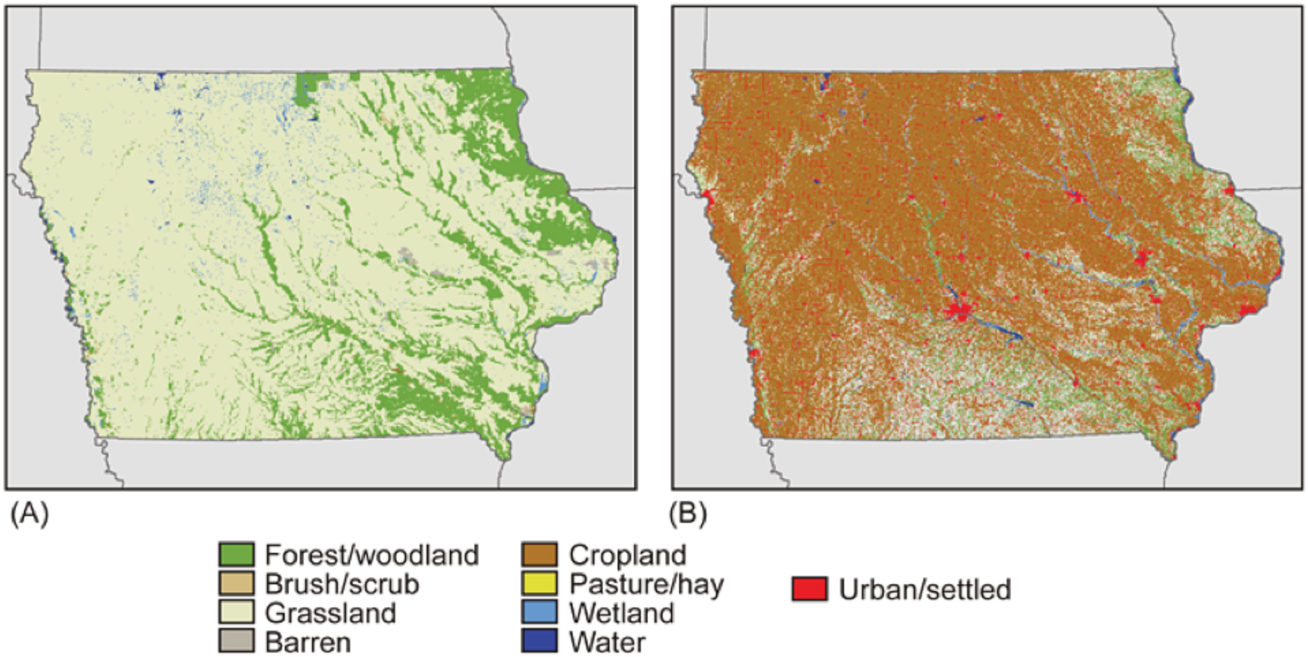


Figure 1. Iowa land cover in the mid-1800s (A) and as of 2001 (B, mapped with data from the National Land Cover Database, https://www.mrlc.gov/). See Gallant et. al (2011).

As we consider the interaction between humans and our environment, it's important to gain a reference point of our natural resources and tangibly experience them. Students will research a local preservation site in order to understand the ecosystem. They will take notes, pictures, and video to record their observations and make inferences about that native area. They will then compare them to expert claims and observations and determine if they have consensus. Then, synthesizing their observations, data, research, and claims, students will present to classmates, younger students, or in an interview to their teacher in a format of their choosing. Their goal will be to tell the story of that natural site and how living and nonliving factors interact with each other within the context of the student's own research question. This is a good opportunity to encourage students to create videos, blogs, comic books, maps, posters, essays, or scientific journals.

Resources to Natural Preservation Sites and Introductory data on the ecology of those areas:

http://www.iowadnr.gov/Places-to-Go/State-Preserves

http://www.inhf.org/resources/publications/

*Special resource for Johnson County: https://www.buroaklandtrust.org

Note: Bur Oak Land Trust is an example of a land conservation group specific to Johnson County and her bordering counties. Other organizations like it exist in many counties across the state.

____

Option 2: Prairie Grass Modeling: How is Prairie Grass different from the grass in our lawns? Should you grow a prairie in your lawn?

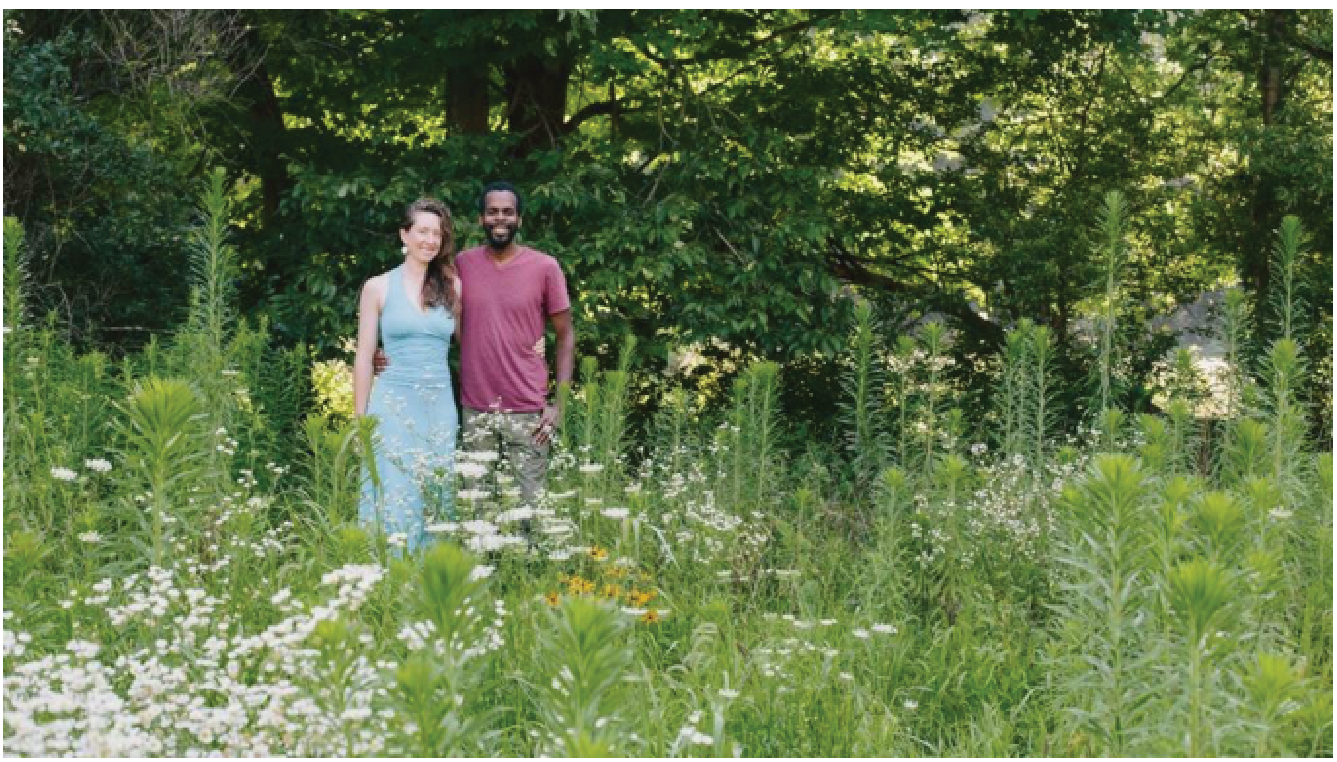
*These represent sample questions that this investigation can address. Students should formulate their own research question as they acquaint themselves with a natural landscape:

- What makes prairie grass so different from grass we grow in our yards?
- How does the difference in root structure affect water absorption?
- How can individuals preserve natural ecosystems?
- What is the benefits of preserving natural ecosystems regarding rainfall, and soil absorption?

This option includes a comparison of prairie grass and lawn grass. There are several social phenomena attached to this investigation that might get the ball rolling for students.

Story Introduction 1: The story of a woman published in a Chicago Tribune story in 2015 who has been in conflict over city ordinances for years over her pollinator friendly yard in Ohio:

Sarah Baker and her partner in Alexandria, Ohio: When I stopped mowing my lawn, a diverse potpourri of plants began to flourish, and a rich assortment of insects and animals followed.



(Courtesy of Sarah Baker) 1000×563

http://www.chicagotribune.com/news/opinion/commentary/ct-natural-lawn-no-mow-movement-20150804-story.html

Story Introduction 2: For students with a higher reading level or who show an interest in anthropology, Michael Pollen explores the American social concept of a lawn in his 1989 article originally published in the New York Times:

http://michaelpollan.com/articles-archive/why-mow-the-case-against-lawns/

Procedure: Students find two different slopes with equal gradient. One slope is covered with native prairie grass (perhaps at the same site their classmates are already studying in the "What's the Story of____?" investigation), one slope is covered in yard grass (probably Kentucky Blue). APVC trough with a collection bucket is constructed and students dump water or set a sprinkler in motion at the top of the slope to determine which type of grass aids in water absorption better. Students determine what factors they will need to control in order to produce a good experiment. They should be encouraged to design and discuss their design with one another and other students outside their group. Students are also encouraged to modify their experiment to test for other factors. Students can synthesize their findings to make claims about modern yards and the costs and benefits of them, or to make inferences about how prairie grass is or is not well adapted to weather patterns and overall climate in Iowa. As students continue to ask questions they are encouraged to repeat and modify their experiment and compare their findings with expert regional and local research. Students are encouraged to choose a method of presenting their findings to a given audience. Students could write letters to lawmakers, develop a pros and cons list, write a story, do a demonstration, create a presentation, or be interviewed by their teacher.

Potential Offshoot questions for Tier 3 projects/investigations:

- Explore preservation and restoration projects in Iowa and their local communities
- Compare runoff in prairie grass, yard grass, and crops (with and without cover crops)
- Compare runoff of grasses and crops to concrete
- Explore the placement of rain gardens in cities and neighborhoods
- Exploration of prairie grass responses to fires and drought

____

Extra Resources:

Students who are curious as to the process of starting their own prairie garden can look here:

https://www.extension.umn.edu/garden/yard-garden/landscaping/establishing-and-maintaining-a-prairie-garden/

Students who would like a guide for local Iowa grasses can look here: http://www.eeob.iastate.edu/research/IowaGrasses/

Sources:

Gallant, A. L., Sadinski, W., Roth, M. F., & Rewa, C. A. (2011). Journal of Soil and Water Conservation.

Experts:

Solutions:

Tier 3: Open investigation

Tier: Open Investigation

Overview:

As they explored Tier 1 and 2, surely students found topics that piqued their interest. Let them run with it. We encourage the class to followup on these in an open investigation tier 3. Learning is for the learner – not for the teacher.

To this end, students should investigate a question that they are interested in. Teachers should facilitate their investigation, and make sure that it has a good relationship to the learning goals of the class, that it allows collection of data, interpretation of that data, and drawing of conclusions or development of solutions. Negotiate how they share what they have done. Options include a youtube video, a letter (for example to local government officials) recommending a policy or practice, a presentation, a paper, a website, a fundraiser for a community improvement….. the sky is the limit.

BUNDLE 6: CLIMATE

Welcome to Bundle 6- Climate

A YouTube element has been excluded from this version of the text. You can view it online here: https://pressbooks.uiowa.edu/8thgradescience/?p=45

Overview:

This is the final and culminating unit to the 8th grade year. Our team of educators, science education researchers, and scientists has assembled a climate change unit for 8th grade students. It's unique aspects include:

- focus on student-centered and active learning
- alignment to Iowa Science Standards
- focus on climate change impacts most relevant to Iowa

- use of local Iowa and Midwestern data for student investigation

You won't find this combination anywhere else! So we hope you find these resources useful as you facilitate authentic student investigation about the climate system in Iowa and beyond. As with all of our bundles, we want to hear your stories from the classroom, and incorporate your suggestions into future versions.

This bundle progresses through four stages or sections. The first is our Tier 1 activity – designed to build student engagement by student interviews with family members on the subjects of climate and weather. These interviews are to help students get beyond the abstract phenomena of climate and weather – and establish personal and localized connections on these topics. We believe this will increase student engagement and interest in the subsequent material.

While students are working on their interview assignment out of class, we recommend in-class introductory investigations of climate and weather using some of our provided lesson outlines. One key take-away for Tier 1 of the climate bundle is to establish the **difference between climate and weather**. At the end of Tier 1, students will have reviewed work from previous grade levels on weather; they will have some interesting questions about climate and weather; they will likely run into a wide range of opinions on climate change and appropriate solutions; and they will have encountered some personal stories and weather anecdotes that may (or may not) intersect with available observational data.

Big ideas:

1. Climate in Iowa, and all over the world, has changed in the last 100 years.
2. Precipitation has changed over the past 100 years, locally, globally and nationally.

Standards addressed:

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.
MS-ESS2-5	Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.
MS-ESS2-6	Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.
MS-ESS3-5	Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

Tiers in depth:

Tier 1:

Students will conduct interviews with family members (or other respected adults) to collect information about whether or not our local climate (and perhaps the climate of other areas) has changed over the years.

Tier 2:

This tier has a part A (changes in precipitation locally and beyond) which we recommend as a whole class activity. We focus on precipitation changes over the last 100 years because this is an important climate impact category that effects nearly all aspects of life and all economic sectors in Iowa. Students investigate how precipitation has changed over the past 100 years, locally, globally and nationally. The class will find that nationally and globally, some places are getting wetter and some drier. But in Iowa, the trend is toward more frequent heavy rains, especially in summertime.

Tier 2 continues with a Part B which allows more differentiation by interest area, learning goals, and ability levels.

Throughout Tier 2, we encourage students and teachers to use authentic (and where appropriate, local) data in a claim and evidence approach. We also feature articles where scientists explain climate and weather phenomena. And we provide a system to teach students how to vet information (such as articles and websites) for reliability. For any climate-related question, there is an important issue of scale – climate, and the types of relevant climate questions and available data, change with scale: from the local county all the way up to continental and global scales. And when using data to make claims about climate (such as stating whether the data support a claim that heat waves are more severe) – there are different levels of data analysis that you can do. At one extreme, you can find claims from other people – often a graph they have made and some conclusions. You just have to make sure you understand it and evaluate the credibility and quality of the source. At the other of the spectrum, one can go through the full process of obtaining observational data (i.e., temperatures) and evaluating claims and hypotheses with them. Along the way, many interesting questions come up that practicing scientists routinely wrestle with: how to handle missing or suspect data; how to define a meaningful average; how to quantify uncertainty and error; and how to handle changes in measurement technologies over time. Choosing how to direct students in terms of selecting climate impact categories (temperature, flooding, drought, heat wave, etc.), spatial scale, and comprehensiveness in data analysis is up to each teacher. We have tried to provide support for a wide range of combinations.

That said, we recommend starting (Tier 2, part A) with the whole class focused on the same climate question (precipitation), the same spatial scale (Iowa), and the same level of data analysis. This gets things started while being manageable, and allows the class to see best practices in terms of claims, evidence, vetting of sources, etc… and allows them to negotiate variables.

Tier 3:

Solutions! What can kids do? How can we limit undesirable changes in climate, and how can we engineer solutions or adaptations that make the consequences of changing climate manageable? Here we look at things like carbon footprints but teacher and student selection topics is encouraged.

Tier 1, Part A: Climate History Interviews Conducted by Students

Tier 1, Part A: Climate History Interviews Conducted by Students

Objective:

Students will conduct an interview(s) of someone who can provide a perspective on what the climate was like when they were younger.

Overview:

This unit has two components that take place simultaneously. The first component is for students to conduct an interview(s) of someone who can provide a perspective on what things were like when they were younger. The objective is for students to interview people who are important in their lives, and who can speak to changes they have seen in their lifetime regarding local climate. This can easily be a cross-curricular interview, aligned with English and Social Studies. We don't envision students needing all day in class to get this going, but realize they will need some time to conduct these interviews. During the assignment period for the out-of-class interviews, teachers can lead in-class investigation into features of weather and climate. Some suggestions are listed and explored in the second part of this section. At some point, the teacher will need to help the students analyze their data, compare with peers, and make an individual/group/class statement about what they have learned during their interviews.

Big questions:

- How has climate changed over the last century?
- What is weather?
- What is climate?
- What is the difference between weather and climate?

Standards addressed:

MS-ESS3-5	Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

Tier in depth:

First, we recommend that teachers help students prepare for their interviews by giving them these questions to think about.

Pre-interview:

1. Determine who you are going to interview. Why do you think they are a good candidate to interview?
2. Develop a list of questions you think are important to understanding if/how the local climate has been changing?
3. Compare and compile a list of questions generated by you and your peers (attached is a sample questionnaire that can be used)
4. Practice interviewing and taking notes with others. Debate the value of recording/transcribing the interviews.

Interview Questions:

What is your name?

How long have you lived in the area?

What is your occupation? Has your occupation changed?

How much time do you spend outdoors now? Did you spend more/less time outdoors in the past?

Compared to the past, today's summer temperatures are:

much hotter somewhat hotter same somewhat cooler much cooler

Compared to the past, today's winter temperatures are:

much colder somewhat colder same somewhat warmer much warmer

Compared to the past, the number of unusually hot days now is:

much more somewhat more same somewhat fewer much cooler

Compared to the past, the number of unusually cold days now is:

much more somewhat more same somewhat fewer much cooler

Compared to the past, our climate today is:

much wetter somewhat wetter same somewhat drier much drier

Compared to the past, the first frost now occurs:

much earlier somewhat earlier same somewhat later much later

Compared to the past, bird migration now occurs:

much earlier somewhat earlier same somewhat later much later

Compared to the past, ice breaking in spring now occurs:

much earlier somewhat earlier same somewhat later much later

We have more heavy downpours now than in the past

strongly agree agree disagree strongly disagree not sure

We have more droughts now than in the past

strongly agree agree disagree strongly disagree not sure

We have more snow now compared to the past

strongly agree agree disagree strongly disagree not sure

We shovel our driveways more frequently than in the past

strongly agree agree disagree strongly disagree not sure

Overall, would you say that climate has changed significantly during your lifetime? If so, how has it changed?

What have been the impacts of these changes on you and the place where you live? What will happen in your area if these changes continue?

How have you responded or adapted to these changes?

What will you do in your own community in the future in response to these changes?

It may be useful to have students summarize their interview in written form using these five sections. Students can write personal climate narratives (by replacing interview subject with "yourself") but because they cannot remember back over multiple decades, the changes students see from year to year do not constitute trends in climate.

1. **Start with a paragraph about the interview subject.** The story should start with name, town or city, state. Include their profession and recreational activities.
2. **Tell us how long the interview subject has lived or worked in the area.** The length of time observing changes is an important part of climate science.
3. **Tell us the changes the interview subject witnessed and described.** This section should just be about what is happening. It might be changes in the seasons, rainfall, etc... It is important

to describe only the changes – keep them separate to your description of what the changes mean for individuals and for the community.

4. **Tell us the consequences of climate change.** “Consequences” could be problems for wildlife or farm animals, changes in recreation activities like hunting and fishing seasons, damage to crops, or people. Include effects on people, neighbors, employment, livelihoods, etc.

5. **Tell us what solutions you want to see from local or national leaders, or what you plan to do locally.** Climate witness stories naturally touch on solutions to problems that people are seeing. Describe them.

Tier 1, Part B: What's the difference between weather and climate?

Tier 1: Part B: What's the difference between weather and climate?

Objective:

Students use information from their interviews to learn about the differences between weather and climate. These are NOT interchangeable words. Understanding the difference is important for many reasons. Understanding climate versus weather comes into play in examples such as: (a) understanding weather reports, (b) interpreting data, (c) reading articles about changing climate; and (d) for asking good questions about the relationships between the building blocks of the climate system.

Overview:

Students should use information from their interviews and various sources to learn about the differences between weather and climate.

Big questions:

- What is the difference between weather and climate?

Standards addressed:

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.
MS-ESS2-5	Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.
MS-ESS2-6	Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.
MS-ESS3-5	Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

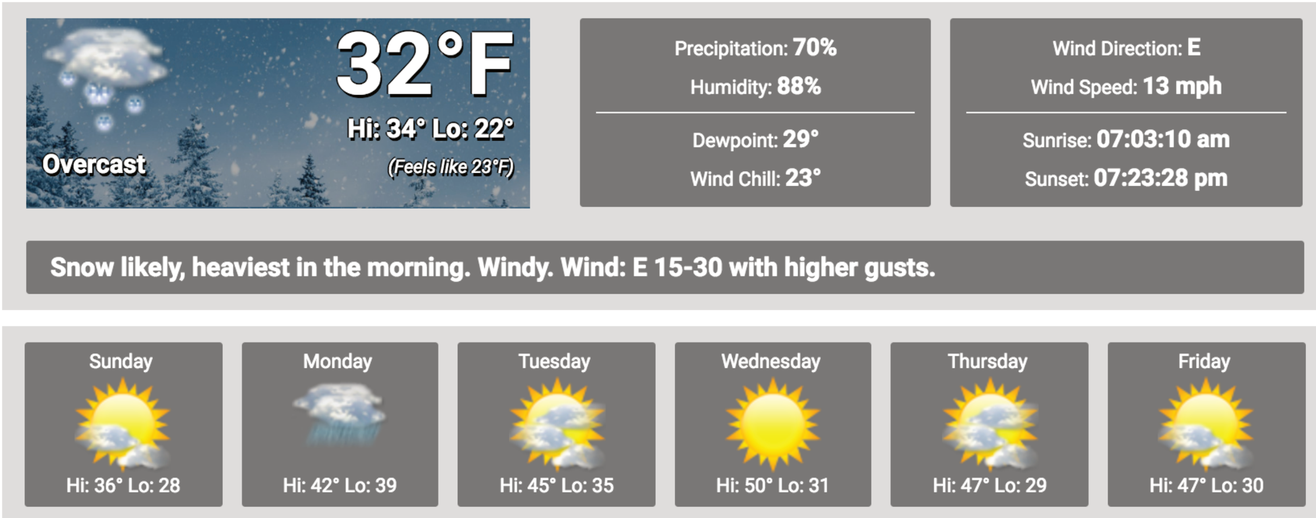
Tier in depth:

Tier 1B – Weather vs. Climate

To be posed at the students: During the interview you're conducting, you've been asking questions about things like temperatures in the summer and wintertime, number of downpours, and time spent shoveling the driveway, all things that you might associate with the weather. You're also asking questions about the climate, and how it has changed. We might hear people use the terms weather and climate almost as if they were interchangeable, but do they really mean the same thing?

Weather:

When we turn on the radio, or local news we frequently hear someone giving us the weather report, similar to what you might see below. This might consist of a five-day forecast that tells you the temperature and, whether its going to be sunny or cloudy, or partly sunny, or partly cloudy (aren't those the same thing?!). The weather is really a snapshot of how hot or cold, and how wet or dry things are going to be for you over the course of a fairly short time period, be it a few few hours or weeks, based on local atmospheric conditions. What are some reasons that you might be interested in knowing about the weather? Can you think of a situation where weather played an important role in your life?



http://www.kcrg.com/weather/

Climate:

If we change our focus, and observe over a longer period of time, and over greater geographic areas, we begin to see how weather behaves on average. During the months of December through January, you can expect it to be cold and snowy if you live in the upper midwestern United States. But, on the other hand, it is often hot and humid during the late part of July and August. This average weather over many months, or even years of time, makes up what is meant by the the climate of a particular region. Why should we be interested in the differences between weather and climate? How would you describe the climate of your local area?

Average precipitation in the lower 48 United States

Here are a few resources that will help further clarify some of the differences between weather and climate:

Cosmos – https://www.youtube.com/watch?v=cBdxDFpDp_k

https://climate.nasa.gov/interactives/climate-time-machine

https://www.nasa.gov/mission_pages/noaa-n/climate/climate_weather.html

https://oceanservice.noaa.gov/facts/weather_climate.html

National Geographic – https://www.youtube.com/watch?v=zz_CRzcIT-Q

Crash Course – https://www.youtube.com/watch?v=YbAWny7FV3w

Once your students have reviewed the definitions and examples on climate and weather from the links above, or other resources, have students compare that the their interviews. How much of each particular interview was focused on weather, and how much was focused on climate? Are there specific events from the interviews or from student memories that can be compared to actual past weather data? These might be a good topic for discussion. Have students reflect on how their views and perceptions of climate, weather, and weather extremes change as they complete their interviews and move through the unit. Also have them keep note of the questions that come up along the way.

At this point in the unit, student investigations of weather variables (temperature, rainfall, humidity, soil moisture) can optionally be integrated into the unit. How do measurements taken over a few days or weeks compare to weather data from previous years? or to historical climate values which are usually long-term averages for specific months?

Do a Google search for Historical Weather Data and see what you're able to come up with. How do your findings compare with what you were told during the interview?

Resources:

- Google search for "Historical Weather Data" will return tools

Additional Related Questions:

- Are all weather reports the same?
- How accurate are wather forecasts 24 hours in advance? 48 hours? 7 days?

Experts:

- National Weather Service: https://www.weather.gov/
- Your local office of the Weather Service
- TV meteorologists for your local stations.

Tier 2: Sizing Up Climate Questions

The Iowa Science Standards for 8th grade include focus on asking questions, using evidence, monitoring environmental impact, and collecting data. We combine and support these focus areas in our bundle.

While some textbooks would (at this point) introduce the important concepts from content knowledge about climate, we instead recommend a student-centered process of investigation, and then tying in key concepts as they arise naturally. However, it is important to be able to “size up” a climate or weather question – whether it is from students, or it forms the key concept on a unit you normally teach. The “notecard” pictured below is a compact questionnaire about a climate impact question (e.g. how has intense rainfall changed in the last 100 years in Iowa?) or a climate forcing (e.g., how has atmospheric methane changed over the past 100 years?). We recommend that teachers complete a short questionnaire of this type for each big idea that is tackled in a climate unit. For each example in our book, we provide a filled out card that might help show how the example fits in to the larger bundle, and the classroom-specific interests, goals, and constraints.

Topic: (fill in)	*Topic type (select one)* ☐ Impact Category ☐ Climate Forcing

Sizing up the topic?	☐ Student interest	☐ Window to science principles & cause-effect
☐ Directly affects Iowa	☐ Data available	☐ Launching point for developing solutions
☐ Directly affects U.S.	☐ Controversial?	☐ Supported in this "8th Grade Bundle" book?

Investigation Type	***Scale of Interest***				
	County	State	Midwest	U.S.	Globe
View/interpret premade graphs	See note				
Work with ready-to-graph data					
Navigate through data websites with multiple options for locations and variables (Iowa mesonet, NOAAView, etc.)					
Work with computer models & simulators of climate impacts & solutions					
Design methods for monitoring and minimizing human impact; engineering and testing solutions					

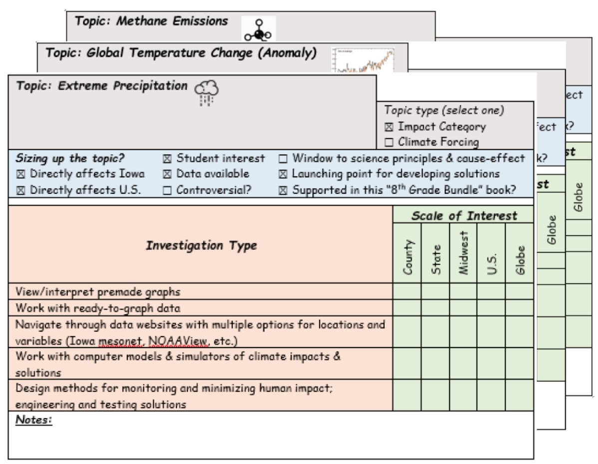
Notes:

Figure. Notecard-sized questionnaire for assessing climate topics. In the upper right corner, each topic can be classified as a climate impact (a consequence of changing climate, such as heat waves) or a climate forcing (a change to the earth system that has consequences to climate). In the blue section, are a number of qualitative questions about each topic that may help to assess the importance or fit of a specific topic within the class. In the orange section are a number of different types of investigations that students could do. And in the green section is a space to indicate what scale of interest the investigation or solution will take.

The reason that sizing up a topic using this questionnaire, or an equivalent tool, is important – is to determine how a topic fits into the bundle, and what combinations of spatial scale and data sources will work for a given topic or question. Since students cannot take their own data to assess how climate is changing (because 30 year records or longer are required at global scale – and even longer than that at smaller scales), it is important to assess whether data is available for investigating a certain trend at a certain spatial scale. Furthermore, teachers may have in mind a specific balance of studying forcings to the climate system (e.g. greenhouse gases, volcanic eruptions, solar variability) vs. impacts (rainfall, temperature, sea level, heat waves, etc.). And teachers may want to guide the class towards studying solutions to climate forcing (i.e., mitigation, or reducing emissions of greenhouse gases) versus creating solutions to impacts (i.e., adaptation to a changing climate, such as modifying storm drainage systems or changing farming practices).

We recommend that teachers start with a guided example, where students investigate a local climate trend using real-world data. Due to its relevance to every day life here in Iowa, and the good data availability, we recommend starting with intense rainfall. Once the teacher models or guides students through this process with Iowa intense rainfall, the class can begin to answer a broader set of questions.

Over time, teachers and students might build a whole set of climate forcing and impact notecards, as shown below.



An example of a set of three assessment cards covering two climate impacts and one climate forcing.

Drawing from published assessments of climate change in Iowa, the following variables are thought to be important climate impacts here in Iowa. These are the topics where we would check "Directly effects Iowa" on the notecard.

- Extreme Precipitation (annual average)
- Springtime Extreme Precipitation
- Springtime Total Precipitation
- Fall Soil Temperature
- Average nighttime temperatures
- Flood Frequency / Flood Severity
- Heat Index

- Dew Point
- Absolute Humidity
- Timing of Spring
- Frost Free Days / Growing Degree Days
- Heating Degree Days
- Cooling Degree Days
- Planting (Spring) and Growing (Summer) Soil Moisture (mean, and extremes)
- Summer Maximum Temperatures / Summer Maximum Pavement Temperatures
- Combined impacts on agriculture

While not all of these impacts are covered in our 8th grade bundle, the process of investigating a climate impact is the same each time, and generalizing from our examples is possible. Each time the investigation process includes: (1) identifying a question (e.g., is weather phenomenon X changing over time), (2) identifying a data source that could be used to answer that question, (3) accessing and analyzing the data (often through graphs or in some cases maps), (4) coming to a conclusion supported by evidence, including consideration of the cause-and-effect relationships at play, (5) deciding whether the change represents a problem that needs a solution, and (6) settling in on a solution. For all of the steps involved, one typically chooses as spatial scale to work at (county, state, Midwest, nation, global, etc.). The spatial scale is critical at determining what datasets and sources are used.

Tier 2, Part A: Investigating Precipitation-Locally, Nationally, and Globally

Tier 2, Part A: Investigating Precipitation- Locally, Nationally, and Globally

Objective:

Students will investigate local climate issues using real-world data.

Overview:

The Iowa Science Standards for 8th grade include focus on asking questions, using evidence, monitoring environmental impact, and collecting data. We combine and support these focus areas in our bundle.

Therefore, the goal of this Tier 2 bundle is to have students investigate a local climate trend using real-world data. Students will begin with a guided example (has rainfall changed in Iowa?). In other words, there is a predetermined question, the location of the data source(s) are given, and a fully worked example is available to the teacher.

The investigation of rainfall in Iowa is meant to serve as a template for further investigations. Many investigations will follow a sequence of (1) identifying a question (e.g., is weather phenomenon X changing over time), (2) identifying a data source that could be used to answer that question, (3) accessing and analyzing the data (often through graphs or in some cases maps), (4) coming to a conclusion supported by evidence, including consideration of the cause-and-effect relationships at play, (5) deciding whether the change represents a problem that needs a solution, and (6) settling in on a solution.

Once the teacher models or guides students through this process with an important Iowa climate impact (intense rainfall), they can begin to answer a broader set of questions.

Big questions:

- What causes rainfall?
- Has rainfall changed in Iowa, nationally and globally over the past 100 years?

Standards addressed:

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.
MS-ESS2-5	Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.
MS-ESS2-6	Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.
MS-ESS3-5	Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

Tier in depth:

Part 1

Overview: The goal of Tier 2 is to have students investigate local climate issues, using real-world data. Students will begin with a guided example, with a predetermined question, where they will investigate forcing (what is happening), then, what is the cause, the impact and finally, what can be done/should anything be done? A guided template is below, including resources, to help students with the first iteration.

At the conclusion of this guided inquiry investigation, students will branch off into an open investigation. Students will be given a range of investigations, including open to their interest area, to explore and learn about. They will work in groups but be broken into jigsaw groups to make a consensus statement, supported by the data, with an overall climate statement.

Background Knowledge: What causes rainfall? Heavy rainfall? The science behind precipitation:

Rainfall occurs when the sun causes water on earth's surface to evaporate, creating water vapor that rises upwards through the atmosphere, condenses, and becomes heavy enough to fall back to earth under the influence of gravity. When warm air rises it cools, causing moisture to fall out as precipitation. Warmer air is capable of holding more moisture, leading to extreme precipitation events. As the planet warms, it is predicted that large areas of earth's surface will experience a greater frequency of extreme precipitation that could damage essential infrastructure, or potentially lead to flooding (IPCC). Nationally, there has been an increase in the portion of the

United States that experiences extreme, single-day precipitation events, going back to the early 20th century, with nine of the top 10 years occurring since 1990 (EPA). On a local level, the state of Iowa has seen an upward trend in the number of days that experience more than 1.25 inches of rainfall. Local climatic changes such as these can negatively impact crop production, contributing to delays in planting and harvesting, while also degrading the quality of surface waters (Globalchange.gov).

Probing Question: Has rainfall changed in Iowa, nationally and globally over the past 100 years? Collect data to determine your answer to this question, using real-world data.

Investigation: One option is to look at the number of days with heavy rainfall.

That first starts with asking – how much rainfall is "heavy"?

A commonly used definition is 2" per day – but it would be an opportunity to think about impacts of heavy rain — such as road flooding, flash floods, interruption to businesses, basement flooding, combined sewer overflows, etc. – and see what levels of rain have caused local impacts in the past. The number can be changed to see how different numbers impact the data table. For example, 1 or 1.25 or 1.5 inches.

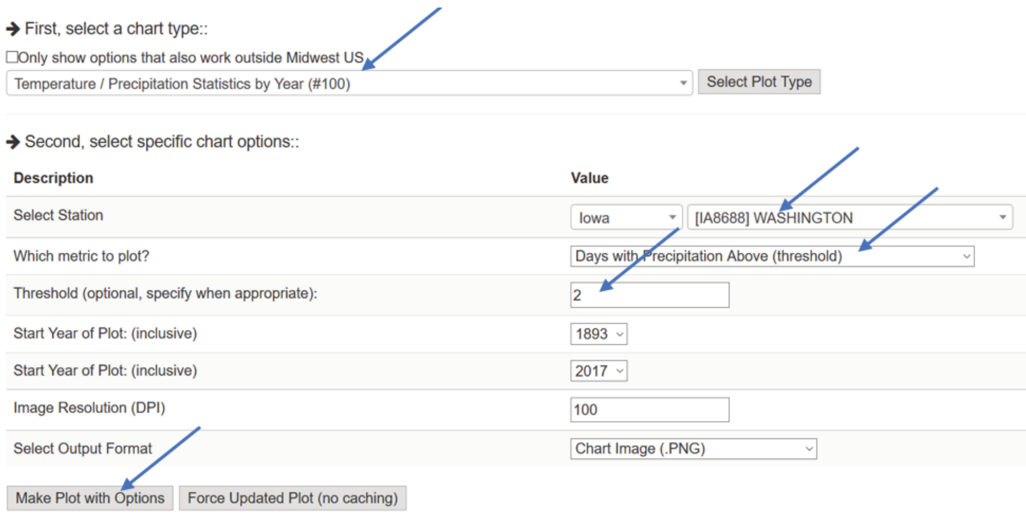
BEGIN INVESTIGATION

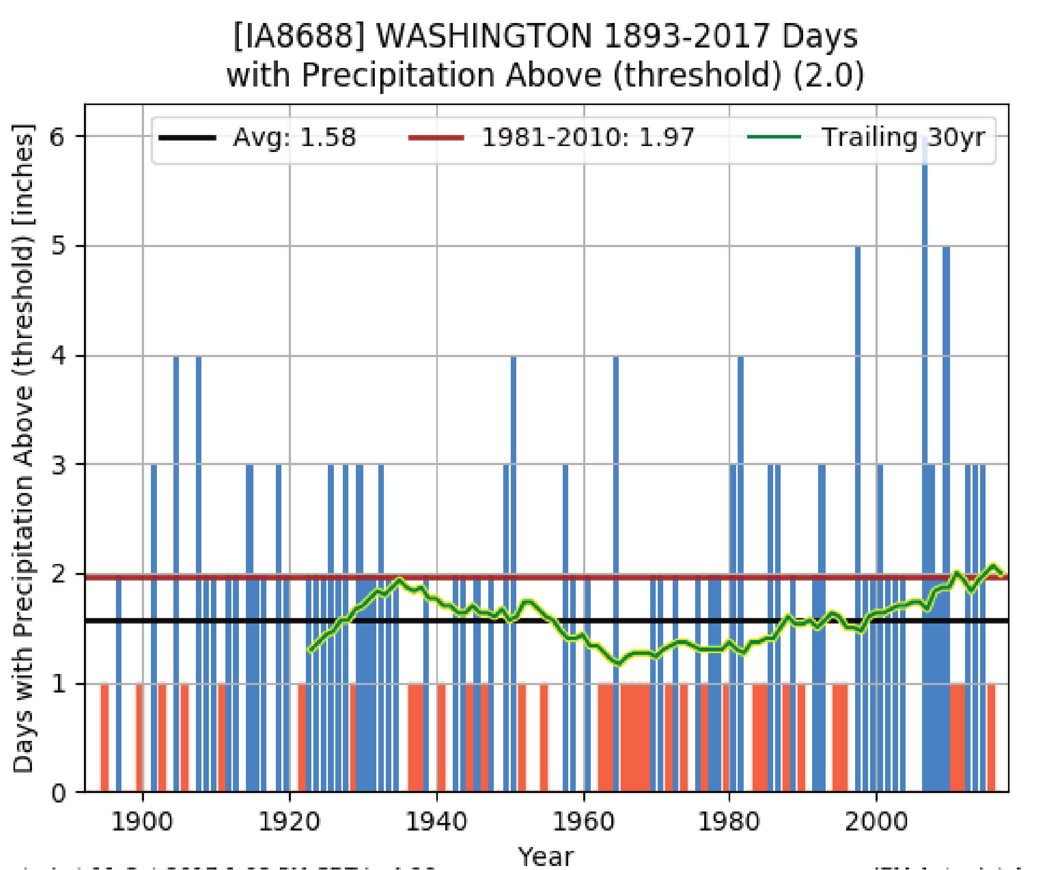
- Go to https://mesonet.agron.iastate.edu/plotting/auto/

1. Make plot #100 in the "yearly" section
2. "Select station" to somewhere "local" to you
3. "Which metric to plot" change to "Days with Precipitation Above (Threshold)
4. "Threshold" change to 2 (signifies days with 2 inches of rain)
5. Select "Make Plot with Options"

o Scroll down to see graph of the data

o Discuss and analyze





Additional Readings/resources: Have students read one or more of the following local, national, and global resources and newspaper articles to get a broader, yet Iowa-based, perspective on the impact a changing climate can have on precipitation.

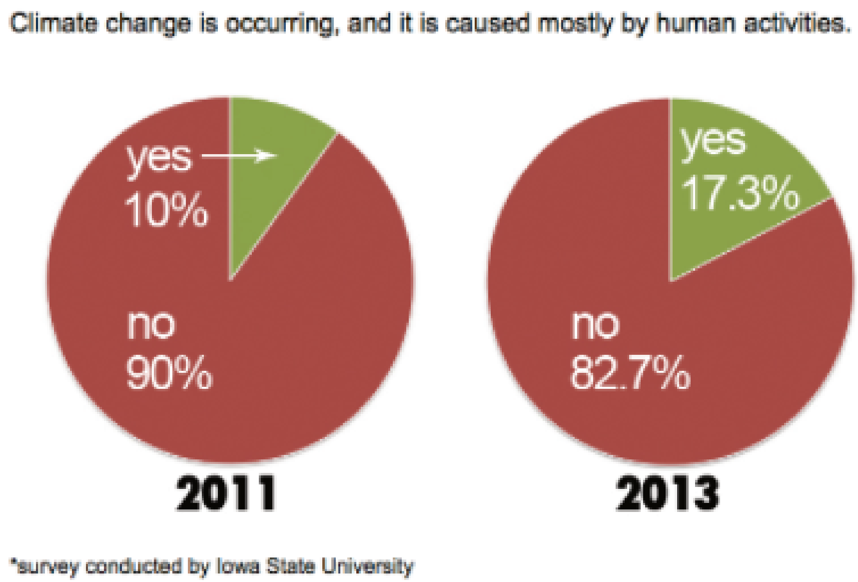
Local (Iowa) Viewpoint:

Wacky weather changing Iowans' climate change perceptions

http://www.thegazette.com/2013/08/10/wacky-weather-changing-iowans-climate-change-perception

Cedar Rapids Gazette (Orlan Love) – August 10, 2013

Results from a 2013 study conducted by ISU suggest that farmers' perceptions about climate change are evolving. Some attribute this shift in opinion to extreme weather events associated with widespread drought in 2012, followed by an exceptionally wet 2013. Notable changes to Iowa's climate include increased humidity, greater annual precipitation, more frost-free days, and more extreme weather events, which is likely the strongest signal of a changing climate in our state.



Iowa land use influences climate, state climatologist says

http://www.thegazette.com/subject/news/iowa-land-use-influences-climate-state-climatologist-says-20170521

Cedar Rapids Gazette (Erin Jordan) – May 21, 2017

An interview with Iowa state climatologist Harry Hillaker where he discusses his role, how it has changed during his career, and the impact that land use can have on climate.

Rainfall Ties 1988 Record

http://wcfcourier.com/news/top_news/rainfall-ties-record/article_adfd2ed1-a84b-5df0-b828-f60a812ca5c5.html

Waterloo/Cedar Falls Courier (Emily Graham) – May 9, 2003

Heavy rainfalls in early May 2003 tied records that had stood for 25 years. While weather forecasters didn't anticipate flooding, farmers were forced to delay the timing of getting crops in the ground, potentially diminishing yields.

Iowa Climate Statement 2017: It's not just heat, it's humidity

http://www.desmoinesregister.com/story/opinion/columnists/iowa-view/2017/08/22/iowa-climate-statement-2017-its-not-just-heat-its-humidity/589861001/

Des Moines Register (Gene Takle and Betsy Stone – Iowa View Contributors) – August 22, 2017

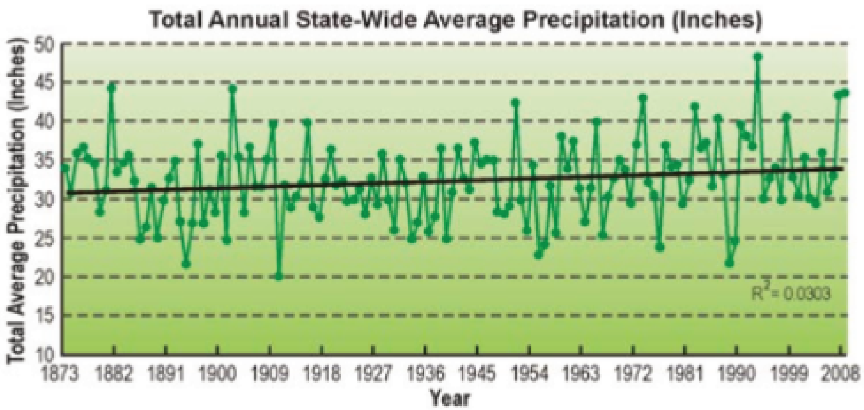
A recent statement issued by science faculty and researchers, describes the impact that heightened humidity levels can have on Iowa's agriculture industry. Stresses include increased frequency in extreme rain events, warmer overnight temperatures, and longer dew periods that can contribute to delayed planting and harvesting, in addition to elevated costs associated with drying grain.

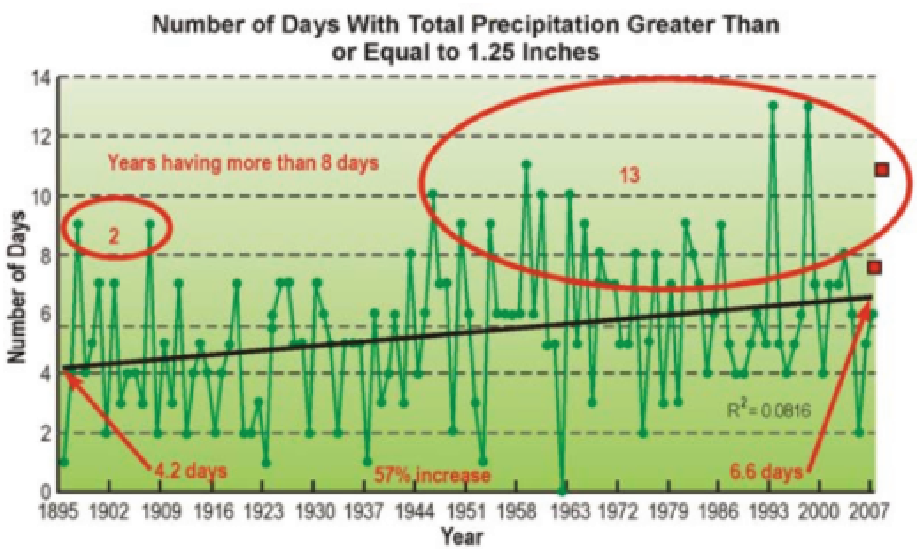
Climate Change Impacts on Iowa 2010

Report to the Governor and the Iowa General Assembly (Iowa Climate Change Impacts Committee)

http://www.water.iastate.edu/sites/www.water.iastate.edu/files/iowawatercenter/Climate%20Change%20Impacts%20on%20Iowa%202010.pdf

A comprehensive report and summary completed in 2010 that takes an in-depth look at how Iowa's climate is changing, and the associated consequences to agriculture, flora and fauna, public health, and Iowa's economy, infrastructure, and emergency services. Of particular interest are the findings related to an upward trend in average annual statewide precipitation (top), and frequency of local (Cedar Rapids) extreme rainfall events (bottom).

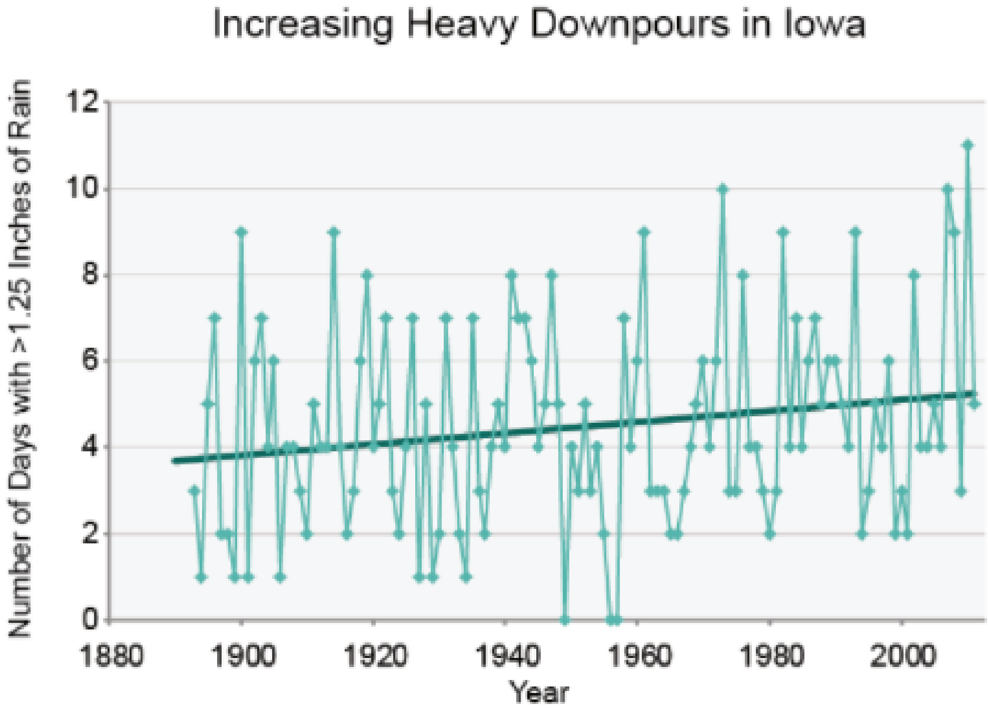




<u>Increasing Heavy Downpours in Iowa</u>

http://www.globalchange.gov/browse/multimedia/increasing-heavy-downpours-iowa

Iowa is the nation's top corn and soybean producing state. These crops are planted in the spring. Heavy rain can delay planting and create problems in obtaining a good stand of plants, both of which can reduce crop productivity. In Iowa soils with even modest slopes, rainfall of more than 1.25 inches in a single day leads to runoff that causes soil erosion and loss of nutrients and, under some circumstances, can lead to flooding. The figure shows the number of days per year during which more than 1.25 inches of rain fell in Des Moines, Iowa. Recent frequent occurrences of such events are consistent with the significant upward trend of heavy precipitation events documented in the Midwest. (Figure source: adapted from Takle 2011)

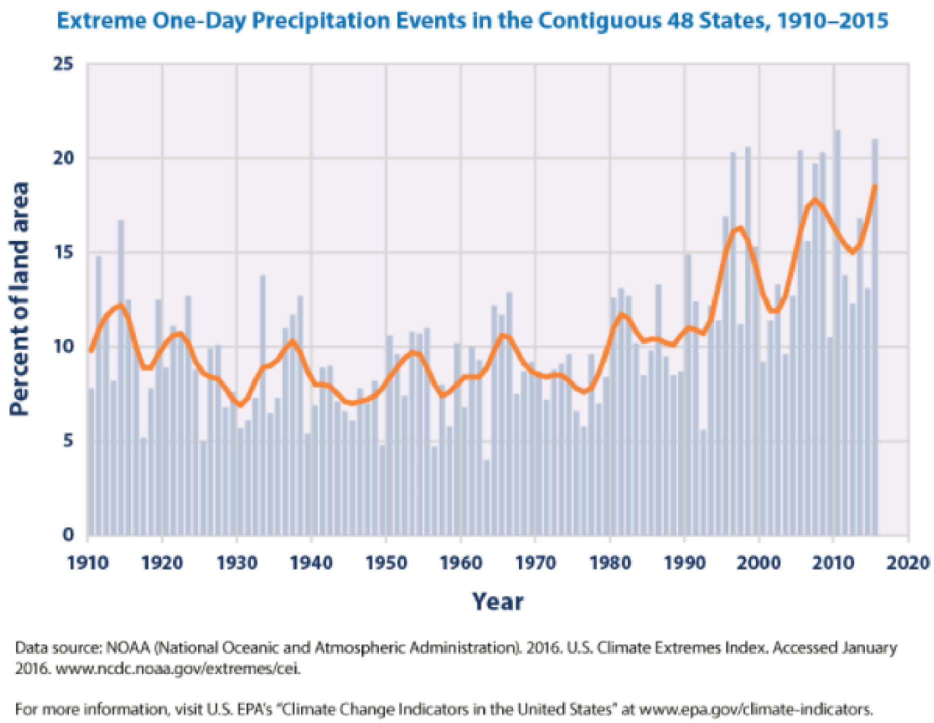


National/Regional Viewpoint:

Climate Change Indicators: Heavy Precipitation

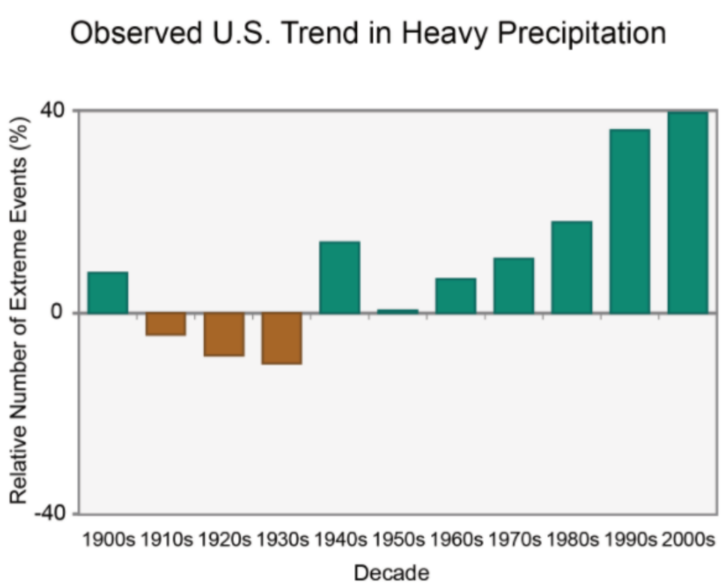
https://www.epa.gov/climate-indicators/climate-change-indicators-heavy-precipitation

This figure shows the percentage of the land area of the contiguous 48 states where a much greater than normal portion of total annual precipitation has come from extreme single-day precipitation events. The bars represent individual years, while the line is a nine-year weighted average.



<u>Observed U.S. Trend in Heavy Precipitation</u>

http://www.globalchange.gov/browse/multimedia/observed-us-trend-heavy-precipitation

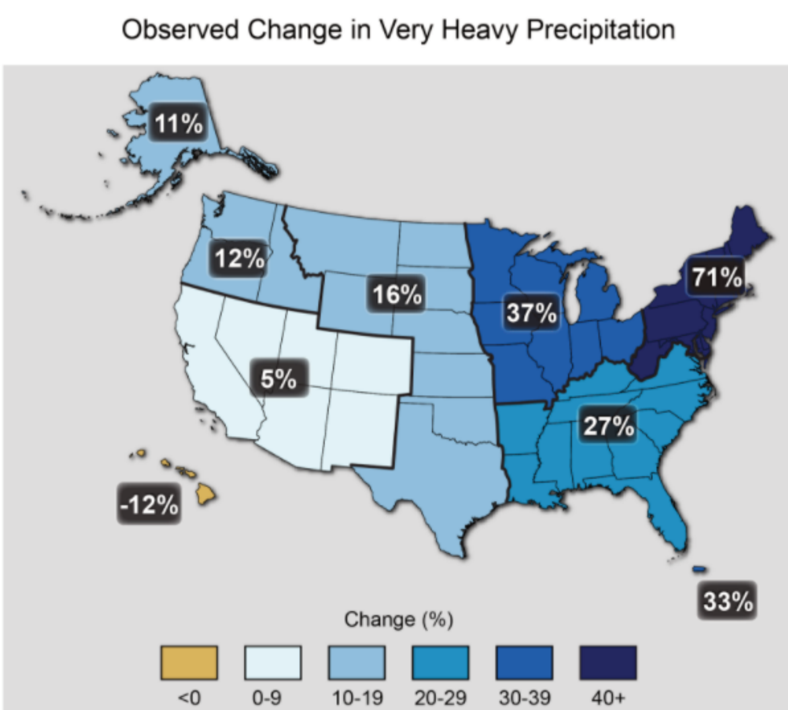


One measure of a heavy precipitation event is a 2-day precipitation total that is exceeded on average only once in a five-year period, also known as a once-in-five-year event. As this extreme precipitation index for 1901-2012 shows, the occurrence of such events has become much more common in recent decades. Changes are compared to the period 1901-1960, and do not include Alaska or Hawai'i. The 2000s decade (far right bar) includes 2001-2012. (Figure source: adapted from Kunkel et al. 2013).

Observed Change in Very Heavy Precipitation

http://www.globalchange.gov/browse/multimedia/observed-change-very-heavy-precipitation-0

The map shows percent increases in the amount of precipitation falling in very heavy events (defined as the heaviest 1% of all daily events) from 1958 to 2012 for each region of the continental United States. These trends are larger than natural variations for the Northeast, Midwest, Puerto Rico, Southeast, Great Plains, and Alaska. The trends are not larger than natural variations for the Southwest, Hawai'i, and the Northwest. The changes shown in this figure are calculated from the beginning and end points of the trends for 1958 to 2012. (Figure source: updated from Karl et al. 2009).

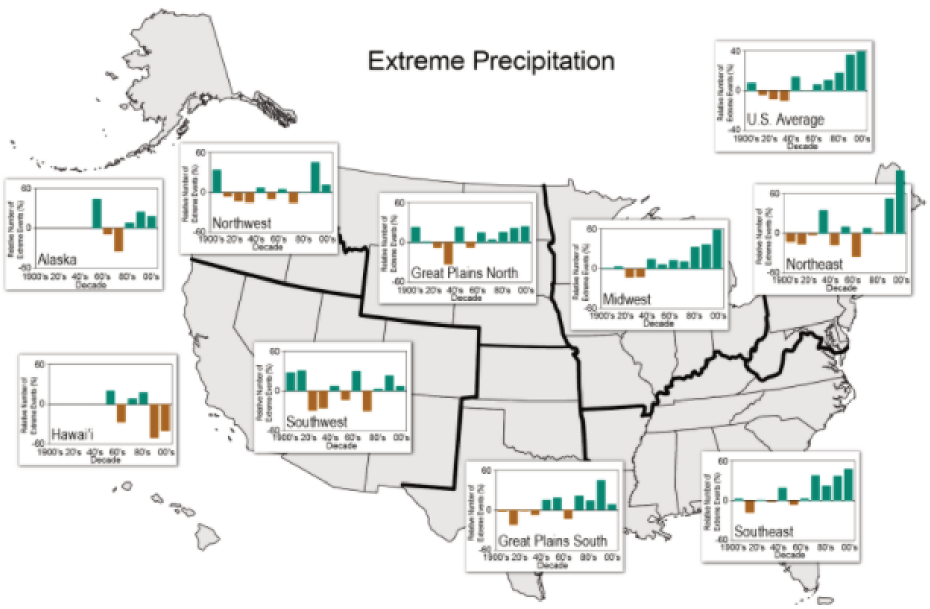


Extreme Precipitation

http://www.globalchange.gov/browse/multimedia/extreme-precipitation

Heavy downpours are increasing nationally, with especially large increases in the Midwest and

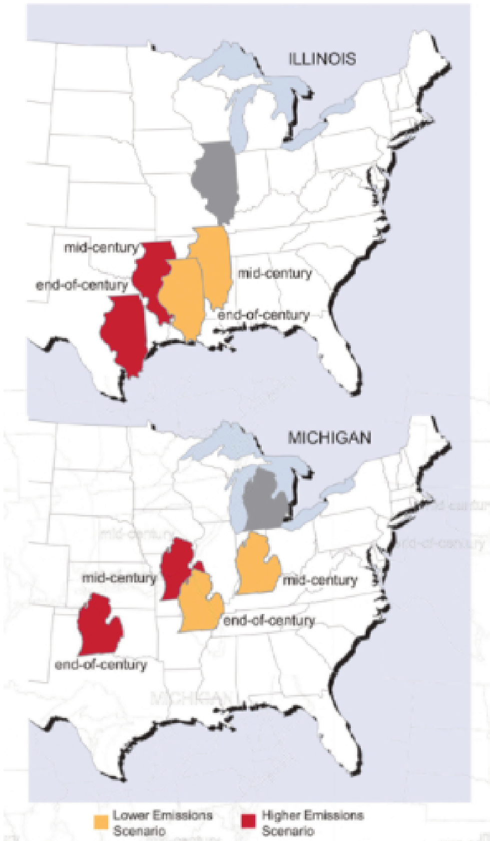
Northeast. Despite considerable decadal-scale natural variability, indices such as this one based on 2-day precipitation totals exceeding a threshold for a 1-in-5-year occurrence exhibit a greater than normal occurrence of extreme events since 1991 in all U.S. regions except Alaska and Hawai‘i. Each bar represents that decade's average, while the far right bar in each graph represents the average for the 12-year period of 2001-2012. Analysis is based on 726 long-term, quality-controlled station records. This figure is a regional expansion of the national index in Figure 2.16 of Chapter 2. (Figure source: updated from Kunkel et al. 2013).



Climate Impacts in the Midwest

https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-midwest_.html

The Midwest has gotten warmer, with average annual temperatures increasing over the last several decades. Between 1900 and 2010, the average air temperature increased by more than 1.5°F. The rate of increase in temperature has accelerated in recent decades, particularly nighttime and winter temperatures. Precipitation is greatest in the eastern part of the Midwest and less towards the west. Heavy downpours are already common, but climate change is expected to intensify storms and lead to greater precipitation across the entire region during this century. Annual precipitation has already risen by as much as 20% in some areas.



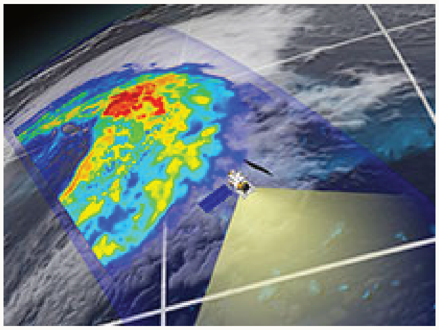
Projected change in summer temperatures under different warming scenarios. Summers in Illinois and Michigan might feel like current summers in Texas or Oklahoma by the end of the century. Source: USGCRP (2009).

Projected change in summer temperatures under different warming scenarios. Summers in Illinois and Michigan might feel like current summers in Texas or Oklahoma by the end of the century. Source: USGCRP (2009).

Global Viewpoint: Student view a selection of resources, including searching for their own resources, that address global precipitation.

New Satellite Boosts Research on Global Rainfall and Climate

Scientists deploy a new tool to help understand global precipitation.



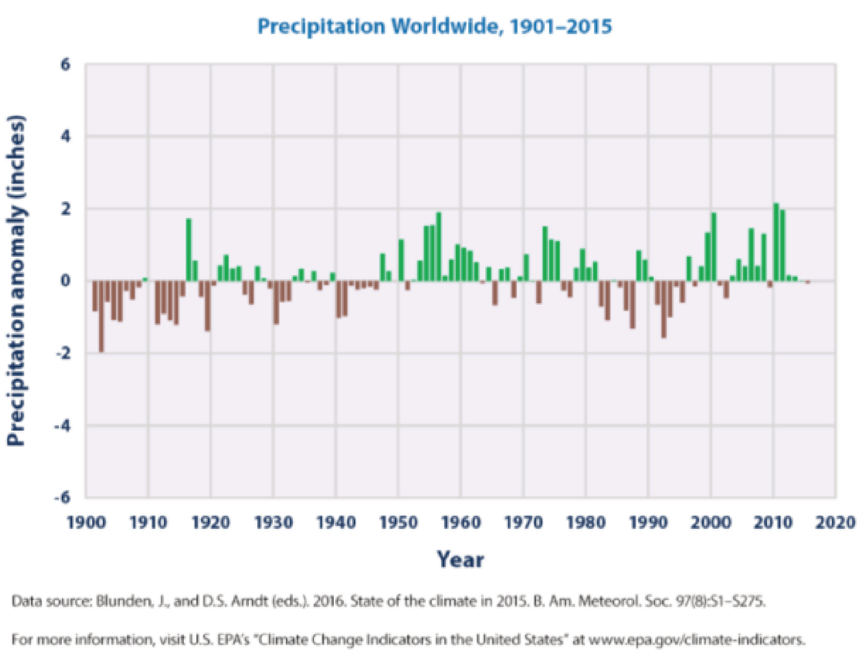
NASA
U.S. and Japanese space agencies released the satellite's first images last month.

http://e360.yale.edu/features/
new_satellite_boosts_research_on_global_rainfall_and_climate

Climate Change Indicators: U.S. and Global Precipitation

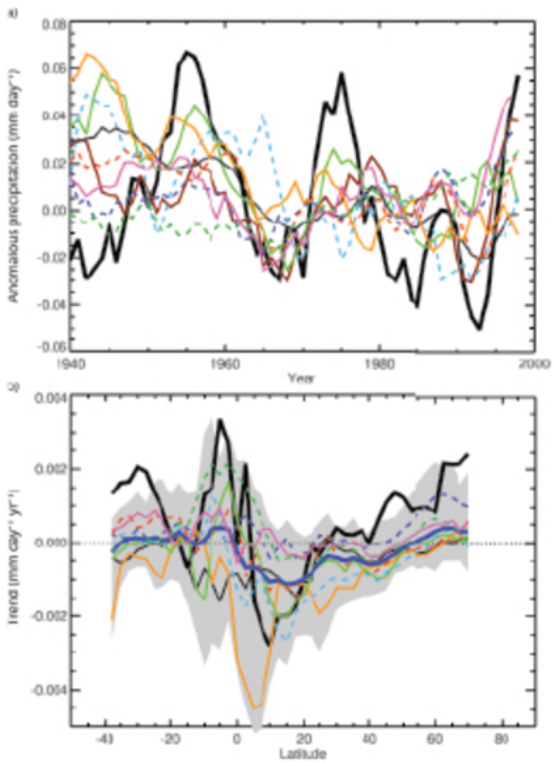
Students can investigate, via selecting a view along the bottom of the screen, if they want to look at national or global data.

https://www.epa.gov/climate-indicators/climate-change-indicators-us-and-global-precipitation



Increasing Atmospheric moisture content:

https://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch9s9-5-4-2.html



Validation of sources: Students will fill out the following guide as a validation tool that their sources are legitimate.

4-Point Check

Is this a trustworthy, scientific source?

€ My source is written to inform and educate.

It's NOT:

Trying to sell something.

Made for entertainment.

Opinion or propaganda.

€ My source has good authority.

It IS:

Written by someone inside the field.

Affiliated with a governmental or well-respected scientific organization

Peer-reviewed by subject matter experts.

Using citations and references.

€ My source is reliable.

It IS:

Published, with an identifiable ISBN number or “doi.”

Stable, and will be there next time I visit the website.

Written recently or updated regularly.

€ My source is thorough.

It is NOT:

Incomplete, or a work-in-progress.

Missing relevant information.

Conclusion: What did you determine is happening with precipitation in Iowa, nationally and globally, over the past 100 years? What is your supporting documentation?

2. Is it really changing? Why does it matter?

Students can answer is it really changing. Then, they can list, discuss things that are impacted by this. Possibly link article from newspaper talked about flooding, bugs, illness/human health, etc…

3. What might be the causes of the change in precipitation?

CHARLIE AND SCOTT

Experts:

Solutions:

Tier 2, Part B: Drought in a Changing Climate

Tier 2, Part B: Drought in a Changing Climate

Objective:

Students investigate local climate issues, using real-world data.

Overview:

The goal of Tier 2 is to have students investigate local climate issues, using real-world data. Students will begin with a guided example, with a predetermined question, where they will investigate forcing (what is happening), then, what is the cause, the impact and finally, what can be done/should anything be done? A guided template is below, including resources, to help students with the first iteration. At the conclusion of this guided inquiry investigation, students will branch off into an open investigation. Students will be given a range of investigations, including open to their interest area, to explore and learn about. They will work in groups but be broken into jigsaw groups to make a consensus statement, supported by the data, with an overall climate statement.

Big questions:

- What is drought?
- How does drought affect humans locally and globally?
- Are droughts more common now than they used to be?

Standards addressed:

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.
MS-ESS2-5	Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.
MS-ESS2-6	Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.
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.
MS-ESS3-3	Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
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.
MS-ESS3-5	Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

Tier in depth:

Background Info: Drought is an insidious hazard of nature. It is often referred to as a "creeping phenomenon" and its impacts vary from region to region. Drought can therefore be difficult for people to understand. It is equally difficult to define, because what may be considered a drought in, say, Bali (six days without rain) would certainly not be considered a drought in Libya (annual rainfall less than 180 mm). In the most general sense, drought originates from a deficiency of precipitation over an extended period of time–usually a season or more–resulting in a water shortage for some activity, group, or environmental sector. Its impacts result from the interplay between the natural event (less precipitation than expected) and the demand people place on water supply, and human activities can exacerbate the impacts of drought. Because drought cannot be viewed solely as a physical phenomenon, it is usually defined both conceptually and operationally. (University of Nebraska)

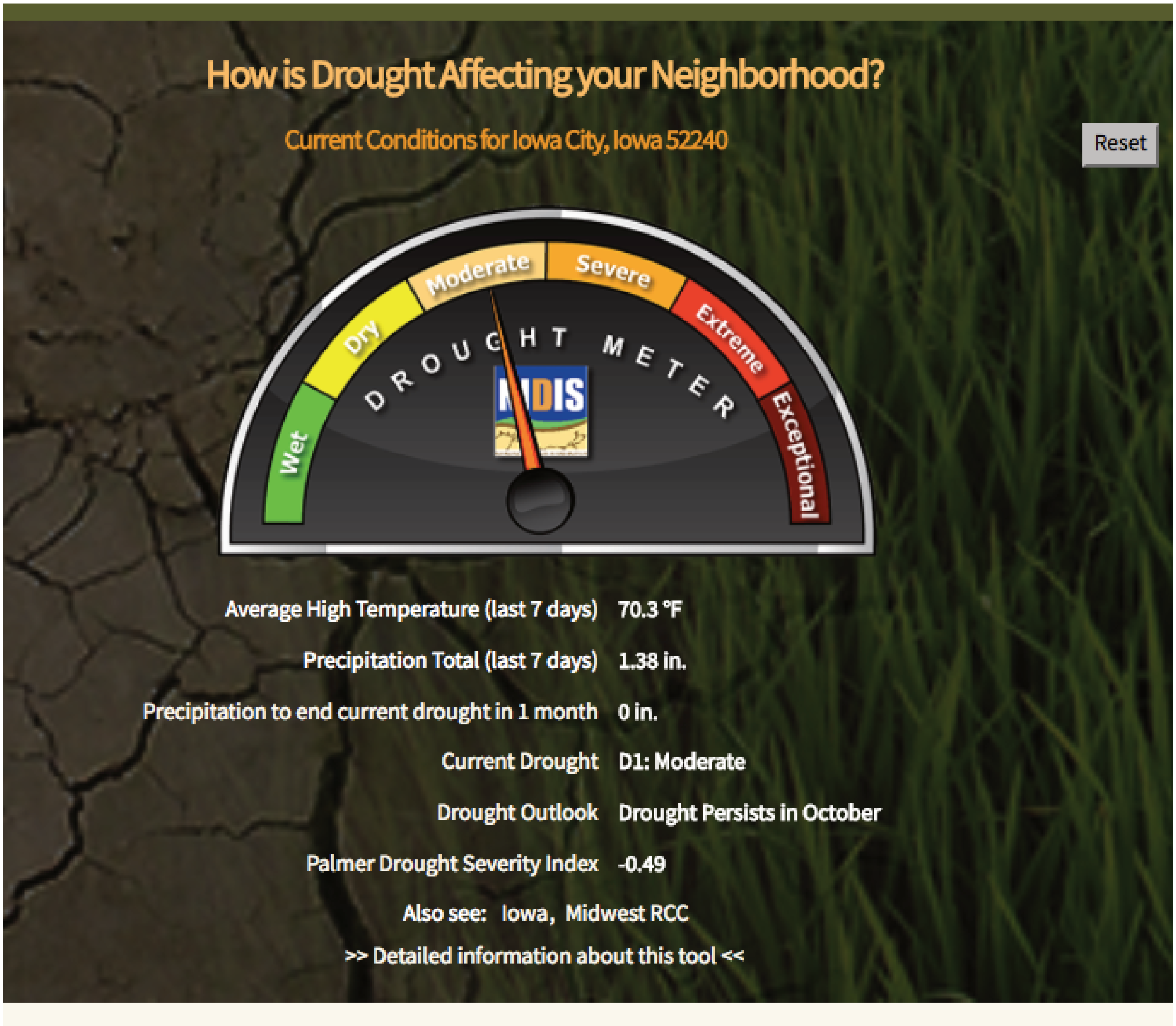
What is drought?

(https://drought.unl.edu/Education/DroughtBasics.aspx)

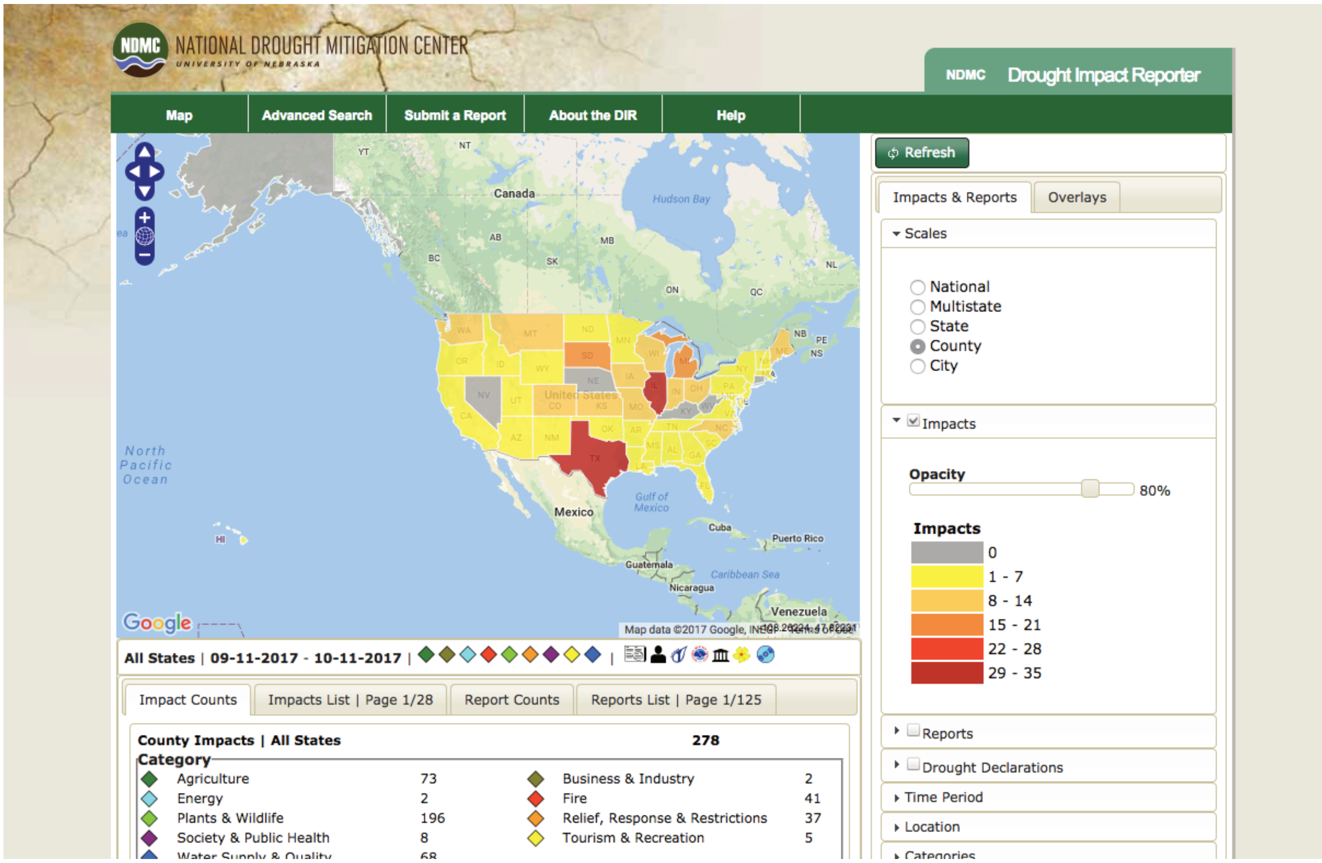
More information: http://droughttest.unl.edu/DroughtforKids/HowCanWeProtectOurselves/UnderstandingDroughtandtheEnvironment.aspx

Initial Engagement Activity: One way to begin the investigation is to bring in a panel of Iowa farmers to open a discussion about how drought has been affecting their crops for the past season and/or years, in comparison. The goal with this activity is to get students to understand the impacts of climate change on agriculture, which is one of the top industries in Iowa. Students will have the opportunity to connect with community members on a personal level about the impact droughts have had on their community. Students should also get a good idea if drought is more common today than it was years ago.

A follow up activity would be to have students visit https://www.drought.gov/drought/states/iowa and type in their zip code to see how affected is their area and pick out certain areas within Iowa that are impacted by the drought. Then proceed to have them look up various locations in the U.S.



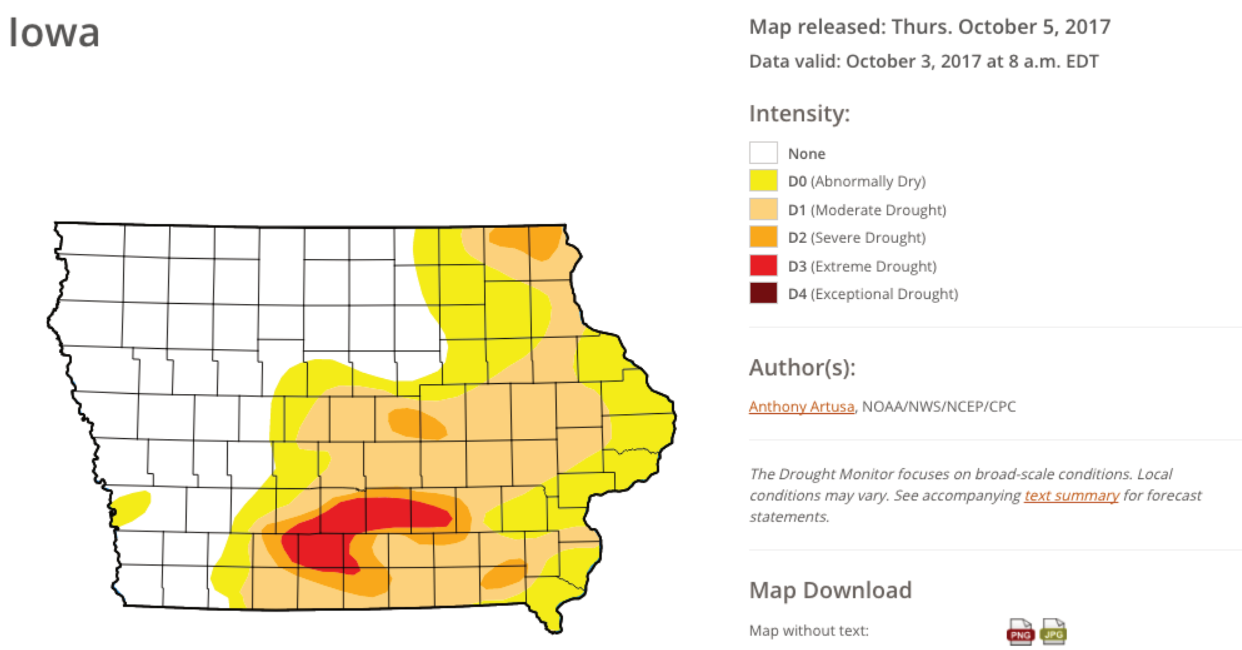
Another Website students would explore in this follow up activity is http://droughtreporter.unl.edu/map/ and discover how drought is affecting various states and counties.



List of Resources:

LOCAL: Iowa Drought Map for October 5, 2017

http://droughtmonitor.unl.edu/CurrentMap/StateDroughtMonitor.aspx?IA



Iowa Climate Statement: The drought of 2012

In a warmer climate, wet years get wetter and dry years get dryer. And dry years get hotter - that is precisely what happened in Iowa this year. We can expect Iowa to experience higher temperatures when dry weather patterns predominate. The latest science, based on overwhelming lines of physical evidence, indicates we can expect dry periods to be more frequent as soon as the 2020s.

(https://cgrer.uiowa.edu/sites/cgrer.uiowa.edu/files/pdf_files/IOWA%20CLIMATE%20STATEMENT%20-%20THE%20DROUGHT%20OF%202012_November_19_2012%20FINAL.pdf)

Local Media on the severity of the droughts in Iowa:

The Gazette

Headline: Washington, Keokuk counties eligible for natural disaster help due to drought

The droughts in Iowa during the summer of 2017 were so extreme that they fit the criteria for a natural disaster. 10 counties were listed as primary natural disaster areas, therefore, making these counties eligible for federal financial aid. This establishes a direct relationship between the economic impact of the consequences of Climate Change.

http://www.thegazette.com/subject/news/business/agriculture/washington-keokuk-counties-eligible-for-natural-disaster-help-due-to-drought-20170830

REGIONAL:

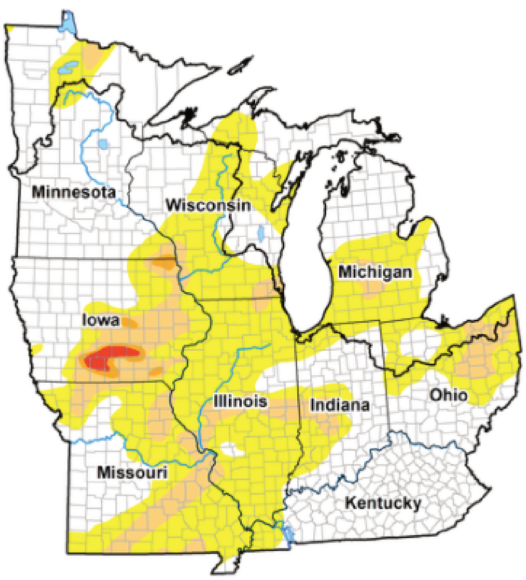
One-category degradations were made to the drought depiction in northern and central Ohio, far western Kentucky, northern and eastern portions of Wisconsin, southern and eastern Iowa, parts of Missouri, and western Upper Michigan. Where positive rainfall departures during the past 30-days generally ranged from 2-4 inches (or more), one-category improvements were made. This included Minnesota and portions of northwestern Iowa.

(https://www.drought.gov/drought/dews/midwest)

U.S. Drought Monitor - Midwest DEWS

As of October 3, 2017

Author: Anthony Artusa,NOAA/NWS/NCEP/CPC



Drought Conditions (Percent Area)

Week	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current 10/03/2017	49.24%	50.76%	14.27%	1.36%	0.48%	0.00%
Last Week 9/26/2017	54.99%	45.01%	10.06%	1.03%	0.34%	0.00%
Three Months Ago 7/04/2017	87.78%	12.22%	1.49%	0.00%	0.00%	0.00%
Start of Calendar Year 1/03/2017	72.28%	27.72%	5.96%	0.00%	0.00%	0.00%
Start of Water Year 10/03/2017	49.24%	50.76%	14.27%	1.36%	0.48%	0.00%
One Year Ago 10/04/2016	94.70%	5.30%	0.00%	0.00%	0.00%	0.00%

Drought Intensities

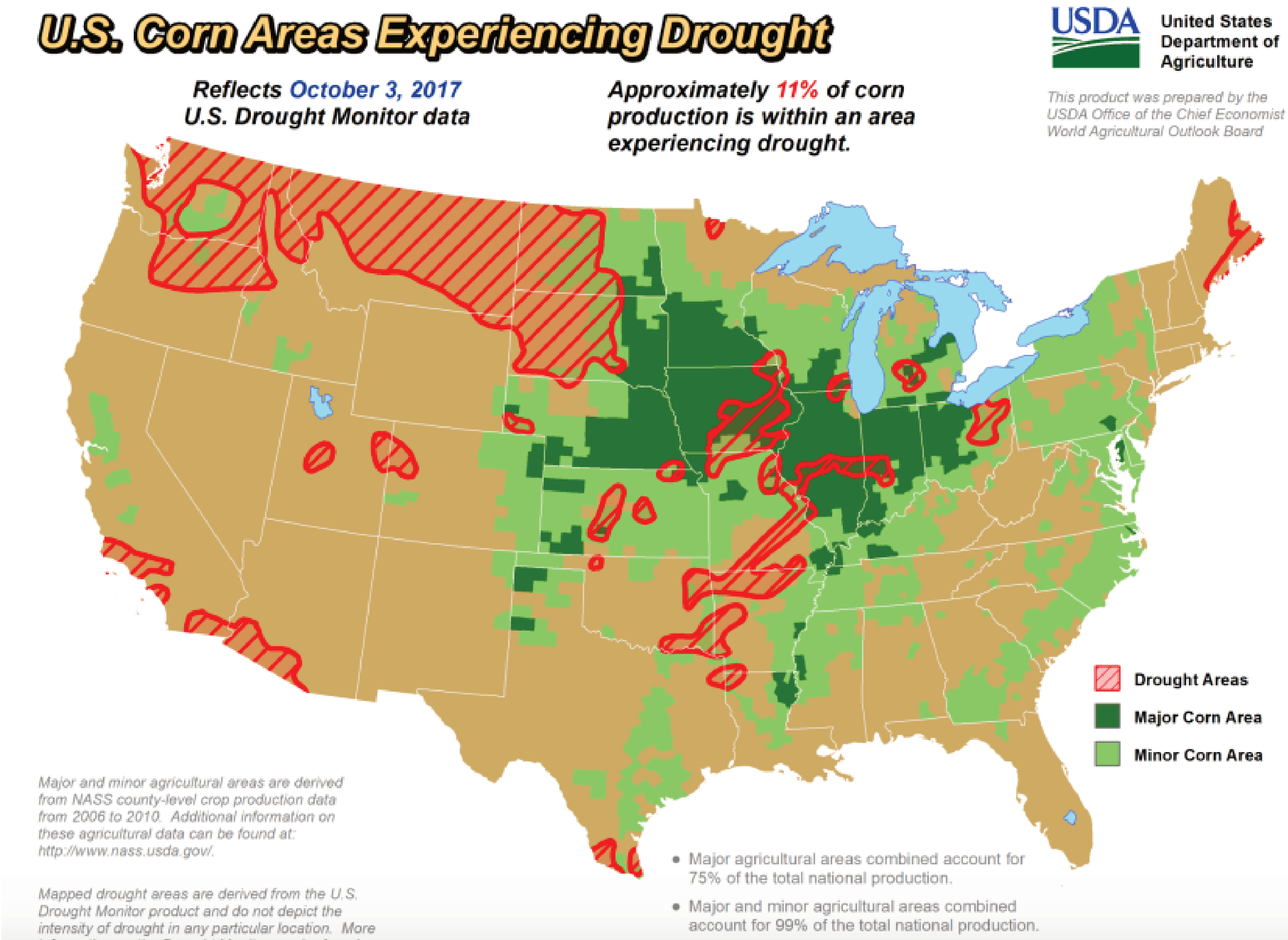
- None: No Drought
- D0: Abnormally Dry
- D1: Moderate Drought
- D2: Severe Drought
- D3: Extreme Drought
- D4: Exceptional Drought

http://droughtmonitor.unl.edu/

NATIONAL: Map of Corn Production Regions Experiencing Droughts

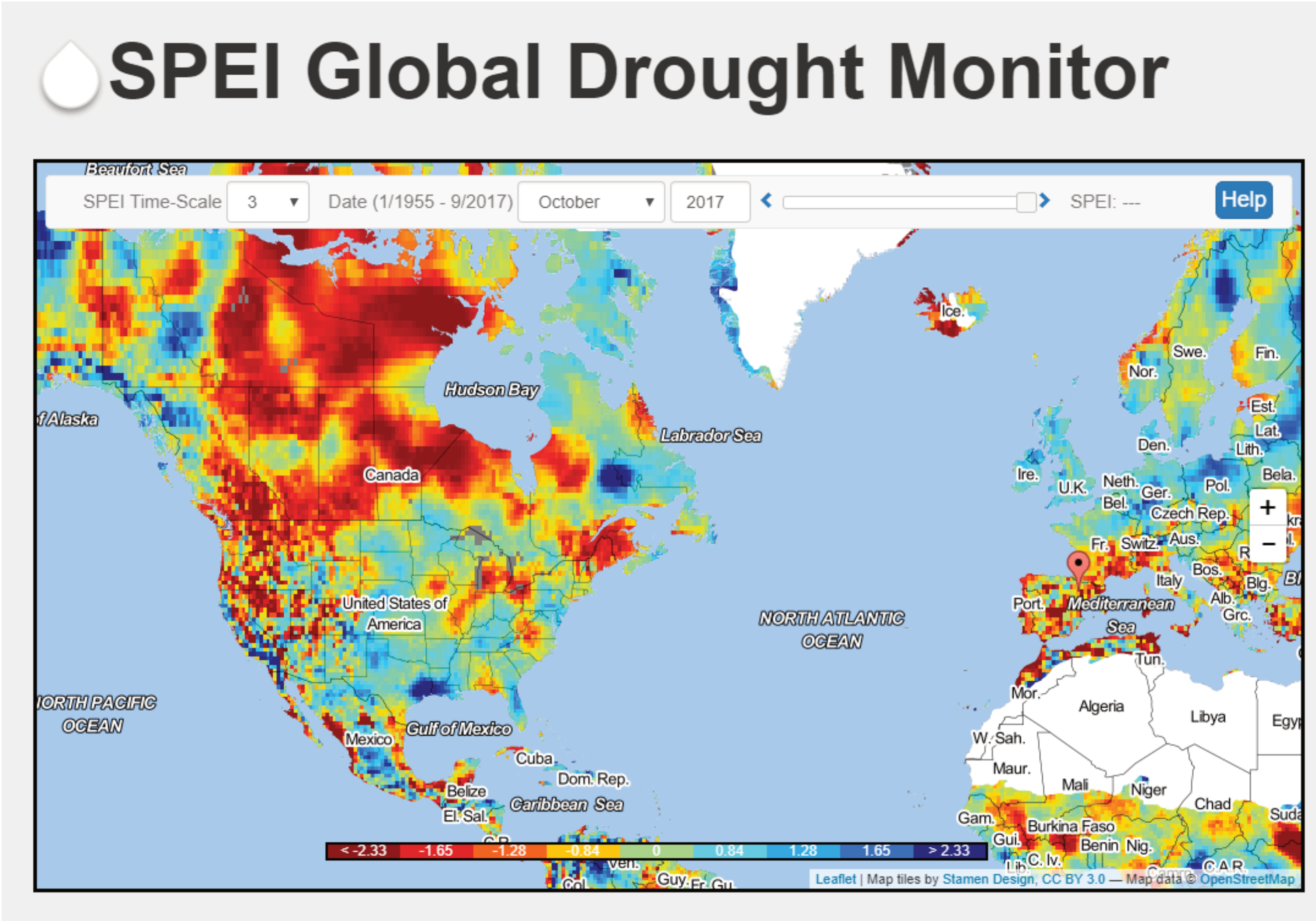
This map, from the USDA, shows the areas in the U.S where corn is grown and areas in which there are currently droughts occurring.

https://www.usda.gov/oce/weather/Drought/AgInDrought.pdf



GLOBAL: Global Drought Monitor

This interactive global drought monitor offers information in real-time. http://spei.csic.es/map/maps.html#months=1#month=8#year=2017



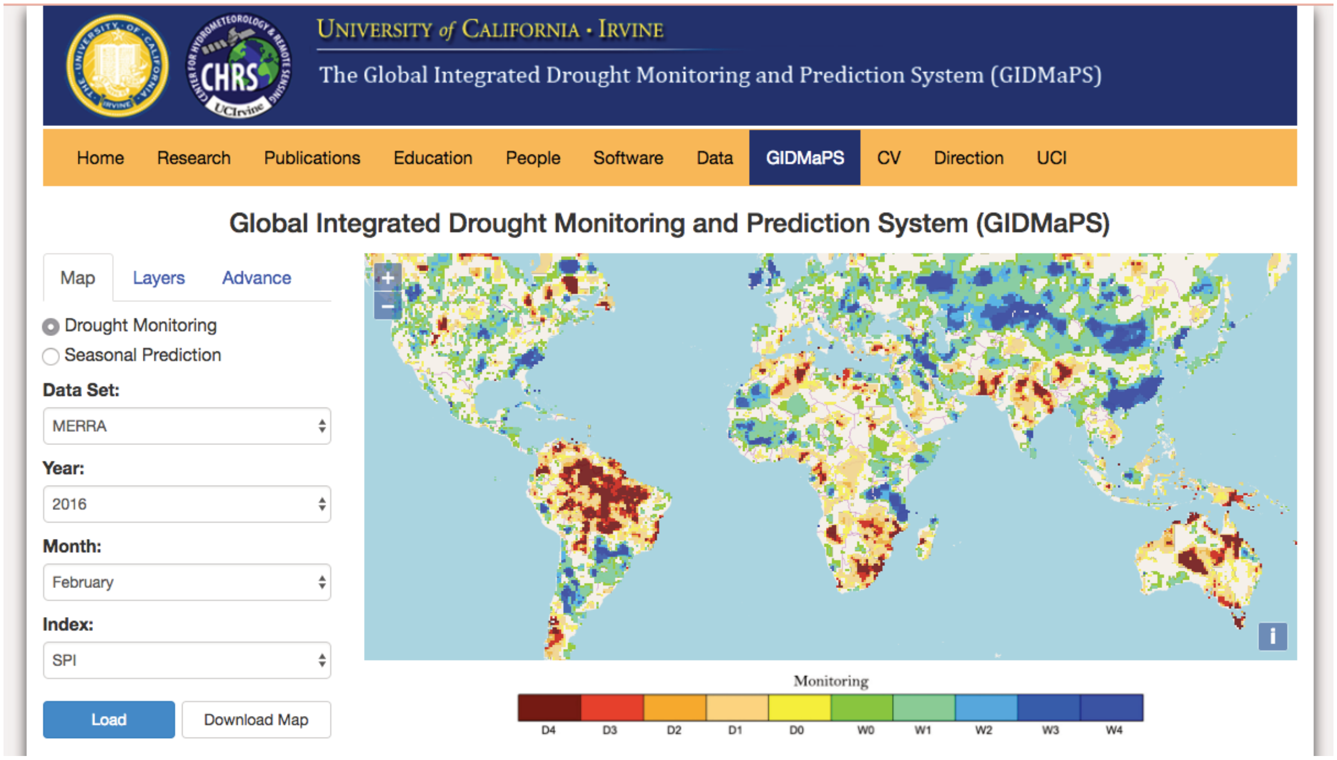
Italy Drought: Rome Forced to Cut Water Pressure at Night

This article from the BBC focuses on the drought affecting Italy in the summer of 2017. It explains some of the measures Roman authorities were forced to take to maintain the city's water supply and highlights that people around the globe are experiencing and having to deal with droughts.

http://www.bbc.com/news/world-europe-41081066

Global Integrated Droughts: The Global Integrated Drought Monitoring and Prediction System (GIDMaPS) is a drought monitoring and prediction system that provides near real-time drought information based on multiple drought indicators and input data sets.

http://drought.eng.uci.edu/



Experts:

Solutions:

Tom Hader, Gaby Mendoza, Alex Martinez, Sal Lopez

Tier 2, Part B: No more "snowy" holidays?

Tier 2: Part B: No more "snowy" holidays?

Objective:

Students investigate local climate issues, using real-world data.

Overview:

The goal of Tier 2 is to have students investigate local climate issues, using real-world data. Students will begin with a guided example, with a predetermined question, where they will investigate forcing (what is happening), then, what is the cause, the impact and finally, what can be done/should anything be done? A guided template is below, including resources, to help students with the first iteration. At the conclusion of this guided inquiry investigation, students will branch off into an open investigation. Students will be given a range of investigations, including open to their interest area, to explore and learn about. They will work in groups but be broken into jigsaw groups to make a consensus statement, supported by the data, with an overall climate statement.

Big questions:

- Has snowfall changed in Iowa, nationally and globally over the past 10 years resulting in less snow during the Holiday season?

Standards addressed:

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.
MS-ESS2-5	Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.
MS-ESS2-6	Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.
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.
MS-ESS3-5	Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

Tier in depth:

Background Knowledge: How many of us have happy memories of beautiful white fluffy snow covering the landscape on Christmas? It seems that the idyllic image of Christmas is incomplete without snow. However, each year it seems snow falls later and later and the chances of the perfect Christmas get smaller and smaller. So what's going on? By looking at the snowfall data from several years in the past we can see exactly how much the winters in our country are changing. What could be causing this change?

Every day we are seeing the effects of global warming in our own backyard. Climate change has a diverse array of effects that can reach anywhere from the mountain tops, to here in Iowa. It is important to follow the changes in the world to predict future trends and prepare for a changing environment.

Many people know that water freezes at 32 degrees Fahrenheit. Once the temperature outside reaches that threshold we know to be on the lookout for snow. So what does global warming have to do with snow? When sunlight comes in and warms the surface of the Earth, some rays bounce back into space. Before they can reach outer space however, they must pass through the atmosphere which is composed of many different gases in various concentrations. Some of the gases prevent the sun's rays from reaching space, and instead reflect them back down to the planet. This means Earth is warmed by rays directly from the sun, and ones that have been reflected back from the atmosphere. That's a lot of rays! This has the effect of gradually warming the surface of the planet, making days much warmer than they have been in past years. If this is true, there would be fewer days below 32 degrees Fahrenheit which means fewer days with snow. Do you think we are in danger of no more snowy holidays?

Probing Question: Has snowfall changed in Iowa, nationally and globally over the past 10 years resulting in less snow during the Holiday season? Collect data to determine your answer to this question, using real-world data.

Investigation: One option is to look at the total amount of snowfall in December for any given city in Iowa.

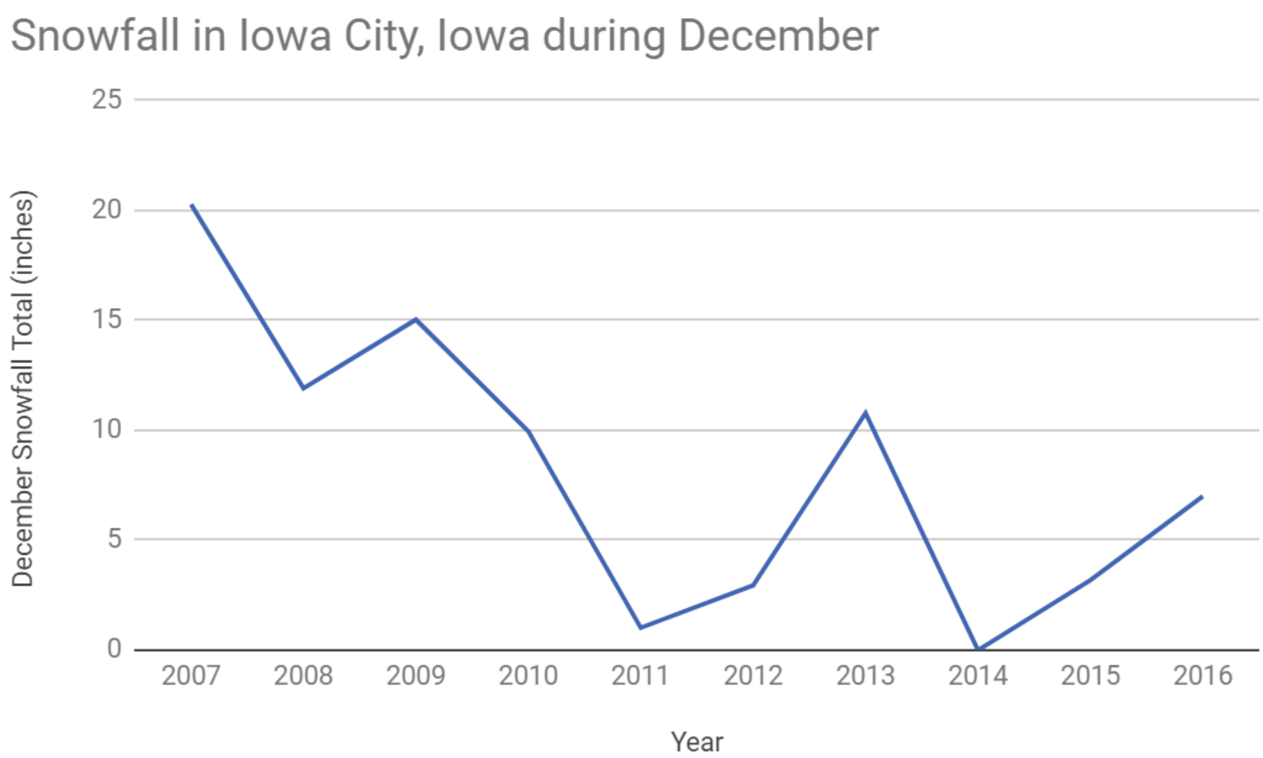
Begin investigation:

- Go to https://usclimatedata.com

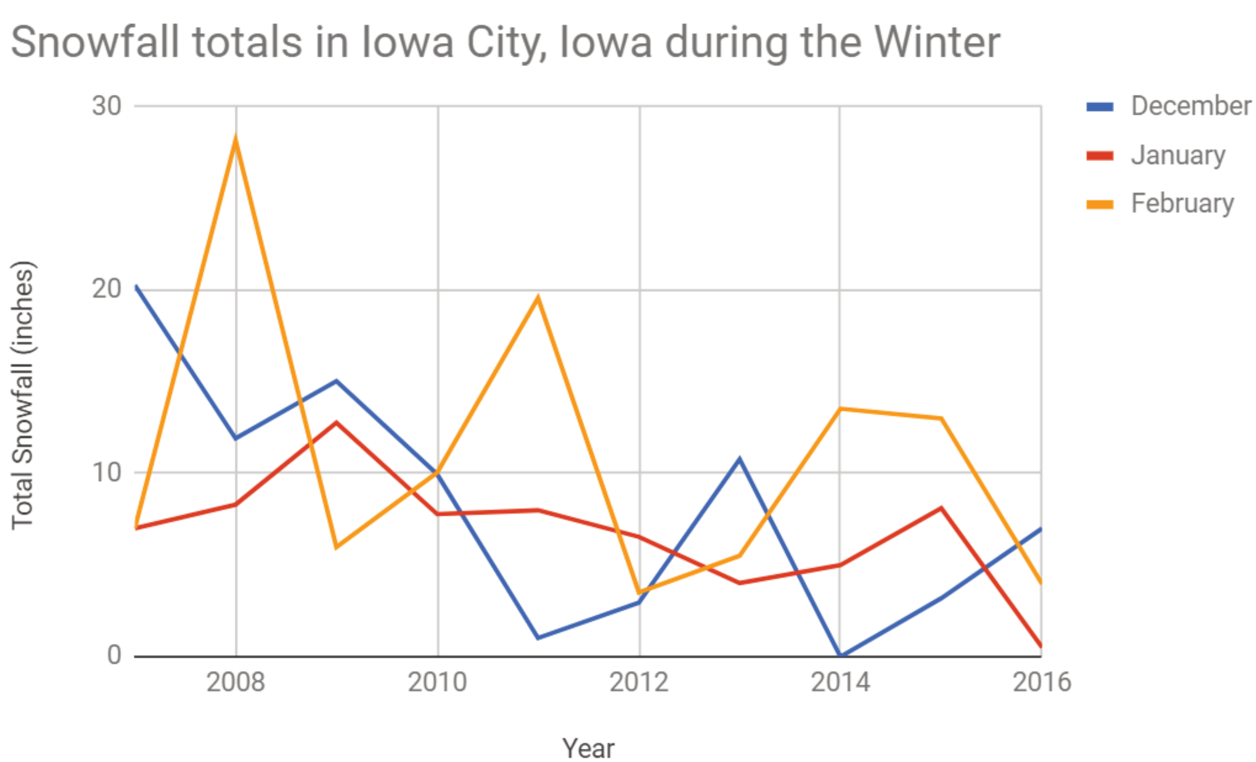
1. Enter any city in Iowa in the search box at the top of the page.
2. Click on the History tab to look at data over the years.
3. Using the drop down menus, pick a year and the month of December and record that "Total Snowfall" amount found on the left side of the page.
4. Repeat these steps in order to collect the total snowfall amounts in December for your city for the past 10 years.
5. Once you have your data, create a depicting the total amounts of snowfall over the past ten years.

Example: Snowfall totals in December for Iowa City, Iowa.

Year	December Totals in inches
2007	20.27
2008	11.91
2009	15.03
2010	9.95
2011	1.02
2012	2.95
2013	10.78
2014	0
2015	3.19
2016	7

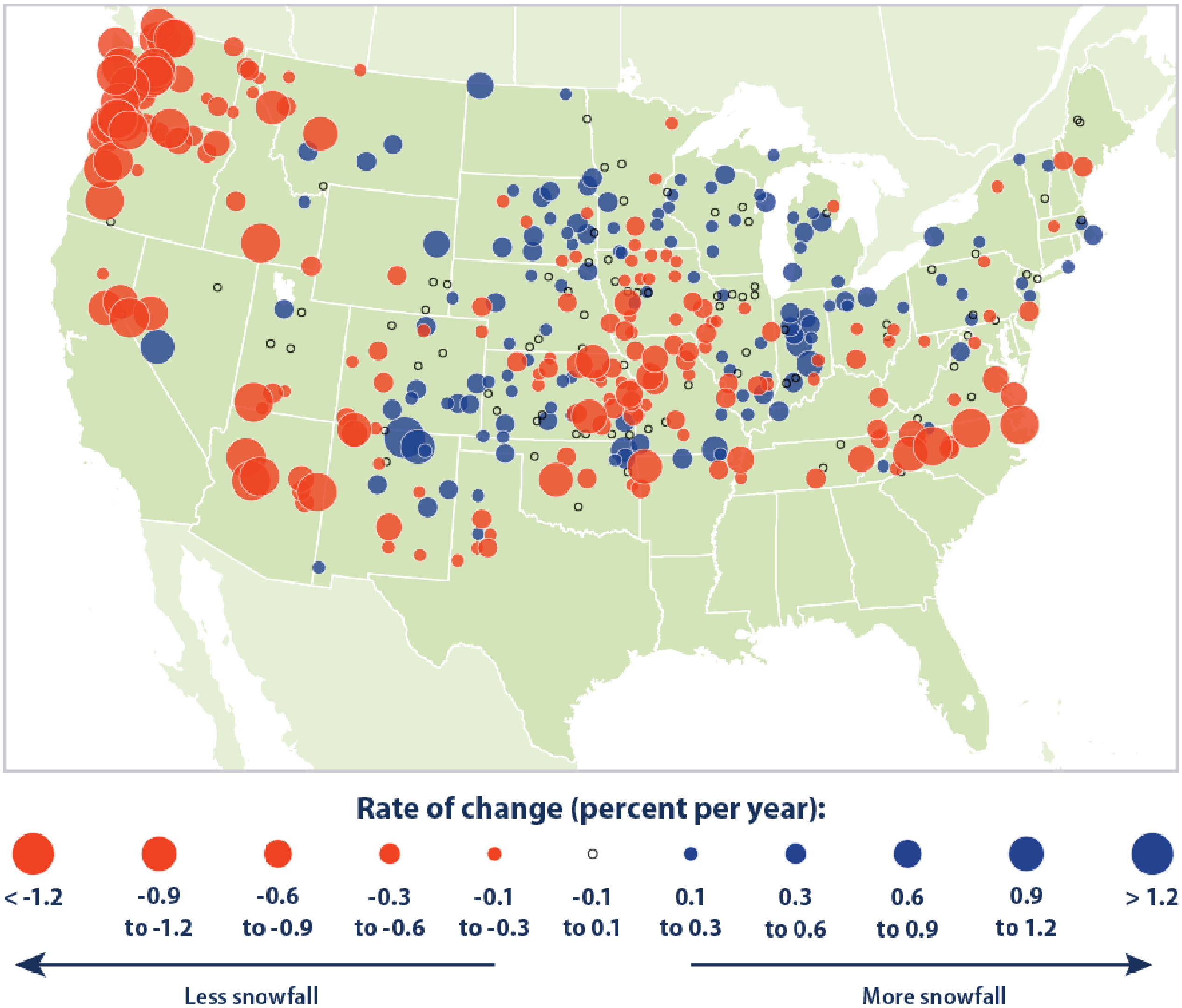


More options: Students can also compare data for the months of December, January, and February.



National/Global Viewpoint:

Introduce students to changes in snowfall across the nation, using this site: https://www.epa.gov/climate-indicators/climate-change-indicators-snowfall

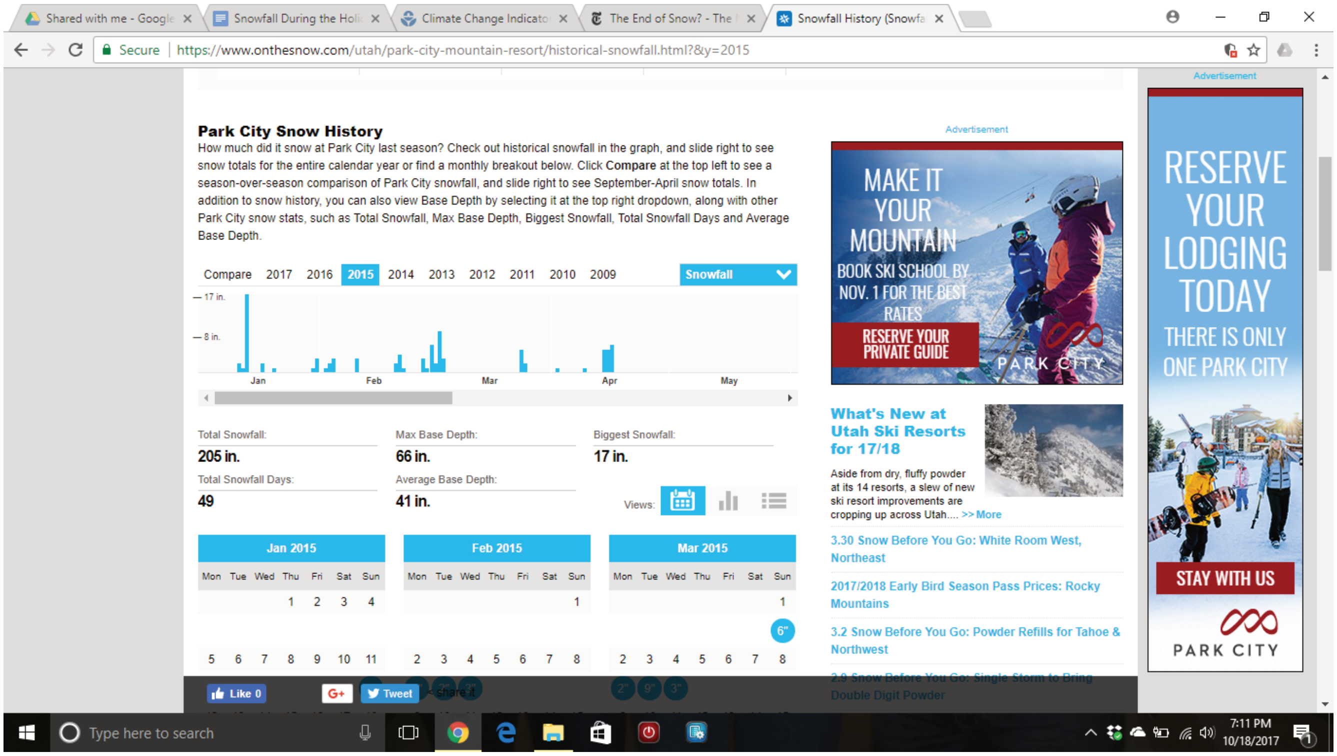


Students will then find their own data to test how snowfall has changed across the nation. Have students visit this website: http://www.onthesnow.com/.

Students select two specific ski resorts anywhere in the U.S.

Students click on the 'Historical Snowfall' tab. In this tab, students can view snowfall totals over the past 9 years.

Students create a graph for each selected location with snowfall totals over the past 9 years.



To introduce this concept globally, have students read this article about less snow fall in the Alps and the ski slopes in this region: http://www.telegraph.co.uk/travel/ski/news/climate-change-research-predicts-70-per-cent-less-snow-alps/

Last, have students read this article discussing decreasing amounts snowfall in regards to skiing over the past decades in response to climate change: https://www.nytimes.com/2014/02/08/opinion/sunday/the-end-of-snow.html

Students can compare/contrast the ideas in the article to their individual findings from part 2.

Article:

Minnesota. Maine. Upstate New York. The Allegheny Mountains of Pennsylvania and West Virginia. Practically anywhere in Idaho. And of course, the Rockies or the Sierra Nevada Mountains. These are the parts of the Lower 48* where weather history suggests you want to be if you're looking for the best chance of a white Christmas.

The map at right shows the historic probability of there being at least 1 inch of snow on the ground in the Lower 48 states on December 25 based on the latest (1981-2010) U.S. Climate Normals from NOAA's National Centers for Environmental Information (NCEI). The background map shows interpolated values for all locations. (Interpolating means estimating unknown values using known values and physical relationships, such as the way temperature is known to change with altitude.) You can also click and zoom in to specific stations used for the interpolation.

Darkest gray shows places where the probability is less than 10%. (Sorry West Coast, Gulf Coast, Deep South!) White shows probabilities greater than 90 percent.

The 1981–2010 Climate Normals are the latest three-decade averages of several climatological measurements. This collection contains daily and monthly normals of temperature, precipitation, snowfall, heating and cooling degree days, frost/freeze dates, and growing-degree days calculated from observations at approximately 9,800 stations operated by NOAA's National Weather Service.

While the map shows the historical probability that a snow depth of at least one inch will be observed on December 25, the actual conditions in any year may vary widely from these because the weather patterns present will determine the snow on the ground or snowfall on Christmas day. These probabilities are useful as a guide only to show where snow on the ground is more likely. For prediction of your actual weather on Christmas Day, check out your local forecast at Weather.gov.

If you would like to keep track of the snowfall across the United States on a daily basis, see the National Operational Hydrologic Remote Sensing Center's National Snow Analyses. For a more detailed assessment of the probability of a white Christmas as well as documentation of the methodology used to calculate the map's underlying climatological statistics, see the scientific paper, White Christmas? An Application of NOAA's 1981-2010 Daily Normals, by NCEI scientists and published in the Bulletin of the American Meteorological Society. You can also download a spreadsheet to see the full list of stations and their historic probabilities.

*The station network in Alaska is too sparse to allow scientists to interpolate with confidence.

This post was adapted from an article first published by the National Climatic Data Center. It was first published on December 11, 2013, and is reviewed each year and updated as needed.

Experts:

Solutions:

Tier 2, Part B: Soil and Soil Erosion

Tier 2, Part B: Soil and Soil Erosion

Objective:

Students investigate local climate issues, using real-world data.

Overview:

The goal of Tier 2 is to have students investigate local climate issues, using real-world data. Students will begin with a guided example, with a predetermined question, where they will investigate forcing (what is happening), then, what is the cause, the impact and finally, what can be done/should anything be done? A guided template is below, including resources, to help students with the first iteration. At the conclusion of this guided inquiry investigation, students will branch off into an open investigation. Students will be given a range of investigations, including open to their interest area, to explore and learn about. They will work in groups but be broken into jigsaw groups to make a consensus statement, supported by the data, with an overall climate statement.

Big questions:

- What is Soil erosion?
- What are nutrients plants need?

Standards addressed:

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.
MS-ESS2-5	Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.
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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.
MS-ESS3-5	Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

Tier in depth:

What is Soil erosion? What are nutrients plants need?

Background Knowledge: Soil erosion is a natural process that affects all landforms. It involves soil being worn down and moved, usually by way of water, wind, or in recent history, humans. Erosion is a big concern for humans, because we are highly dependent on agriculture for food. The amount of erosion dictates how much topsoil is present, which can then determine what crops can be planted on a given field, and the potential yields. There are a variety of different types of erosion within wind and water, and humans can impact the degree. A big part of the soil is the chemical nutrients that plants use within it. The most crucial nutrients plants depend on are nitrogen, phosphorus, and potassium.

http://www.omafra.gov.on.ca/english/engineer/facts/12-053.htm

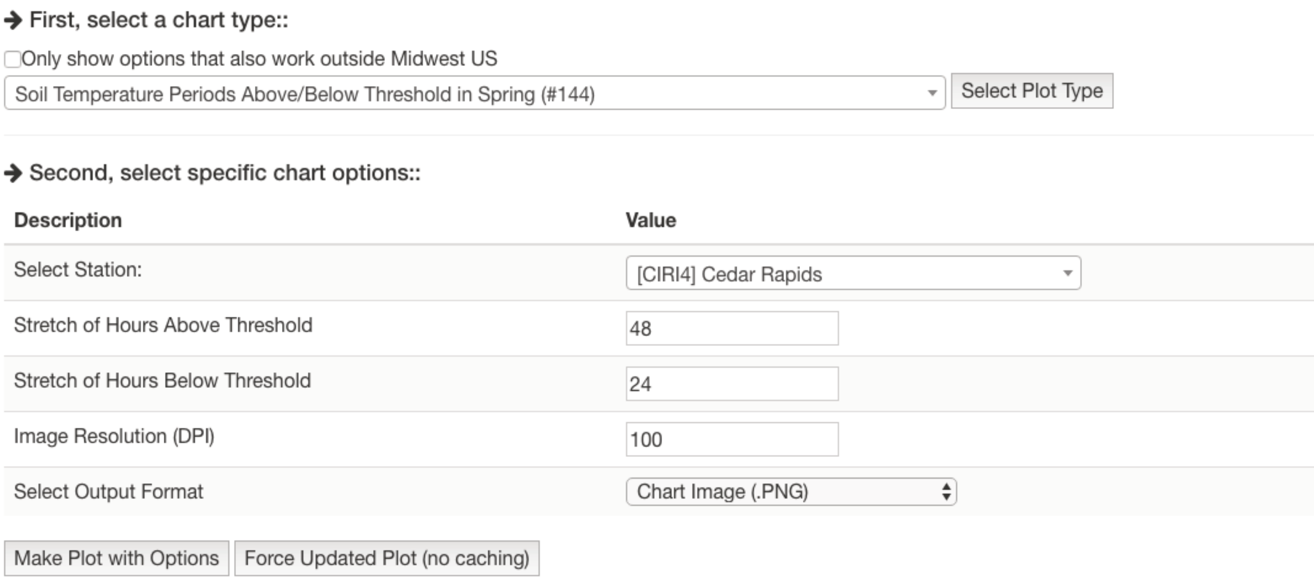
https://ag.umass.edu/fruit/ne-small-fruit-management-guide/general-information/plant-nutrients-major-minor

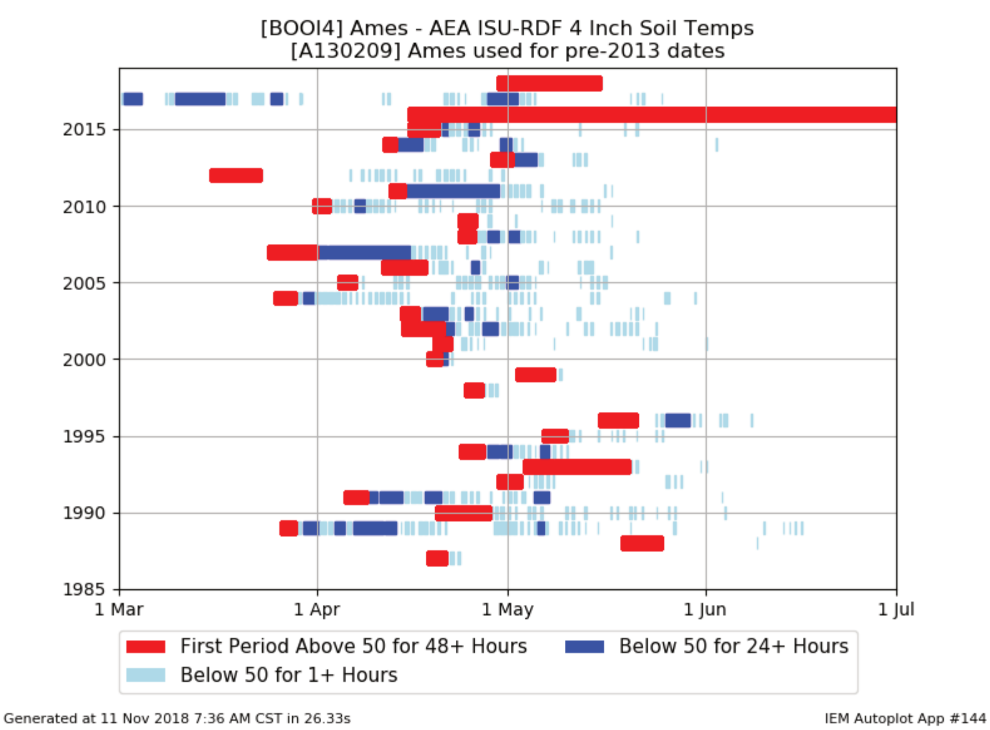
Initial Engagement Activity:

Open https://mesonet.agron.iastate.edu/plotting/auto/?q=144

1. Make plot #144 "Soil Temperature Above/Below Threshold in Spring"

2. Select “Select station” and pick a place local to you
3. Leave other settings unchanged
4. Click “Generate Plot with Options”





The data plot above shows the temperature of soil at a depth of 4 inches below the surface. Data is collected every hour via the Iowa State Soil Moisture Network. Going from left to right, and having the year on the vertical axis, is how this graph should have be read. The first occurrence of color laterally, in each row, is the first time the soil temperature at this location was above or at 50 degrees for a number of hours. Moving farther in the lateral direction, data is plotted that show soil temperature fluctuations. A red bar shows soil temperatures of 50 degrees F for the first period of 48 hours. The blue bar shows temperature of soil below 50 degrees F for a time period of 24 hours or more. The Light Teal color indicates that the temperature was below 50 degrees F for one plus hours.

Prompting Questions: What claims can you make using the evidence from these graphs and other sources you can find?

Alternative Initial Engagement Activity:

Landscape Powerpoint from Integrate (SERC): https://serc.carleton.edu/details/files/54652.html

Natural and Agricultural Erosion Rates: https://serc.carleton.edu/integrate/teaching_materials/sustain_agriculture/activity3.html

Iowa State PEWI: https://www.nrem.iastate.edu/pewi/

Basic PEWI Exercise: https://www.nrem.iastate.edu/pewi/files/lesson_plan/files/Basic%20PEWI%20Exercises_0.pdf

Climate Change and Soil Loss: https://serc.carleton.edu/integrate/teaching_materials/sustain_agriculture/activity5.html

List of Resources:

Iowa lost 15 million tons of soil to erosion:

Iowa's soil is leaving the state and it is causing major financial problems for the farmers and business that rely on agriculture for their living. An Environmental working group estimates that 88,000 farmers will be affected by a 1 billion dollars in lost crop productions. A number of conservation practices are being implemented but still Iowa's soil and nutrients are ending up in the Gulf of Mexico resulting in problems for the ecosystem.

http://www.desmoinesregister.com/story/money/agriculture/2014/08/05/environmental-working-group-says-iowa-lost-million-tons-soil-erosion/13609603/

Iowa NRCS Rainfall Simulator video (contact your local NRCS)

2011 Mississippi River Flood:

The 2011 Mississippi River flood was among the largest and most damaging to occur along this waterway in the past century. This video follows one group of scientists as they investigate sediment deposition in the wetlands of the Mississippi River delta plain. The results of this investigation will lead to a better understanding of how extreme flood events influence sedimentation in wetlands, and also will inform efforts to restore the deteriorating marshes of the Mississippi River Delta.

Chasing the Mud USGS video

Gulf hypoxia not as simple as it seems:

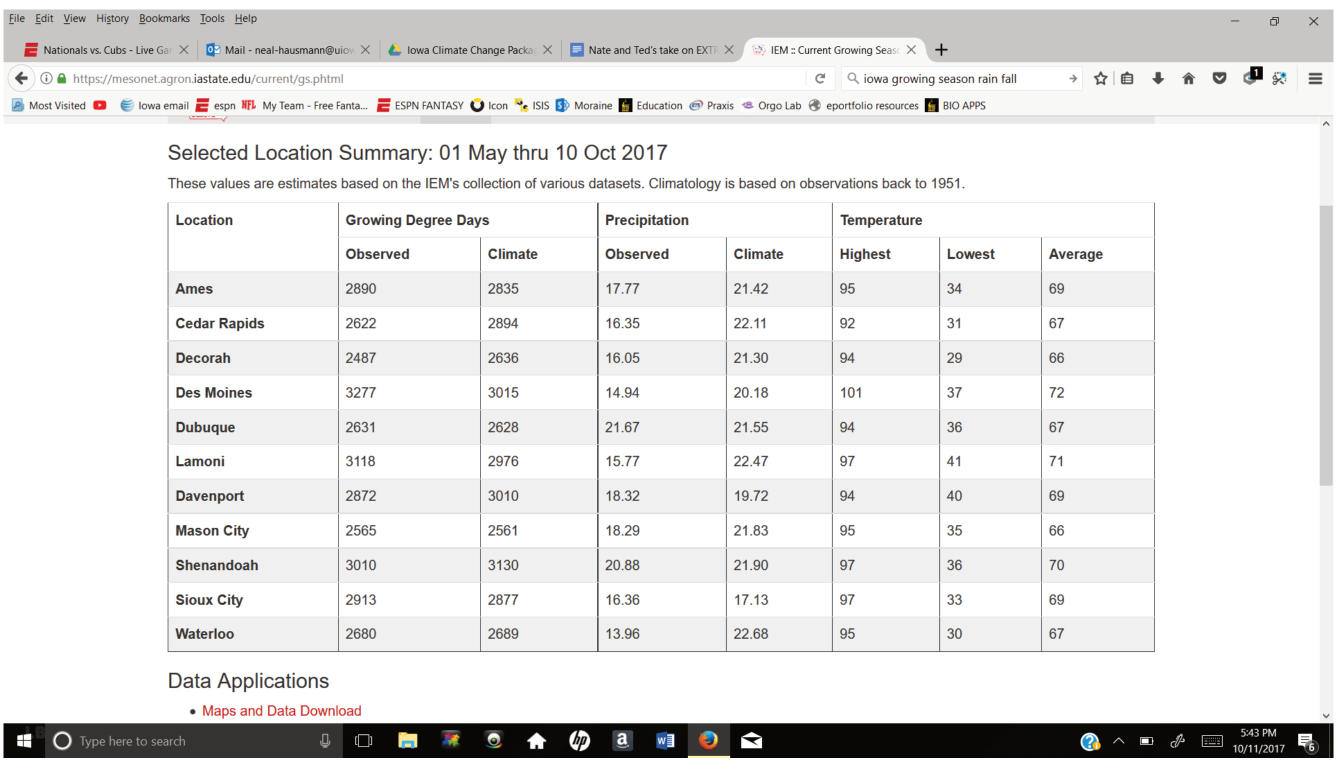
This article talks about the effects of nutrient runoff in Iowa has on bodies of water distant from the state. Oceanic dead zones are produced by the high concentration of nitrogen coming from Iowa and other states use of fertilizers and pesticides.

http://www.desmoinesregister.com/story/opinion/columnists/iowa-view/2017/08/23/gulf-hypoxia-not-simple-seems/590615001/

Article about soil loss and conservation in IA:

http://www.desmoinesregister.com/story/money/agriculture/2015/11/27/what-prescribe-iowas-eroding-topsoil/76447188/

Picture below shows data of growing degree days, precipitation amounts, and temperature data in the state of Iowa. May 1st through October 10th.



Selected Location Summary: 01 May thru 10 Oct 2017

These values are estimates based on the IEM's collection of various datasets. Climatology is based on observations back to 1951.

Location	Growing Degree Days		Precipitation		Temperature		
	Observed	Climate	Observed	Climate	Highest	Lowest	Average
Ames	2890	2835	17.77	21.42	95	34	69
Cedar Rapids	2622	2894	16.35	22.11	92	31	67
Decorah	2487	2636	16.05	21.30	94	29	66
Des Moines	3277	3015	14.94	20.18	101	37	72
Dubuque	2631	2628	21.67	21.55	94	36	67
Lamoni	3118	2976	15.77	22.47	97	41	71
Davenport	2872	3010	18.32	19.72	94	40	69
Mason City	2565	2561	18.29	21.83	95	35	66
Shenandoah	3010	3130	20.88	21.90	97	36	70
Sioux City	2913	2877	16.36	17.13	97	33	69
Waterloo	2680	2689	13.96	22.68	95	30	67

Data Applications

- Maps and Data Download

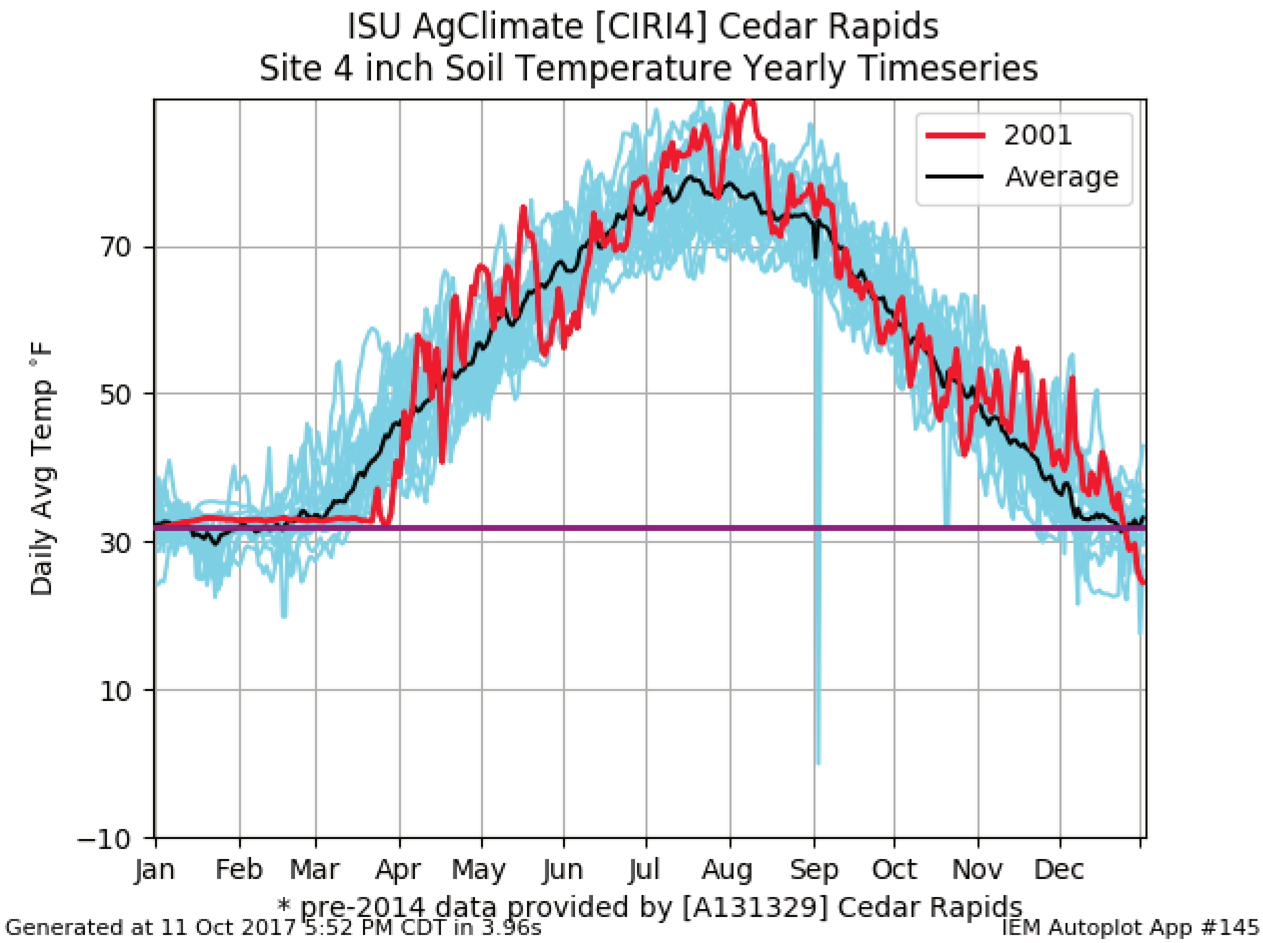
https://mesonet.agron.iastate.edu/current/gs.phtml

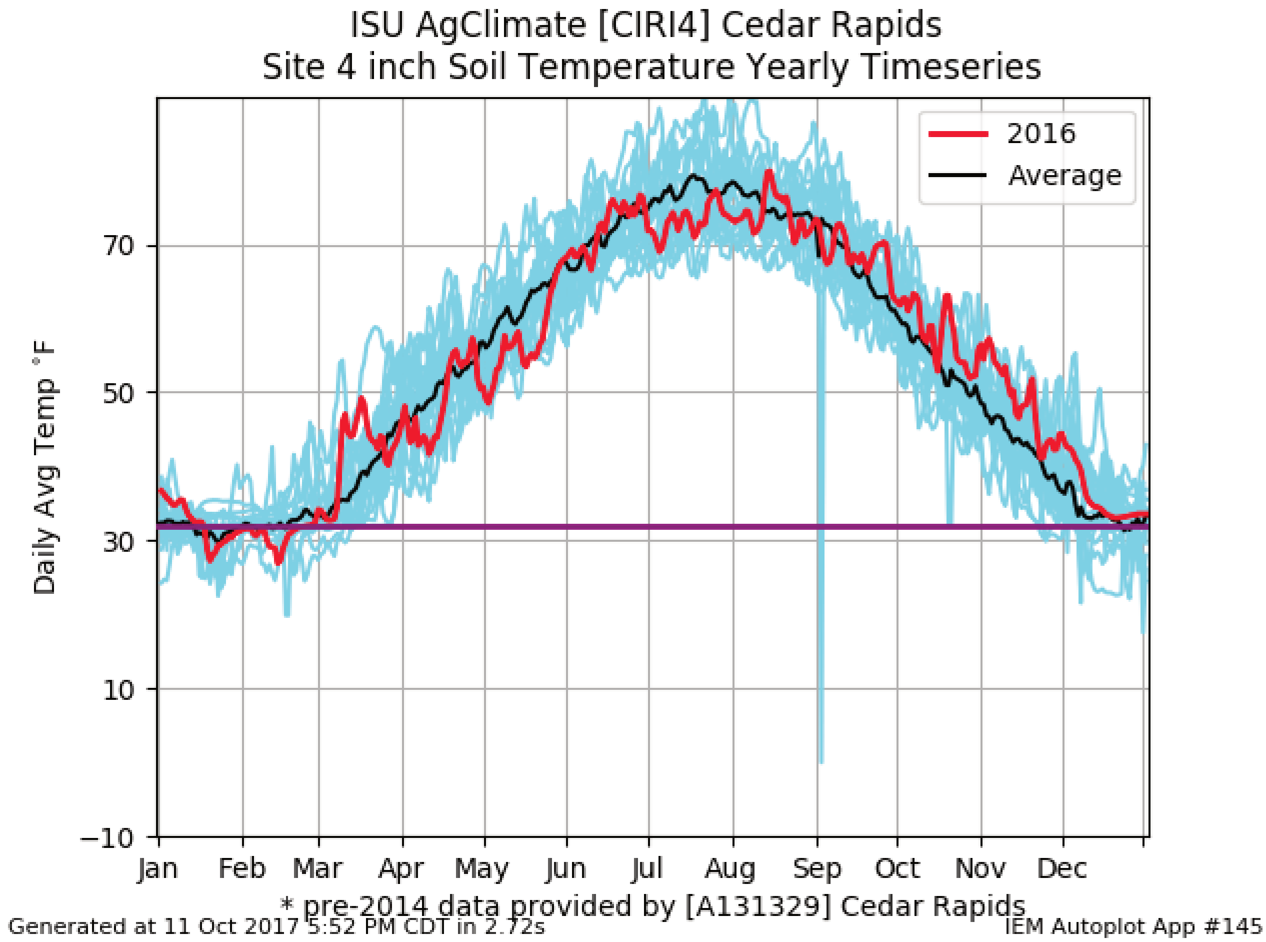
Expected Climate Change Impacts on Soil Erosion Rates: A Review

Compilation and review of studies of climate change on soil erosion and biome:

https://www.researchgate.net/profile/Mark_Nearing/publication/43258785_Expected_Climate_Change_Impacts_on_Soil_Erosion_Rates_A_Review/links/02e7e5304f2526f1be000000/Expected-Climate-Change-Impacts-on-Soil-Erosion-Rates-A-Review.pdf?origin=publication_detail

Soil Temperature in Cedar Rapids, Iowa:


ISU AgClimate [CIRI4] Cedar Rapids
Site 4 inch Soil Temperature Yearly Timeseries
2001
Average
Daily Avg Temp °F
70
50
30
10
−10
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
* pre-2014 data provided by [A131329] Cedar Rapids
Generated at 11 Oct 2017 5:52 PM CDT in 3.96s
IEM Autoplot App #145



Cedar Rapids, Iowa soil temperature taken from the year 2001 and 2016. Data and Graphs were taken and generated using the Iowa State University Mesonet.

SERC Integrate Module on Soil: https://serc.carleton.edu/integrate/teaching_materials/sustain_agriculture/index.html

"This module uses real data to address soil sustainability in the context of land management and climate change."

https://tinyurl.com/Oct28Soil

Experts:

Solutions:

Tier 2, Part B: 500 Year Floods

Tier 2, Part B: 500 Year Floods

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Overview:

The goal of Tier 2 is to have students investigate local climate issues, using real-world data. Students will begin with a guided example, with a predetermined question, where they will investigate forcing (what is happening), then, what is the cause, the impact and finally, what can be done/should anything be done? A guided template is below, including resources, to help students with the first iteration. At the conclusion of this guided inquiry investigation, students will branch off into an open investigation. Students will be given a range of investigations, including open to their interest area, to explore and learn about. They will work in groups but be broken into jigsaw groups to make a consensus statement, supported by the data, with an overall climate statement.

Big questions:

- What is a flood?
- What is the difference between a '100 year flood' and a '500 year flood'?
- What causes flooding? What impacts does flooding have on humans? Alternatively, what impact do humans have on flooding?
- Do floods occur more frequently now than they did 100 years ago?

Standards addressed:

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.
MS-ESS2-5	Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.
MS-ESS2-6	Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.
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.
MS-ESS3-3	Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
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.
MS-ESS3-5	Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

Tiers in depth:

Background info on 500 Year Floods:

Q:If a flood has a 100% chance of happening once every 500 years, what is the probability that it will happen in any given year?

A: 0.2%

Q:If a flood has a 100% chance of happening once every 100 years, what is the probability that it will happen in any given year?

A: 1%

Probing Question:

- Based on the map below, what do you think is the probability of another set of 500 year floods in a period of 15 years? Can the population do anything to combat the high occurrence of 500 year floods in their area?

Initial Engagement Activity:

- Have students brainstorm natural disasters and see if "floods" are brought up.

    - Explain how floods are natural disasters that are brought on by rain. The conditions for floods must be pretty perfect to be disastrous and damaging.

- Use map of floodplains in iowa to explore 100 and 500 year floodplain maps throughout the state
    - Maps of Floodplains in Iowa: http://ifis.iowafloodcenter.org/ifis/maps/
    - How to use:
        - Pick a county in Iowa that experiences flooding. (Linn and Johnson Counties are good choices)
        - Have students zoom in until they can see the flood zones mapped. They should observe see what infrastructure may be affected. They can search specific addresses of buildings that have been affected by floods in the past (the IMU on the university of Iowa campus for example.)
        - Students can also discuss why the flood zones are shaped like they are. What land features contribute to this shape? What about built features like dams?
- Discuss the implications, societal or environmental, of flooding
- What caused these floods to happen
    - They can look into the 1993 or 2008 flood
- Once they have established causes for flooding they can explore how one cause is changing the probability of floods. They can explore:
    - Increased precipitation
    - Streamflows

Resources:

What's a flood?: This article talks about how floods are developed and how they can impact populations/areas that they affect.

http://www.nationalgeographic.com/environment/natural-disasters/floods/

Flood Occurrences Explained: This article explains that there are recurrence intervals of epic floods, how they work, and how they can impact populations.

https://water.usgs.gov/edu/100yearflood.html

Maps of Floodplains in Iowa:

http://ifis.iowafloodcenter.org/ifis/maps/

EPA information on Climate Change in Iowa: How climate change impacts heavy precipitation, flooding, tornadoes, and air pollution in the iowa area.

https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/climate-change-ia.pdf

History of Top 5 Iowa Floods: Overview including causes, description, and impacts of the most disastrous floods in the state of Iowa.

http://www.crh.noaa.gov/Image/dmx/hydro/HistoricalIowaFloods_Top5.pdf

1993 Flood -What Happened?: Outlines the catalyst and impact of the great flood of 1993.

https://www.weather.gov/dvn/071993_greatflood

2008 Flood – What Happened?: Pictures, graphs,and maps depicting the unprecedented and historic midwest floods of 2008.

https://pubs.usgs.gov/pp/1775/pdf/pp1775.pdf

How Cedar Rapids population combatted flooding: Compares the flood of 2016 to the flood of 2008.

http://www.cnn.com/2016/09/27/us/iowa-wisconsin-flooding/index.html

Des Moines Register: Pictures of 2008 flood in Waterloo and Cedar Rapids

http://www.desmoinesregister.com/picture-gallery/news/2016/09/24/14-photos-remembering-the-2008-floods-in-waterloo-cedar-rapids/91051318/

Cedar Rapids Gazette: Talks about how the close proximity of a nuclear power plant could prevent flood death.

http://www.thegazette.com/2012/09/05/report-says-nearness-of-nuke-plant-helped-cedar-rapids-during-flood

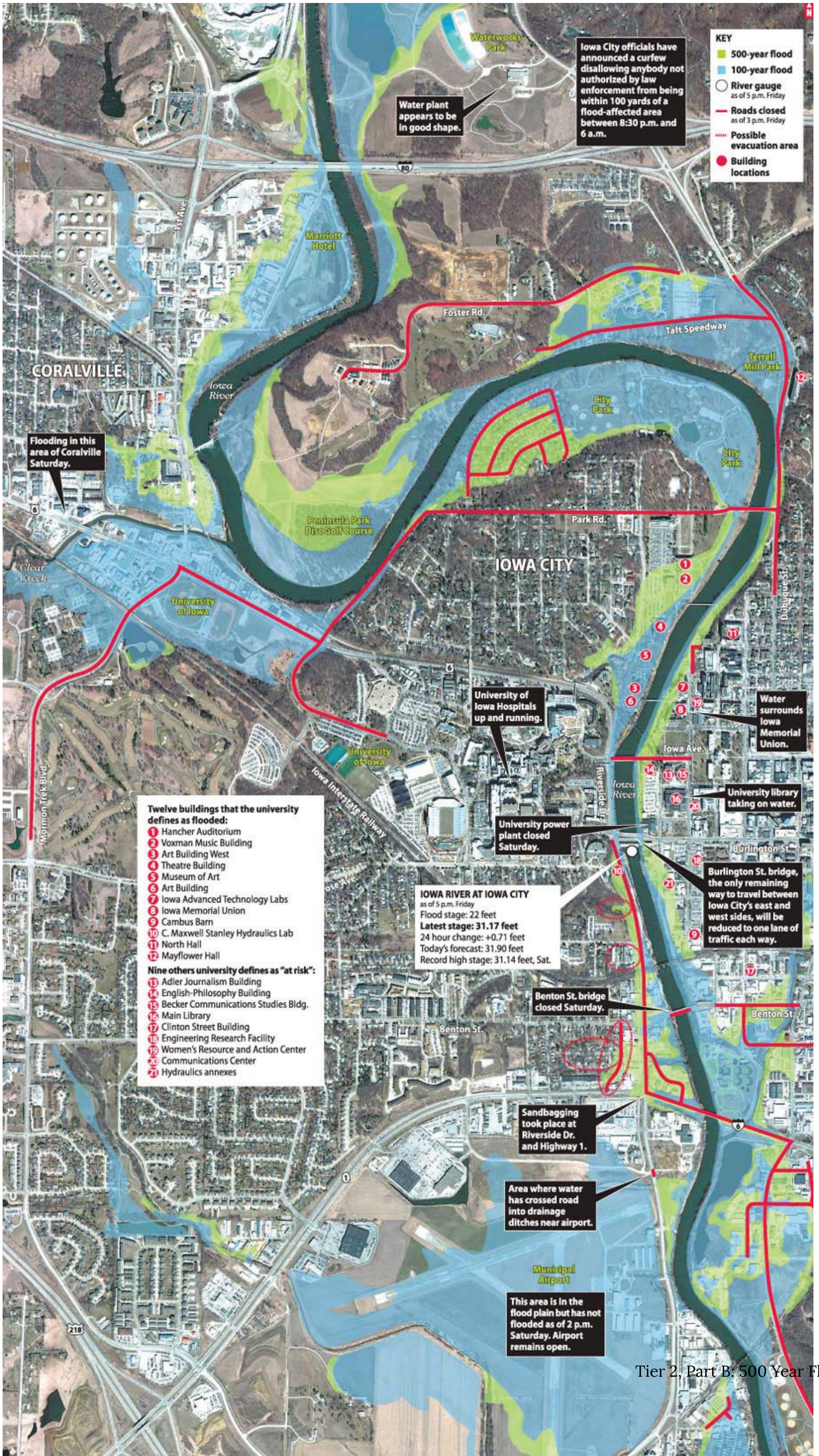
Delhi Dam break: Talks about the rainfall event that flooded the Maquoketa River in Delaware County to the point that the Delhi Dam failed.

http://www.cnn.com/2010/US/07/24/iowa.dam.breach/index.html

https://www.cbsnews.com/news/iowas-lake-delhi-dam-bursts-due-to-flooding/

2008 Flood Pictures

http://stories-etc.com/Iowa_flood_08.htm


KEY
500-year flood
100-year flood
River gauge as of 5 p.m. Friday
Roads closed as of 3 p.m. Friday
Possible evacuation area
Building locations
Iowa City officials have announced a curfew disallowing anybody not authorized by law enforcement from being within 100 yards of a flood-affected area between 8:30 p.m. and 6 a.m.
Water plant appears to be in good shape.
Waterworks Park
Marriott Hotel
Foster Rd.
Taft Speedway
Terrell Mill Park
CORALVILLE
Iowa River
City Park
Flooding in this area of Coralville Saturday.
Peninsula Park Disc Golf Course
Park Rd.
IOWA CITY
Clear Creek
University of Iowa
Dubuque St.
Water surrounds Iowa Memorial Union.
University of Iowa Hospitals up and running.
Iowa Ave.
Riverside Dr.
University library taking on water.
Iowa Interstate Railway
Mormon Trek Blvd.
Twelve buildings that the university defines as flooded:
1 Hancher Auditorium
2 Voxman Music Building
3 Art Building West
4 Theatre Building
5 Museum of Art
6 Art Building
7 Iowa Advanced Technology Labs
8 Iowa Memorial Union
9 Cambus Barn
10 C. Maxwell Stanley Hydraulics Lab
11 North Hall
12 Mayflower Hall
Nine others university defines as "at risk":
13 Adler Journalism Building
14 English-Philosophy Building
15 Becker Communications Studies Bldg.
16 Main Library
17 Clinton Street Building
18 Engineering Research Facility
19 Women's Resource and Action Center
20 Communications Center
21 Hydraulics annexes
University power plant closed Saturday.
Burlington St.
Burlington St. bridge, the only remaining way to travel between Iowa City's east and west sides, will be reduced to one lane of traffic each way.
IOWA RIVER AT IOWA CITY
as of 5 p.m. Friday
Flood stage: 22 feet
Latest stage: 31.17 feet
24 hour change: +0.71 feet
Today's forecast: 31.90 feet
Record high stage: 31.14 feet, Sat.
Benton St. bridge closed Saturday.
Benton St.
Sandbagging took place at Riverside Dr. and Highway 1.
Area where water has crossed road into drainage ditches near airport.
Municipal Airport
This area is in the flood plain but has not flooded as of 2 p.m. Saturday. Airport remains open.

Mayflower – 1110 N. Dubuque St. Iowa City, Iowa 52245

http://www.thegazette.com/subject/news/government/iowa-flood-efforts-win-big-boost-20160121

http://www.thegazette.com/subject/news/government/plan-ahead-for-trips-to-kinnick-hancher-due-to-gateway-project-20160816

IMU – 125 N. Madison St. Iowa City, IA 52245

Aerial photos of the UI campus taken when the Iowa River was about 31 feet. Flood stage for the Iowa River at Iowa City is 22 feet. The previous record was set in 1993 at 28.5 feet.

https://now.uiowa.edu/2015/09/10-things-you-might-not-know-about-iowa-memorial-union

https://ostc.uiowa.edu/facilities/iowa-advanced-technology-laboratories

Located next to the Iowa Memorial Union the Iowa Advanced Technology Laboratories is relected in the Iowa River.

Experts:

Solutions:

Tier 2, Part B: Adapting Agriculture

Tier 2, Part B: Adapting Agriculture

Objective:

The goal of Tier 2 is to have students investigate local climate issues, using real-world data.

Overview:

The goal of Tier 2 is to have students investigate local climate issues, using real-world data. Students will begin with a guided example, with a predetermined question, where they will investigate what is happening, what are potential causes, what impacts are associated with those causes, and finally, how can/should we respond? A guided template is below, including resources, to help students with the first iteration. At the conclusion of this guided inquiry investigation, students will branch off into an open investigation. Students will be given a range of investigations to explore and learn about, including an open option if the student has an area of interest that is not included in the examples. They will work in jigsaw groups with the later goal of making a consensus statement, supported by the data, which will add to an overall climate statement.

Big questions:

- What conditions do plants need to grow?
- What determines the growing season for crops?
- Have growing conditions changed in Iowa over the past 100 years?

Standards addressed:

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.
MS-ESS2-5	Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.
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MS-ESS3-5	Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

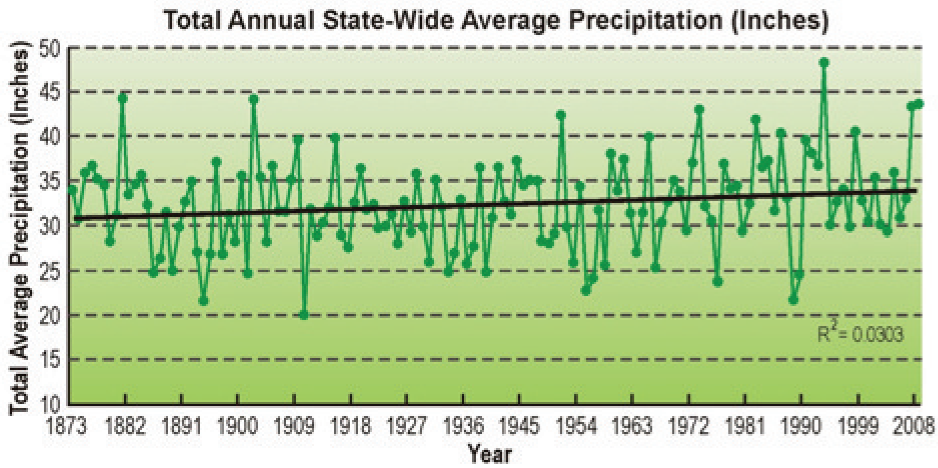
Tier in depth:

What conditions do plants need to grow? What determines the growing season for crops?

Background Knowledge: There are many factors that affect the rate at which plants grow. There are genetic factors within the plants themselves that set the stage for growth, and there are environmental factors that interact with the growing plant to either aid or harm the growth of the plant. Within these environmental factors, there are biotic and abiotic factors. The biotic factors are the living components of the environment that exist alongside the growing plant. The abiotic factors, those which we are interested in today, can be considered climate factors, and these include the nonliving parts of the environment. This includes things like soil, precipitation, humidity, sunlight, temperature, and carbon dioxide in the air. These qualities form an interplay that not only affects the growth rate of plants, but also affects the time of the year they should be planted or harvested. Iowa produces over 10 billion dollars worth of agricultural exports each year. As the climate shifts, there have been changes to the agricultural norms in regards to what weather conditions you can expect at certain times of the growing season, as well as a small increase in the length of the growing season itself. Understanding these changes is important to make any needed adjustments to maximize the agricultural land use in Iowa.

Probing Question: Have growing conditions changed in Iowa over the past 100 years? Collect information to determine your answer to this question, using real-world data.

There is a very slight increase in the total average precipitation for Iowa state for the past 100 years. Growing conditions have improved over the past 100 years, but it is mostly due to the longer growing season, not the larger amount of precipitation.



Investigation: One option is to look at the number of frost free days in Iowa. How does frost affect the growth of plants?

Answer: Very poorly in Iowa's case. Farmers and gardeners alike, who wish to maximize the growing season, have to wait for the frost of Winter to officially leave before planting in the spring. The soil has to be warm enough for the seeds to germinate and take root, but if you cut it too close to the beginning of the season, a final frost could kill the seeds and stop growth just as it starts. Another factor to look at, is extending the growing season through the end of fall, which allows for later planting of crops, longer growing periods, and multiple growing periods fit into a single season.

BEGIN INVESTIGATION

1. Go to https://mesonet.agron.iastate.edu/plotting/auto/
2. Make plot #10 in the "yearly" section.
3. Go to "select station" and alter it to somewhere "local" to you
4. Under the "which metric to plot" change it to "Last Spring/First Fall Temperature Below Threshold"
5. "Threshold" should be 32 (Signify freeze which impacts plant growth)
6. Select "Make Plot with Options"

- Scroll down to see graph of the data

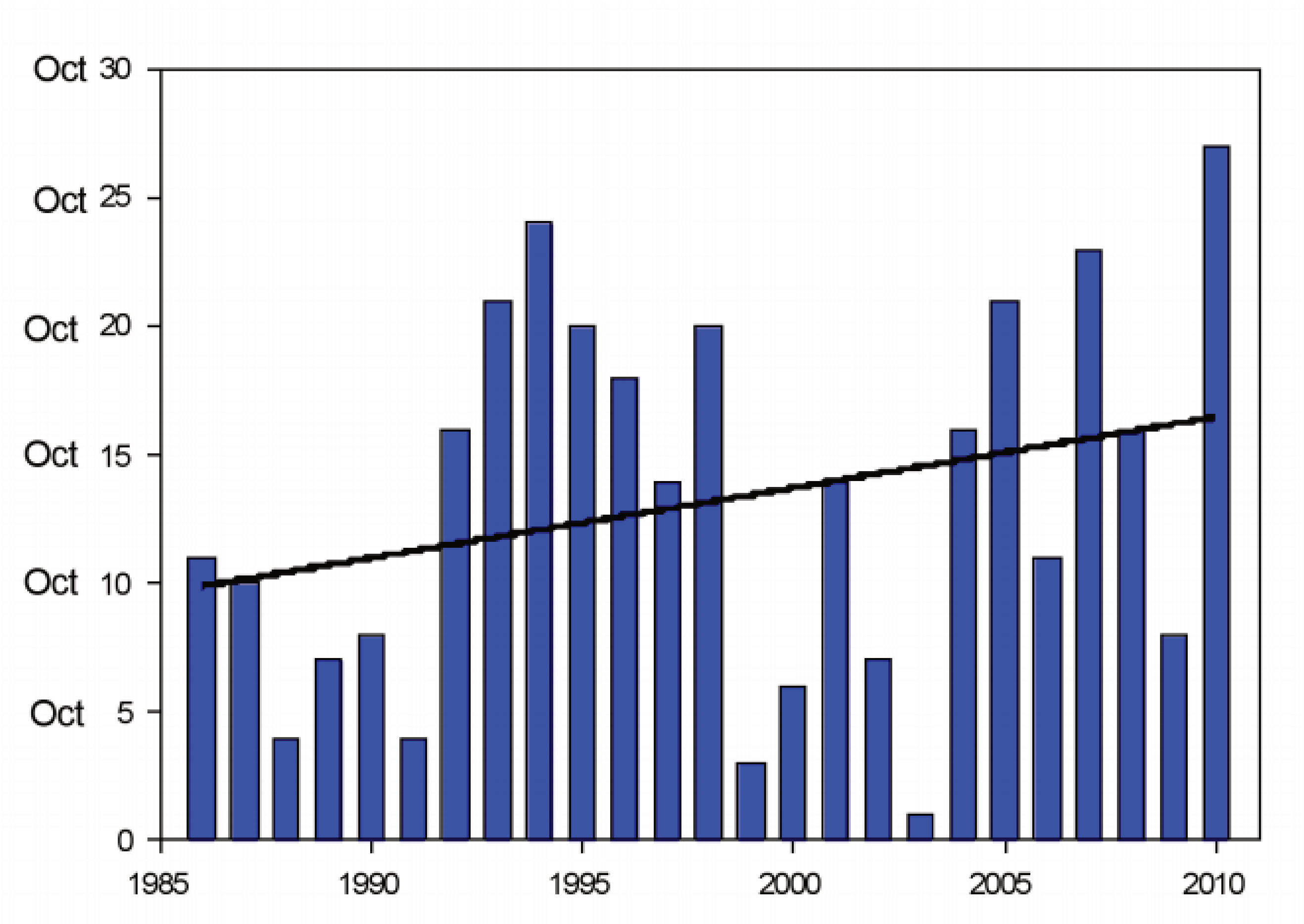
- Discuss and analyze

Planting Data from 1996:

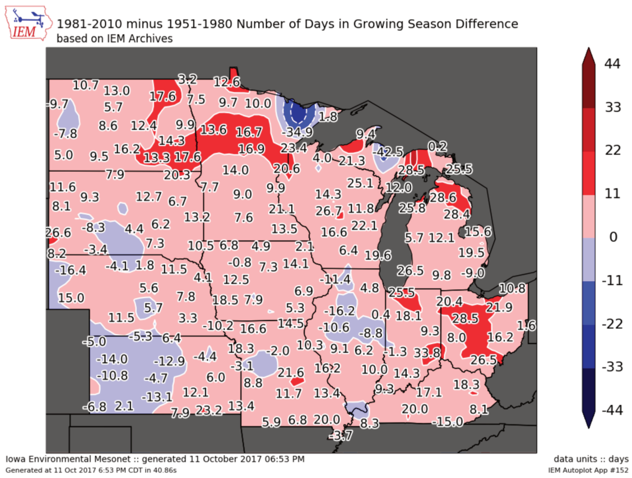
https://usda.mannlib.cornell.edu/usda/nass/planting/uph97.pdf

Climate Change Impacts on Iowa 2010:

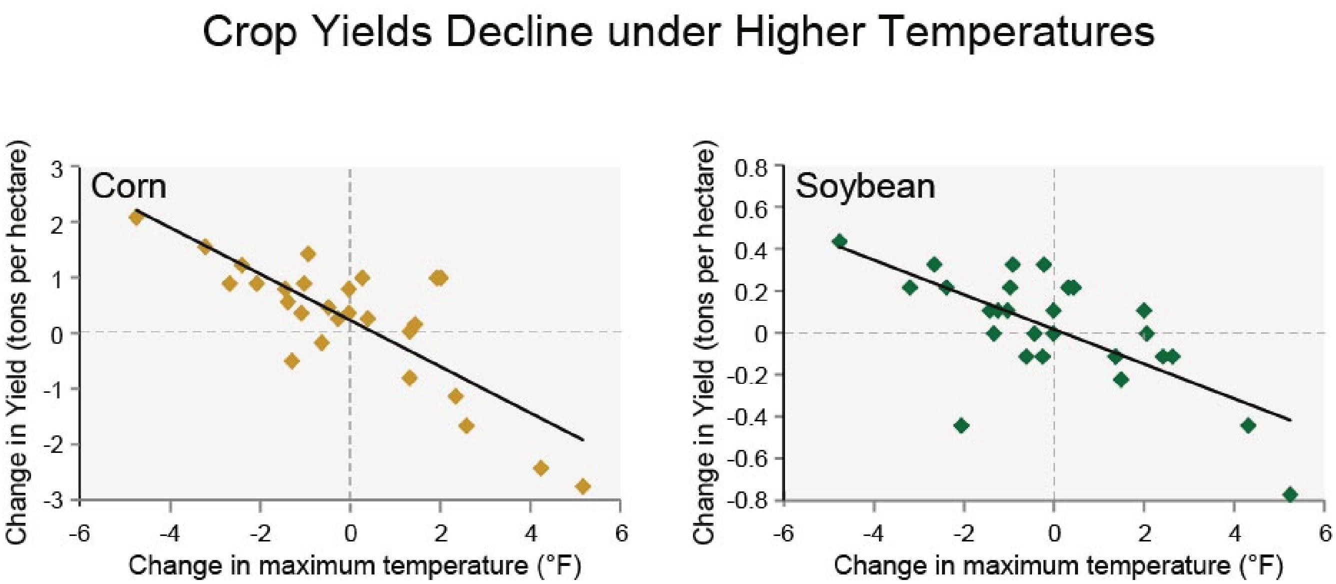
http://lib.dr.iastate.edu/cgi/viewcontent.cgi?article=1095&context=leopold_pubspapers



This graphic shows why people are hard to convince that increasing temperatures are a bad thing, but they fail to look at graphs like the one above it.

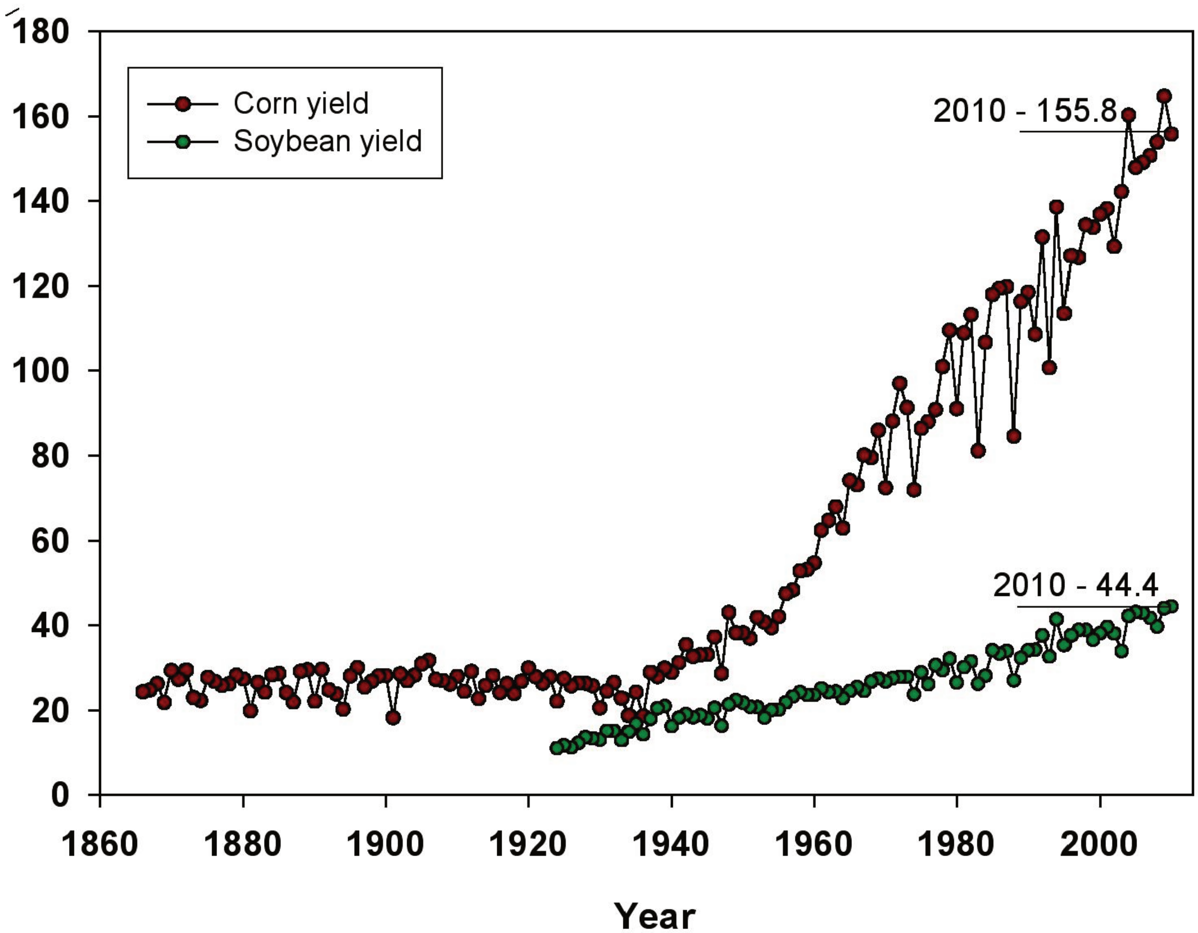


Source: Agricultural Marketing Resource Center



Increasing temperature will eventually be too high and be counter productive

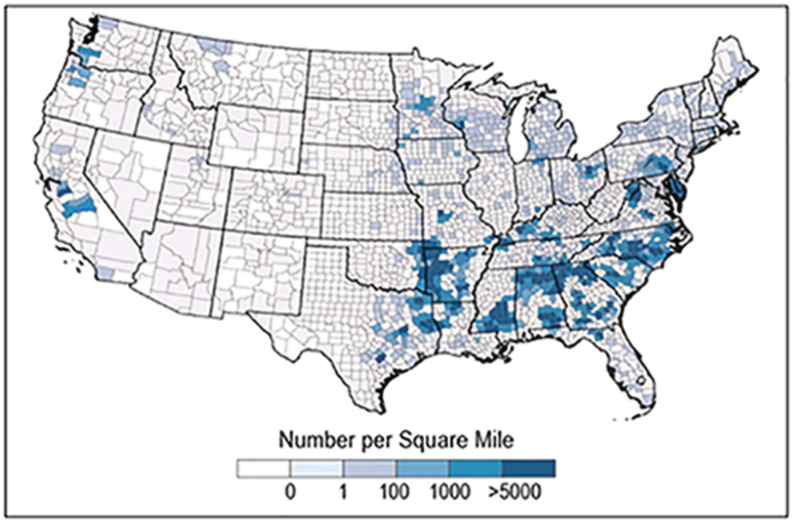
Source: Globalchange.net (Midwest National Climate Assessment)



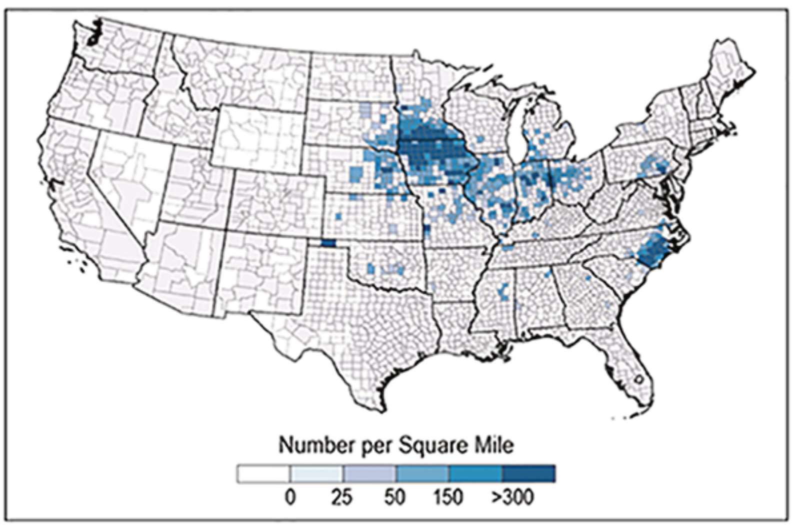
The graph below shows Iowa as the nation's leader in pig production. Nardone et. al and Rojas-Downing et. al. show higher temperatures negatively affects 'production (growth, meat and milk yield and quality, egg yield, weight, and quality) and reproductive performance, metabolic and health status, and immune response.' How will Iowa farmers have to respond to continue leading the nation in pork production?

Locations of Livestock

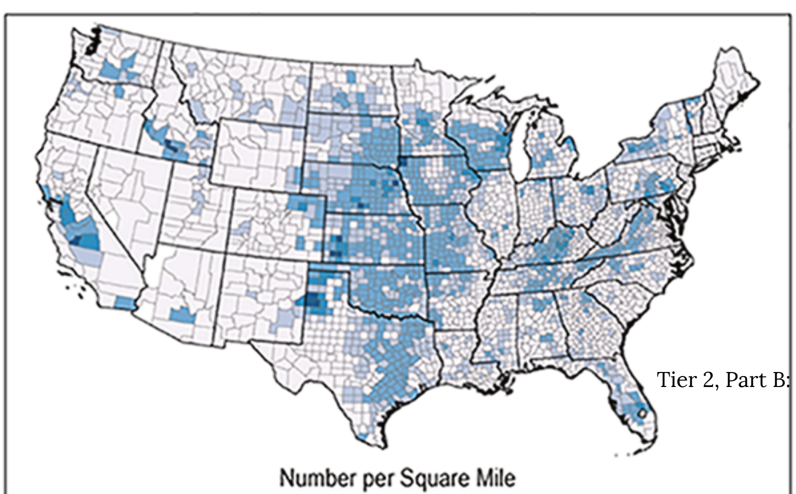
Number of Broilers and Other Meat-Type Chickens per Square Mile, 2012



Number of Hogs and Pigs per Square Mile, 2012



Number of Cattle and Calves per Square Mile, 2012



Conclusion: We concluded that the most beneficial factor that we have experienced in Iowa is the extended growing seasons, which results in higher crop yields.

Experts:

Solutions:

Tier 3: Open Investigation

Tier 3: Open Investigation

Overview:

As they explored Tier 1 and 2, surely students found topics that piqued their interest. Let them run with it. We encourage the class to followup on these in an open investigation tier 3. Learning is for the learner – not for the teacher.

To this end, students should investigate a question that they are interested in. Teachers should facilitate their investigation, and make sure that it has a good relationship to the learning goals of the class, that it allows collection of data, interpretation of that data, and drawing of conclusions or development of solutions. Negotiate how they share what they have done. Options include a youtube video, a letter (for example to local government officials) recommending a policy or practice, a presentation, a paper, a website, a fundraiser for a community improvement….. the sky is the limit.

Appendix

This is where you can add appendices or other back matter.

James Hansen, former NASA scientist and University of Iowa alum, on Climate Change:

Wishes he was wrong, he wasn't

Advice for Students:

A VideoPress element has been excluded from this version of the text. You can view it online here: https://pressbooks.uiowa.edu/8thgradescience/?p=7

His work:

A VideoPress element has been excluded from this version of the text. You can view it online here: https://pressbooks.uiowa.edu/8thgradescience/?p=7