Integrating Global Agricultural Issues into Sustainable Agriculture and Science Education in Kentucky

UK College of Agriculture Team

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Sheena Thomas – Brown – 4-H Agent Livingston County

Outline

Overview of issues in US agriculture context

Undergraduate education

- Teaching approaches, lessons learned, new majors to deal with changing global challenges

P-16 Science and environmental education

- Policy framework, changing standards, assessment and novel teaching strategies

Characteristics of US Agriculture

- *Mechanized*
- *Labor-minimizing*
- *Focus on industrialization and economic efficiency*

(Lyson, 2010)

Characteristics of KY Agriculture

- Small (relatively)
- Diversified
  - By region
  - On farms
- Transitioning
  - Post-tobacco
  - New crops vs. getting bigger

Highest value crops in Kentucky

- *Broiler chickens*
- *Horses (92% of US sales)*
- *Cattle*
- *Corn*
- *Soybeans*

(USDA-ERS, 2011)

Challenges to Agricultural Sustainability in US and Kentucky

	United States	Kentucky
Average farm size (hectares)	167	66
Average farmer age (years)	57.1	56.5
Farmers working off-farm (percent)	55%	61%

Largely due to scale and industrialization

Economic

High input costs & small profit margins = need to expand farming operations to remain viable

In Kentucky, transitioning agricultural economy away from tobacco

Environmental

Loss of agricultural biodiversity with expansion of scale, nutrient and pesticide pollution, etc.

Social

Who will be our next generation of farmers?

How do we define agricultural sustainability?

1990 US "Farm bill" defines sustainable agriculture:

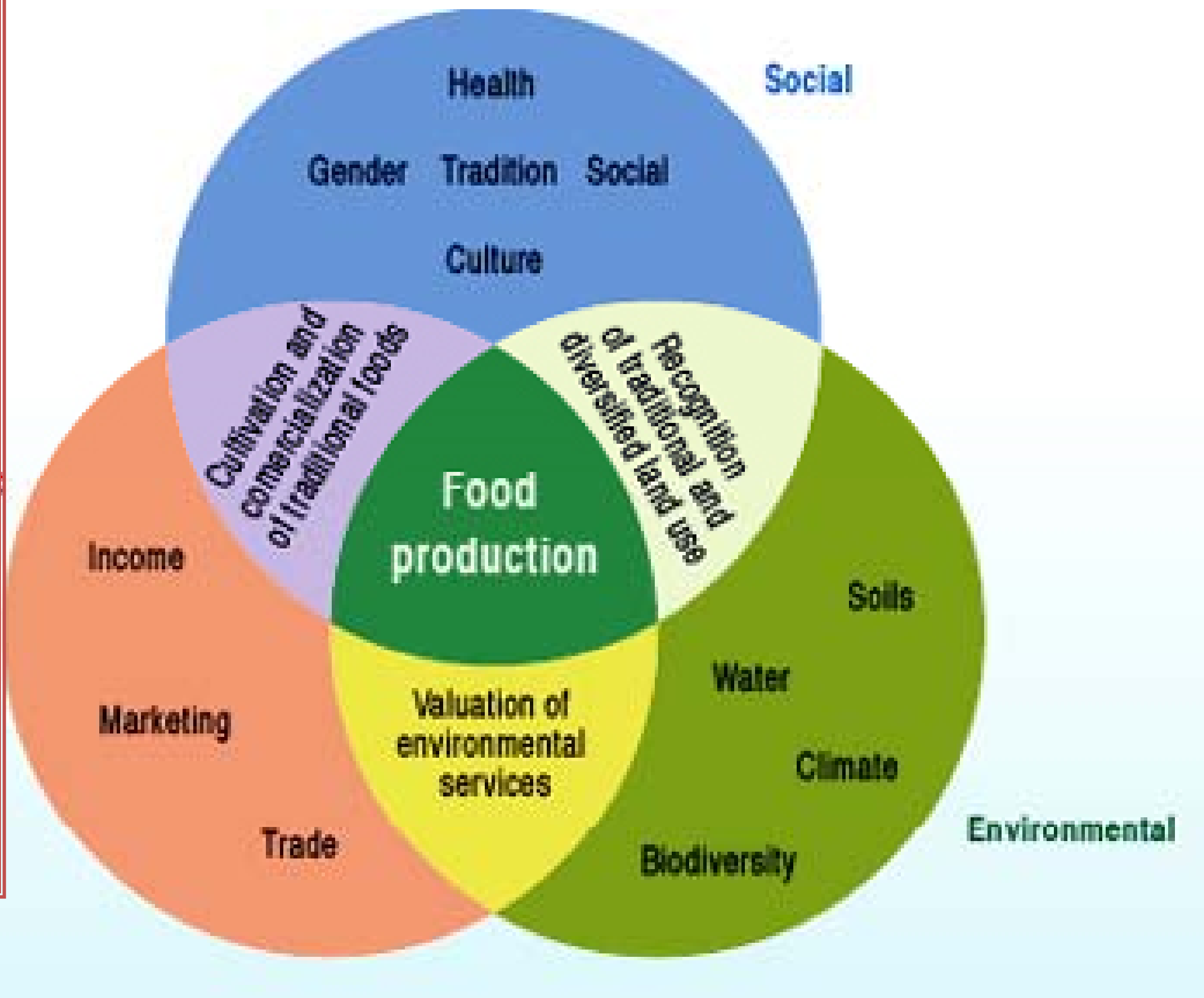
"the term sustainable agriculture means an integrated system of plant and animal production practices having a **site-specific** application that will, over the long term:

- satisfy human food and fiber needs;
- enhance **environmental** quality and the natural resource base upon which the agricultural economy depends;
- make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls;
- sustain the **economic** viability of farm operations; and
- enhance the quality of life for farmers and **society** as a whole."

How do we define agricultural sustainability?

Sustainable Agriculture integrates economic, environmental and social goals.

It is an approach or a goal, and always a "moving target."



Teaching Global Agricultural Issues to Undergraduates at UKy

Global Issues

- Biodiversity
- Climate change
- Food security
- Energy & Biofuels

Approaches and lessons learned through UK Sustainable Agriculture Program & College of Agriculture Coursework

- Overview of issues in US context
- Integration of social and natural science research
- Challenges and lessons learned

Biodiversity Issues in US Agriculture

Loss of habitat

- Percent of land in agriculture has not changed in 150 years
- Habitat loss occurring with removal of conservation measures on farms

Loss of genetics

- 75% of agricultural biodiversity lost in the la century
- Traditional seed saving practices are being abandoned

<u>How do we connect our students to this global issue?</u>

- *Make it local*
- *Explore from multiple disciplines and approaches*

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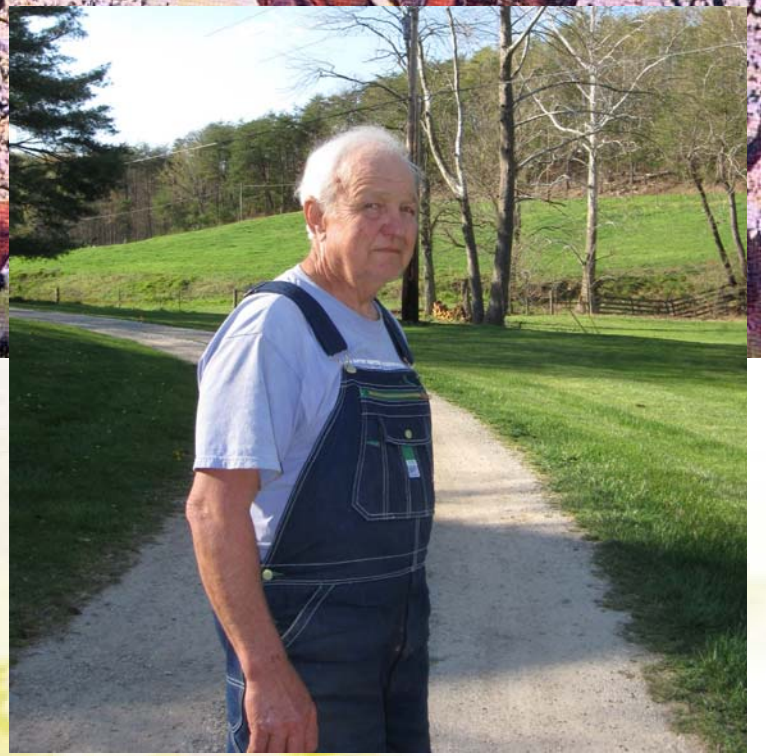
Teaching Biodiversity

Cultural context for scientific concepts

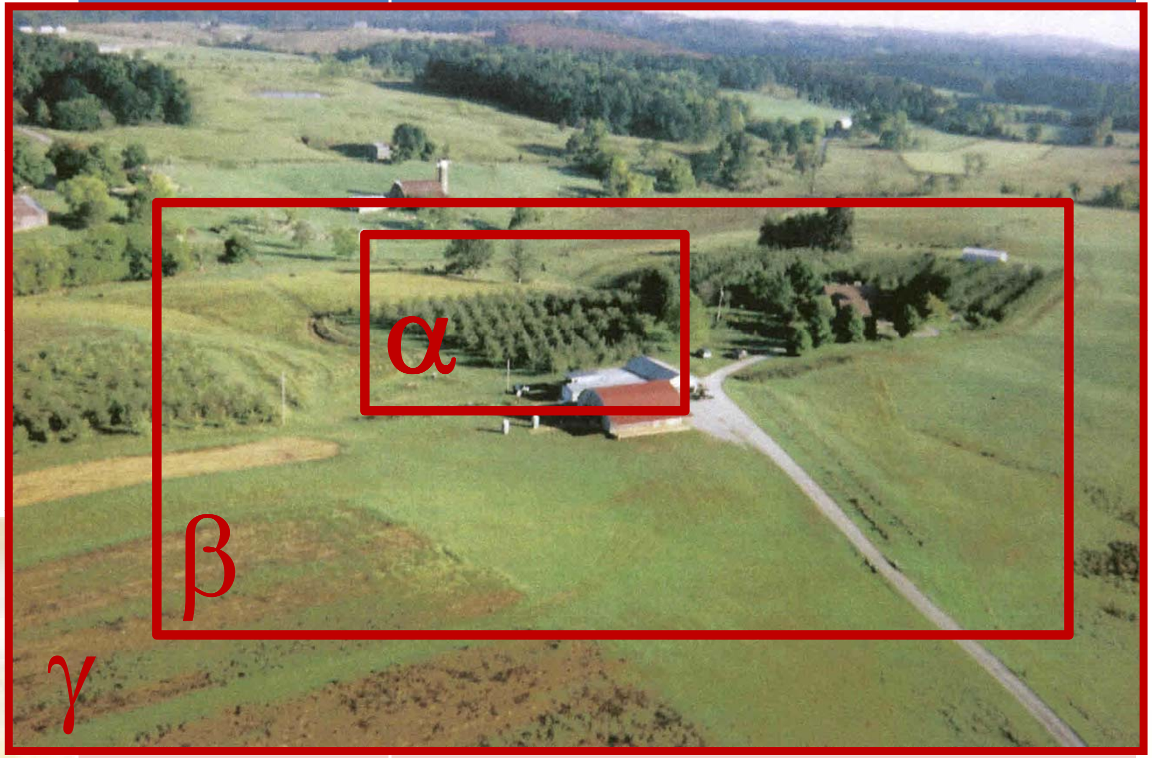
- In the U.S. more than 7000 apple varieties were grown in the last century, today 2 apples count for 50% of the crop, 85% are extinct
- Incorporate local experts



Teaching Biodiversity

Explore scientific concepts in multiple formats

- Quantitative exercises
- Exercises to conceptualize biodiversity in the field



system

After Gliessman, 2007

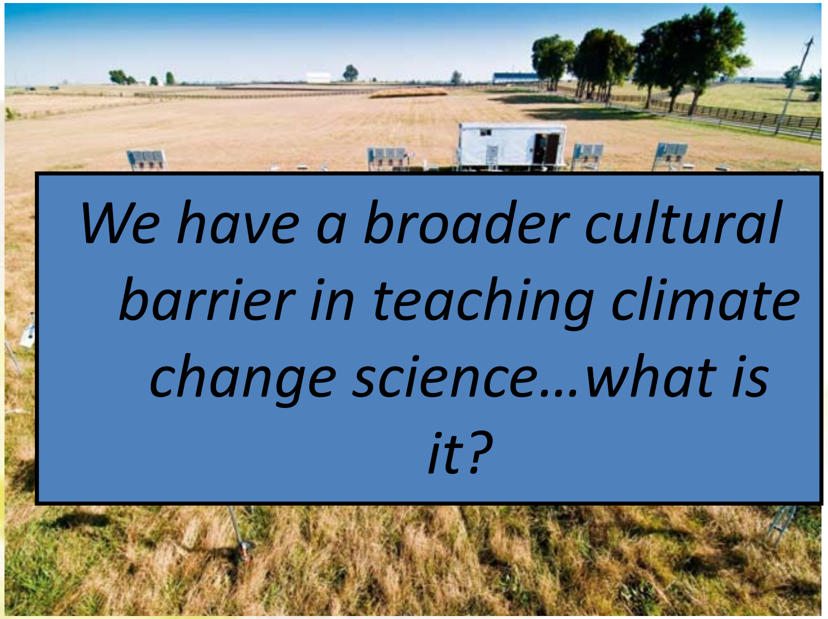
Climate Change & US Agriculture

Agriculture is 6.3% of US greenhouse gas emissions

- CH_4 from cattle and NO_x from fertilizer biggest contributors
- Variety of UK research activities introduced to course work

However…

- US is 2nd only to China in global greenhouse gas emissions

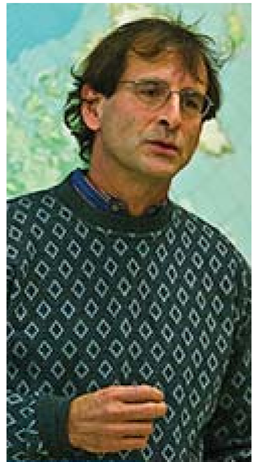


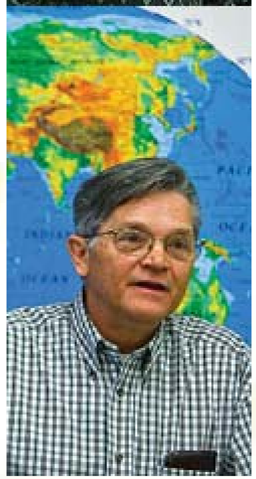
We have a broader cultural barrier in teaching climate change science…what is it?

Teaching Climate Change

There is no public consensus on climate change in the US

- Educational efforts are focused on data to support this and critical thinking skills
- Very little focus on mitigation and adaptation in the classroom





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Food Security and Hunger

US has a "cheap food" policy

American's spend 10% of income on food

-18% in 1966

- Lowest in world

Most industrial countries less than 20%, up to >60% in LDC's

What does 1 USD buy a US food consumer?

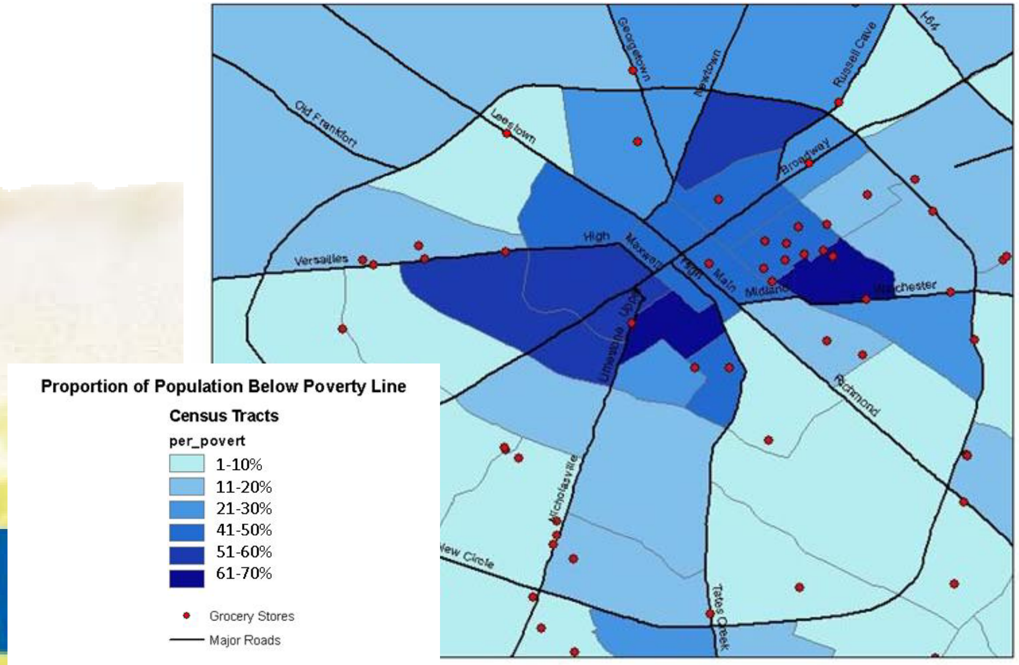
Product	Calories

Hunger is experienced differently in the US; as a lack of nutrition, not a lack of calories. How do we empower students to change this?

American Journal of Clinical Nutrition *in* Time Magazine

Food Security & Hunger

- Engage students in research in Kentucky
  - Lexington Community Food Assessment
  - Food “deserts” – an area where healthy, nutritious food is hard to obtain
- Service learning
- Global context
  - Study abroad trips
    - Ex. Ghana



Source: US Census 2000; LFUG Health Depar

Energy Issues

Kentucky has a long, complicated history with energy resources

Research in the UK CoA focuses on impacts and alternatives

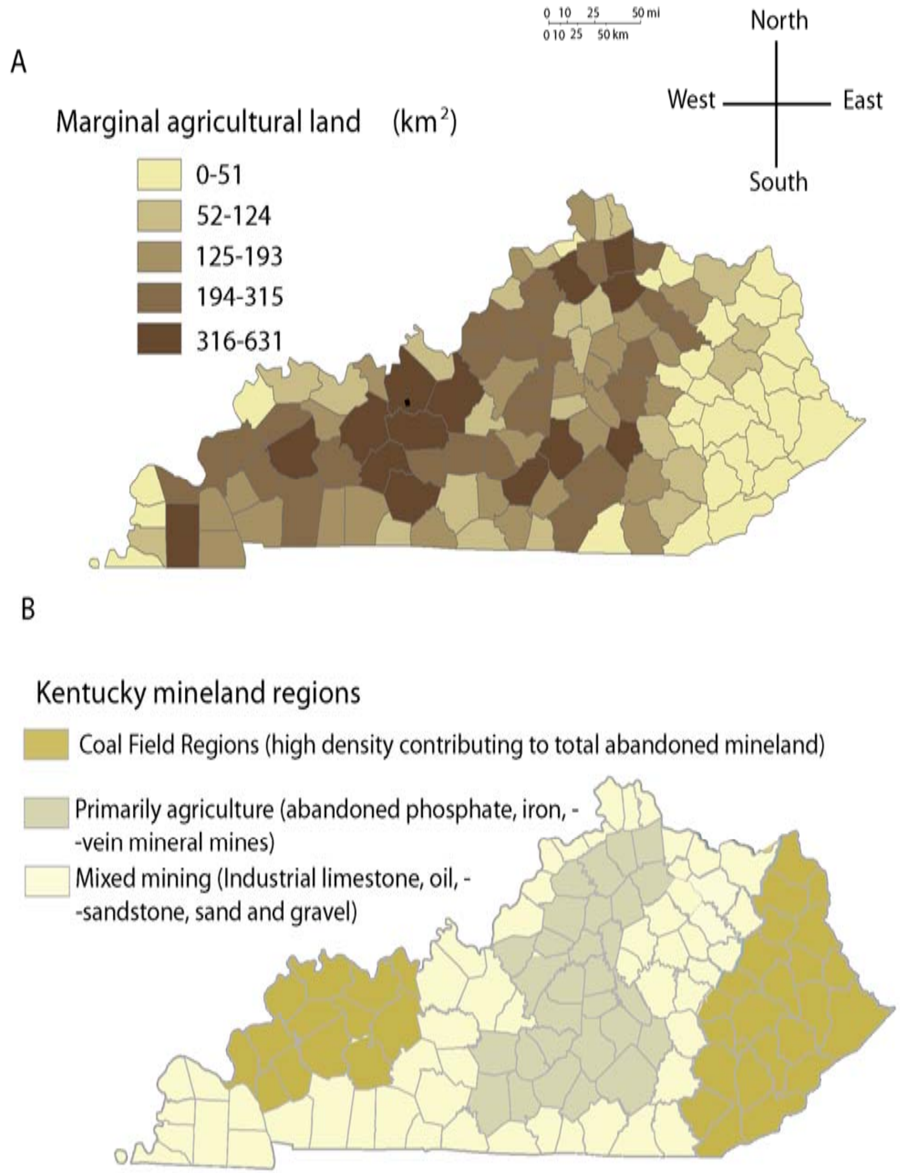
Teaching about energy use is often controversial…integrating research into teaching helps focus on issues and technologies.

Teaching Energy Issues

Working with natural cycles to reduce energy use when possible

Alternatives: Biofuels

– Assessing the "footprint" of first generation and second generation biofuels



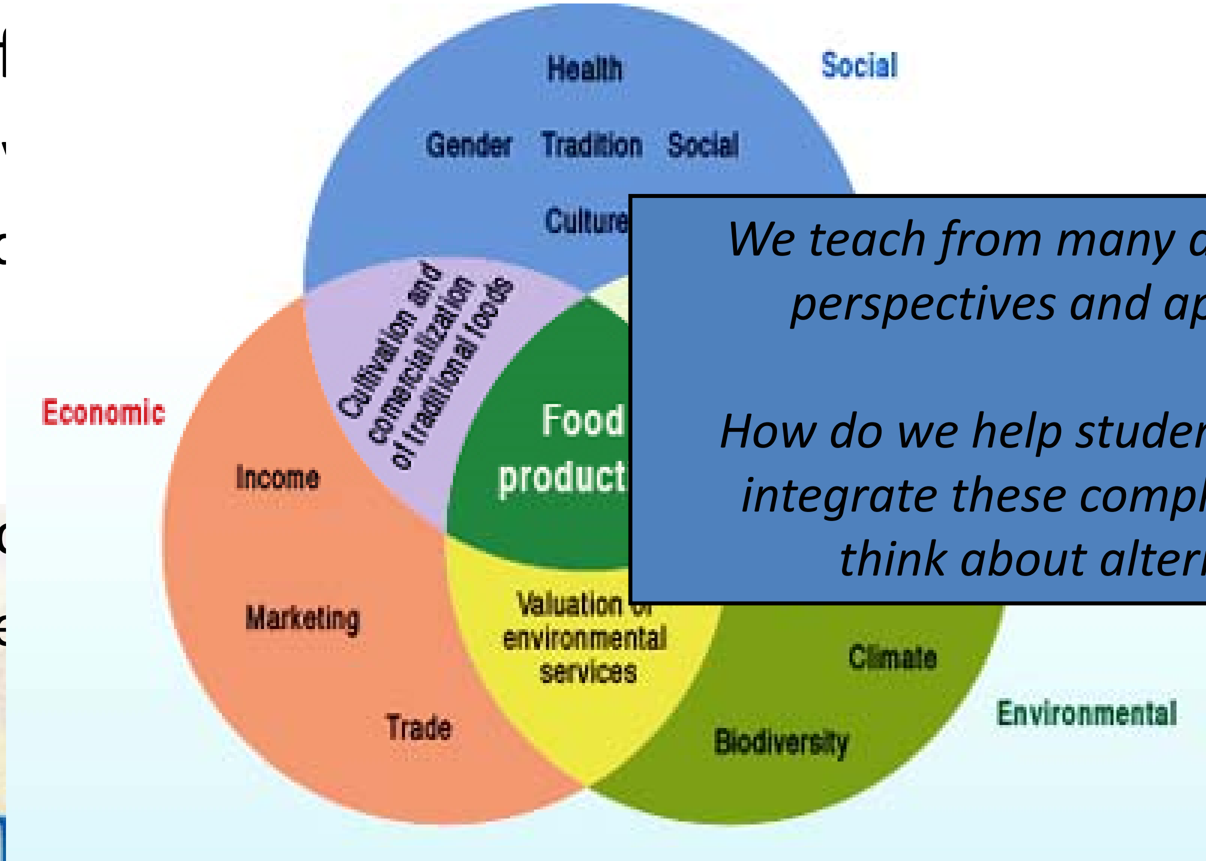
Teaching Sustainability: integrating complex information

Indicators of

- Quantitati
- Single- and

Place-based learning

- Capstone c
- Apprentice



We teach from many disciplinary perspectives and approaches.

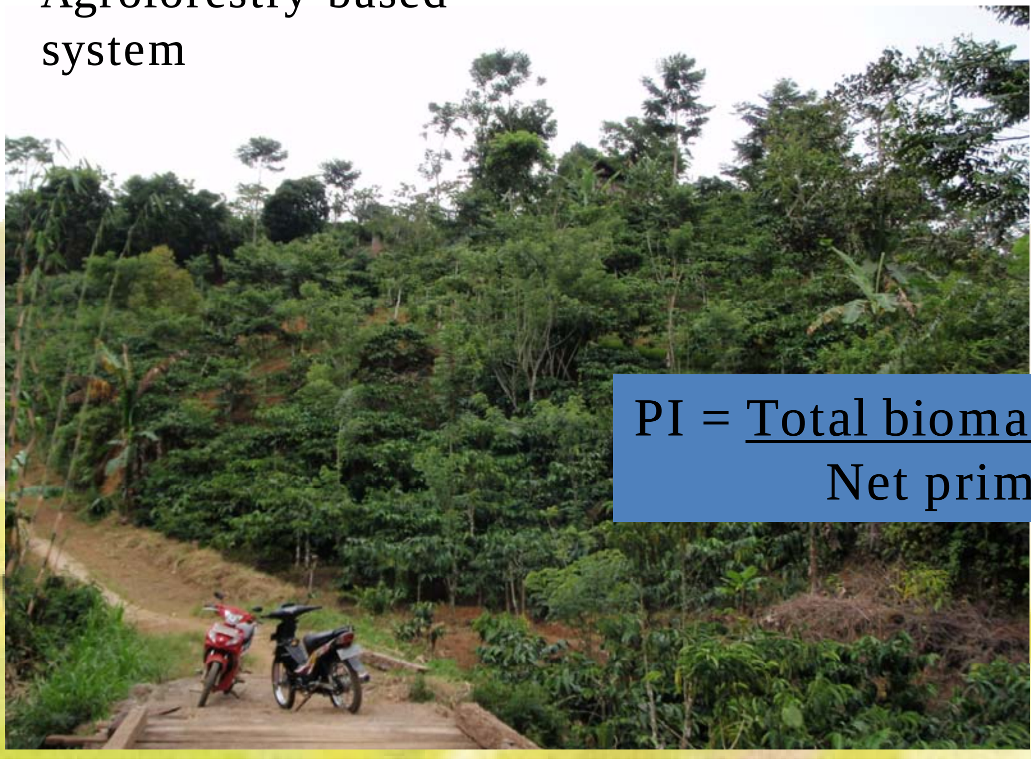
How do we help students learn to integrate these complex ideas and think about alternatives?

Indicators of Sustainability

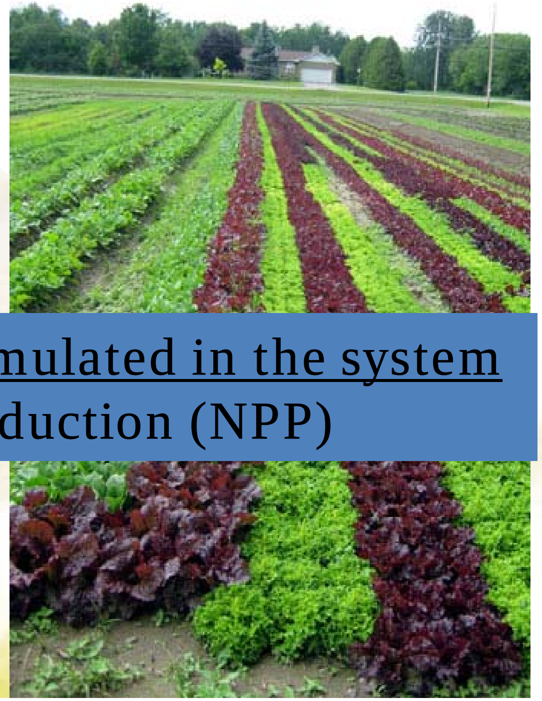
Single discipline - Soil quality indices

Holistic indicators – productivity index

Agroforestry-based system



Lettuce field



$$PI = \frac{\text{Total biomass accumulated in the system}}{\text{Net primary production (NPP)}}$$

Indicators of Sustainability

Multiple disciplines

Amoeba diagrams

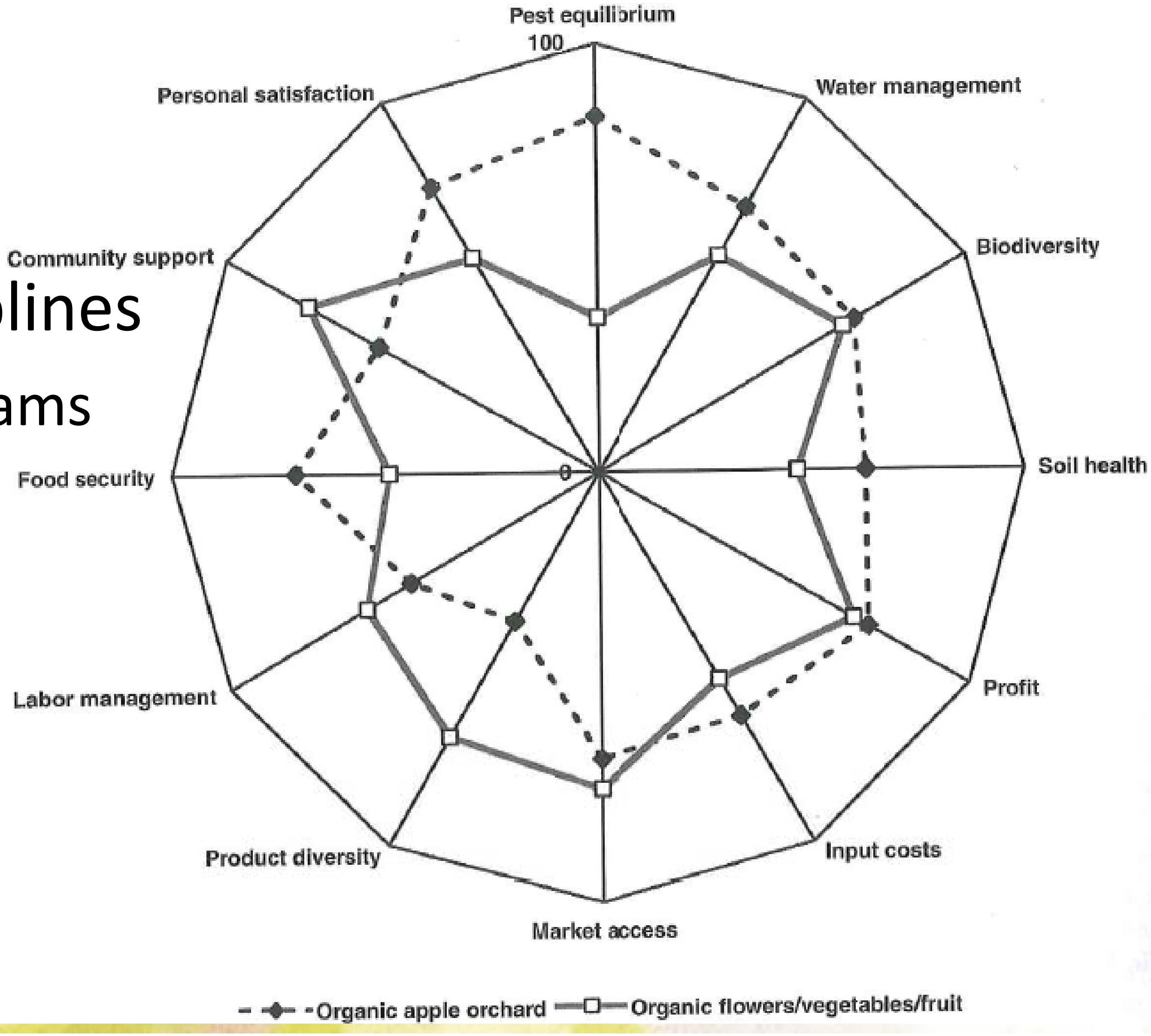


Figure 21.3, Gliessman 2007

Experiential learning: UK Sustainable Agriculture Program

P – 16 Science and Environmental Education in Kentucky

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University of Kentucky

College

Of

Agriculture

Senate Bill 1: College and Career Readiness

- A law passed in 2009 to develop one strategy to improve college completion rate across Kentucky.
- It revises the assessment and accountability system for P-12 education in Kentucky and requires a revision of standards based on national and international benchmarks to increase the rigor and focus of P-12 education, increasing the number of students that are college ready.

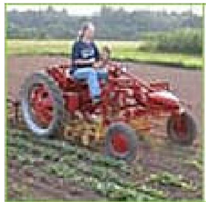
SB 1 Strategies

- Accelerated Learning Opportunities
- Secondary Intervention Programs
- College and Career Readiness Advising
- Postsecondary College Persistence and Degree Completion

What happens at UK?

Learning outcomes at UK should help the smooth transition of Kentucky's recent high school graduates into their first fall semester at UK (see more on this at the Kentucky Council on Postsecondary Education's website on policies regarding Senate Bill 1 and on college readiness); and,

Environmental Programs at UK: College of Agriculture



Requirements:
- Undergraduate - Curriculum
- Graduate
- Academic Enrichment

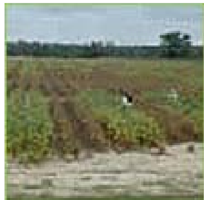
Sustainable Agriculture

Requirements:
- Undergraduate - Curriculum
- Graduate
- Academic Enrichment

Biosystems and Agricultural Engineering (BAE)

Requirements:
- Undergraduate - Curriculum
- Graduate
- Academic Enrichment

Entomology



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Plant Pathology

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Environmental Programs at UK: College of Agriculture

Requirements:
- Undergraduate - Curriculum
- Graduate
- Academic Enrichment

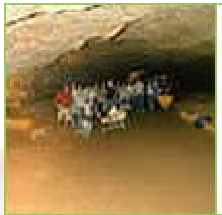
Forestry

Requirements:
- Undergraduate - Curriculum
- Graduate
- Academic Enrichment

Horticulture, Plant and Soil Sciences

Requirements:
- Undergraduate - Curriculum
- Graduate
- Academic Enrichment

Landscape Architecture



Requirements:
- Undergraduate - Curriculum
- Graduate
- Academic Enrichment

Natural Resources and Environmental Science (NRES)

SUSTAINABLE AGRICULTURE
Minor Requirements

DEPT. COURSE DESCRIPTION CREDITS

Minor Prerequisite

- ECO 201 Principles of Economics I 3
- **SUB-TOTAL 3**

Sustainable Agriculture Core (all courses required)

- SAG 101 Introduction to Susta inable Agriculture 3
- SAG 201 Cultural Perspectives on Sustainability 3
- SAG 397 Apprenticeship in Sustainable Agriculture 3
- **SUB-TOTAL 9**

TOTAL CREDITS FOR MINOR 21-23

SUSTAINABLE AGRICULTURE
Minor Requirements

Social Responsibility Cluster (select one)

- SOC 360 c Environnemental Sociology 3
- GEN 501 d Agricultural and Environmental Ethics 3

SUB-TOTAL 3

SUSTAINABLE AGRICULTURE
Minor Requirements

Economic Profitability Cluster (select one)

- AEC 302 b Agricultural Management Principles 4
- AEC 305 b Food and Agricultural Marketing Principles 3
- AEC 445G b Introduction to Resource and Environmental Economics 3

SUB-TOTAL 3-4

SUSTAINABLE AGRICULTURE
Minor Requirements

Environmental Stewardship Cluster (select one)

- GEO 210 Pollution Hazards and Environmental Management 3
- GLY 210 Habitable Planet: Earth Systems Evolution 3
- ASC 382 Principles of Livestock Production 3
- PLS 210 The Life Processes of Plants 3
- PLS 366a Fundamentals of Soil Science 4

SUB-TOTAL 3-4

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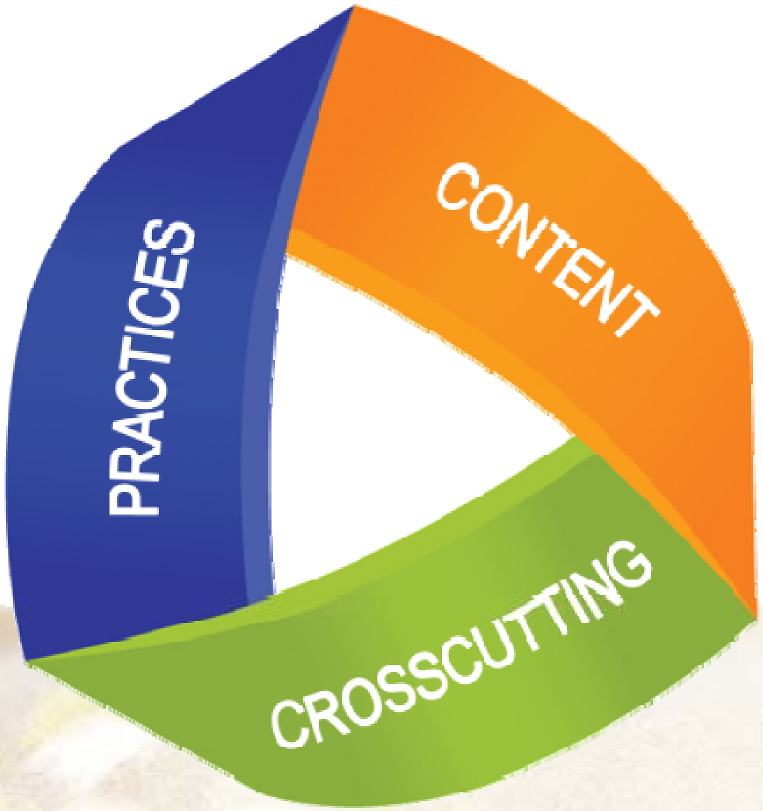
Structure of Next Generation Science Standards



Practices

Scientific and engineering practices describe behaviors that scientists engage in as they investigate and build models and theories about the natural world and the key set of engineering practices that engineers use as they design and build models and systems.

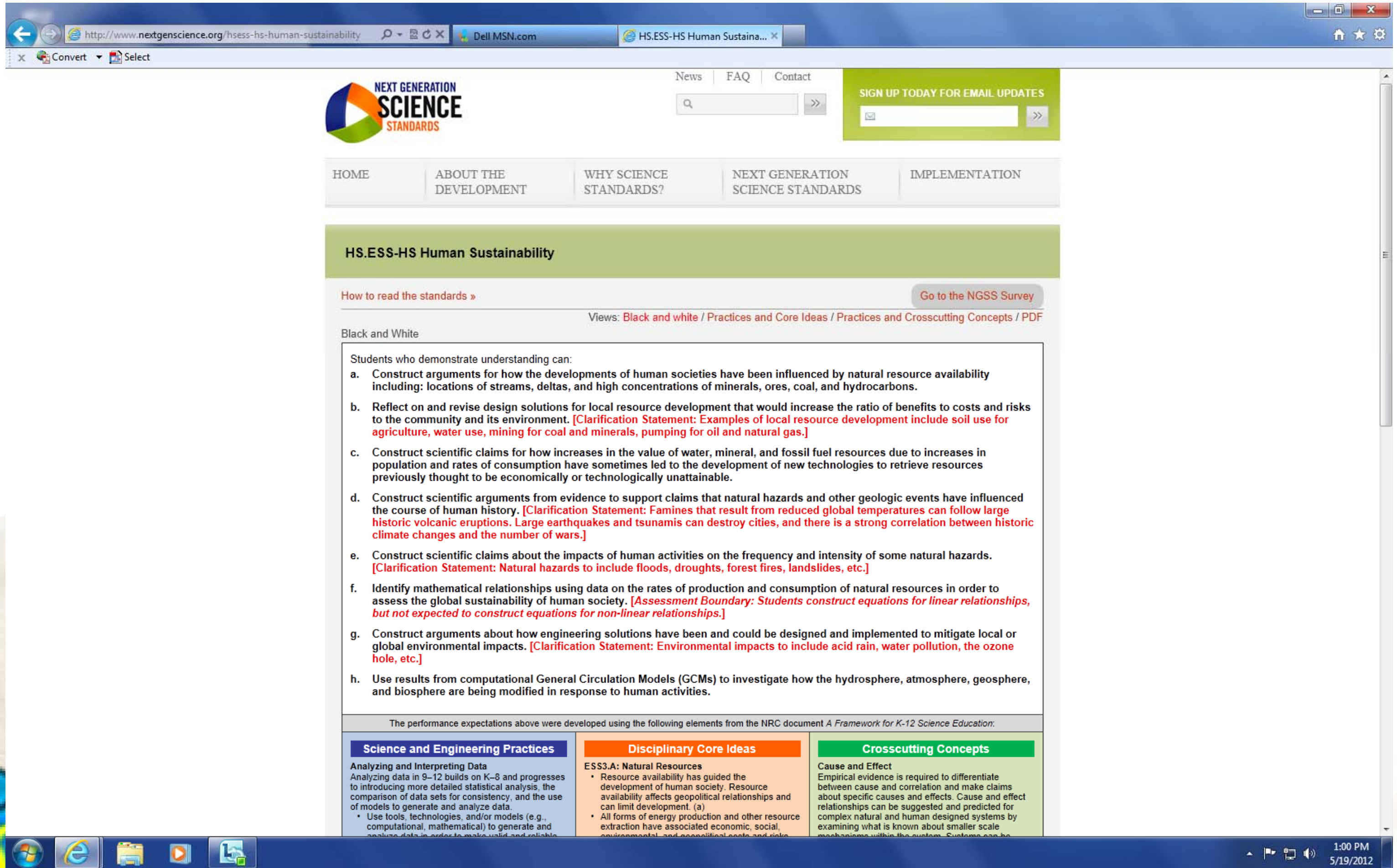
Crosscutting concepts

Crosscutting concepts have application across all domains of science. They are a way of linking the different domains of science. They include: Patterns, similarity, and diversity; Cause and effect; Scale, proportion and quantity; Systems and system models; Energy and matter; Structure and function; Stability and change.

Disciplinary core ideas

Disciplinary ideas are grouped in four domains: the physical sciences; the life sciences; the earth and space sciences; and engineering, technology and applications of science.

Next Generation Standards: Performance Expectations



HS.ESS-HS Human Sustainability

How to read the standards »

Go to the NGSS Survey

Views: Black and white / Practices and Core Ideas / Practices and Crosscutting Concepts / PDF

Black and White

Students who demonstrate understanding can:

a. **Construct arguments for how the developments of human societies have been influenced by natural resource availability including: locations of streams, deltas, and high concentrations of minerals, ores, coal, and hydrocarbons.**

b. **Reflect on and revise design solutions for local resource development that would increase the ratio of benefits to costs and risks to the community and its environment. [Clarification Statement: Examples of local resource development include soil use for agriculture, water use, mining for coal and minerals, pumping for oil and natural gas.]**

c. **Construct scientific claims for how increases in the value of water, mineral, and fossil fuel resources due to increases in population and rates of consumption have sometimes led to the development of new technologies to retrieve resources previously thought to be economically or technologically unattainable.**

d. **Construct scientific arguments from evidence to support claims that natural hazards and other geologic events have influenced the course of human history. [Clarification Statement: Famines that result from reduced global temperatures can follow large historic volcanic eruptions. Large earthquakes and tsunamis can destroy cities, and there is a strong correlation between historic climate changes and the number of wars.]**

e. **Construct scientific claims about the impacts of human activities on the frequency and intensity of some natural hazards. [Clarification Statement: Natural hazards to include floods, droughts, forest fires, landslides, etc.]**

f. **Identify mathematical relationships using data on the rates of production and consumption of natural resources in order to assess the global sustainability of human society.** ***[Assessment Boundary: Students construct equations for linear relationships, but not expected to construct equations for non-linear relationships.]***

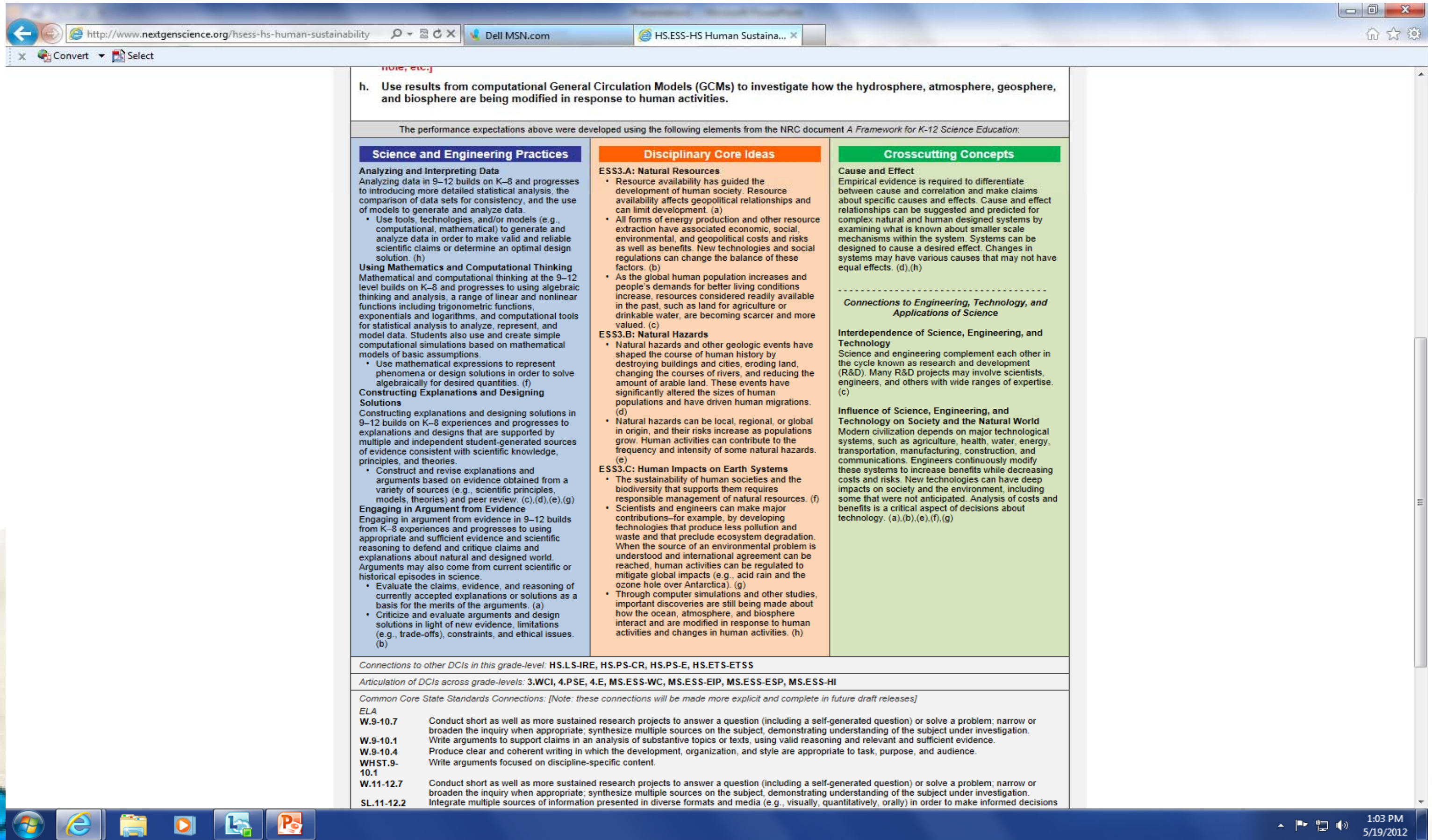
g. **Construct arguments about how engineering solutions have been and could be designed and implemented to mitigate local or global environmental impacts. [Clarification Statement: Environmental impacts to include acid rain, water pollution, the ozone hole, etc.]**

h. **Use results from computational General Circulation Models (GCMs) to investigate how the hydrosphere, atmosphere, geosphere, and biosphere are being modified in response to human activities.**

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing data in 9–12 builds on K–8 and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Use tools, technologies, and/or models (e.g., computational, mathematical) to generate and	**ESS3.A: Natural Resources** • Resource availability has guided the development of human society. Resource availability affects geopolitical relationships and can limit development. (a) • All forms of energy production and other resource extraction have associated economic, social,	**Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale

Next Generation Standards: Foundational Boxes



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Science and Engineering Practices

Analyzing and Interpreting Data
Analyzing data in 9–12 builds on K–8 and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.
- Use tools, technologies, and/or models (e.g., computational, mathematical) to generate and analyze data in order to make valid and reliable scientific claims or determine an optimal design solution. (h)

Using Mathematics and Computational Thinking
Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Students also use and create simple computational simulations based on mathematical models of basic assumptions.
- Use mathematical expressions to represent phenomena or design solutions in order to solve algebraically for desired quantities. (f)

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific knowledge, principles, and theories.
- Construct and revise explanations and arguments based on evidence obtained from a variety of sources (e.g., scientific principles, models, theories) and peer review. (c),(d),(e),(g)

Engaging in Argument from Evidence
Engaging in argument from evidence in 9–12 builds from K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed world. Arguments may also come from current scientific or historical episodes in science.
- Evaluate the claims, evidence, and reasoning of currently accepted explanations or solutions as a basis for the merits of the arguments. (a)
- Criticize and evaluate arguments and design solutions in light of new evidence, limitations (e.g., trade-offs), constraints, and ethical issues. (b)

Disciplinary Core Ideas

ESS3.A: Natural Resources
- Resource availability has guided the development of human society. Resource availability affects geopolitical relationships and can limit development. (a)
- All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (b)
- As the global human population increases and people's demands for better living conditions increase, resources considered readily available in the past, such as land for agriculture or drinkable water, are becoming scarcer and more valued. (c)

ESS3.B: Natural Hazards
- Natural hazards and other geologic events have shaped the course of human history by destroying buildings and cities, eroding land, changing the courses of rivers, and reducing the amount of arable land. These events have significantly altered the sizes of human populations and have driven human migrations. (d)
- Natural hazards can be local, regional, or global in origin, and their risks increase as populations grow. Human activities can contribute to the frequency and intensity of some natural hazards. (e)

ESS3.C: Human Impacts on Earth Systems
- The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (f)
- Scientists and engineers can make major contributions–for example, by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. When the source of an environmental problem is understood and international agreement can be reached, human activities can be regulated to mitigate global impacts (e.g., acid rain and the ozone hole over Antarctica). (g)
- Through computer simulations and other studies, important discoveries are still being made about how the ocean, atmosphere, and biosphere interact and are modified in response to human activities and changes in human activities. (h)

Crosscutting Concepts

Cause and Effect
Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. Systems can be designed to cause a desired effect. Changes in systems may have various causes that may not have equal effects. (d),(h)

- -

Connections to Engineering, Technology, and Applications of Science

Interdependence of Science, Engineering, and Technology
Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. (c)

Influence of Science, Engineering, and Technology on Society and the Natural World
Modern civilization depends on major technological systems, such as agriculture, health, water, energy, transportation, manufacturing, construction, and communications. Engineers continuously modify these systems to increase benefits while decreasing costs and risks. New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (a),(b),(e),(f),(g)

Connections to other DCIs in this grade-level: **HS.LS-IRE, HS.PS-CR, HS.PS-E, HS.ETS-ETSS**

Articulation of DCIs across grade-levels: **3.WCI, 4.PSE, 4.E, MS.ESS-WC, MS.ESS-EIP, MS.ESS-ESP, MS.ESS-HI**

Common Core State Standards Connections: [Note: these connections will be made more explicit and complete in future draft releases]

ELA

W.9-10.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
W.9-10.1	Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.
W.9-10.4	Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
WHST.9-10.1	Write arguments focused on discipline-specific content.
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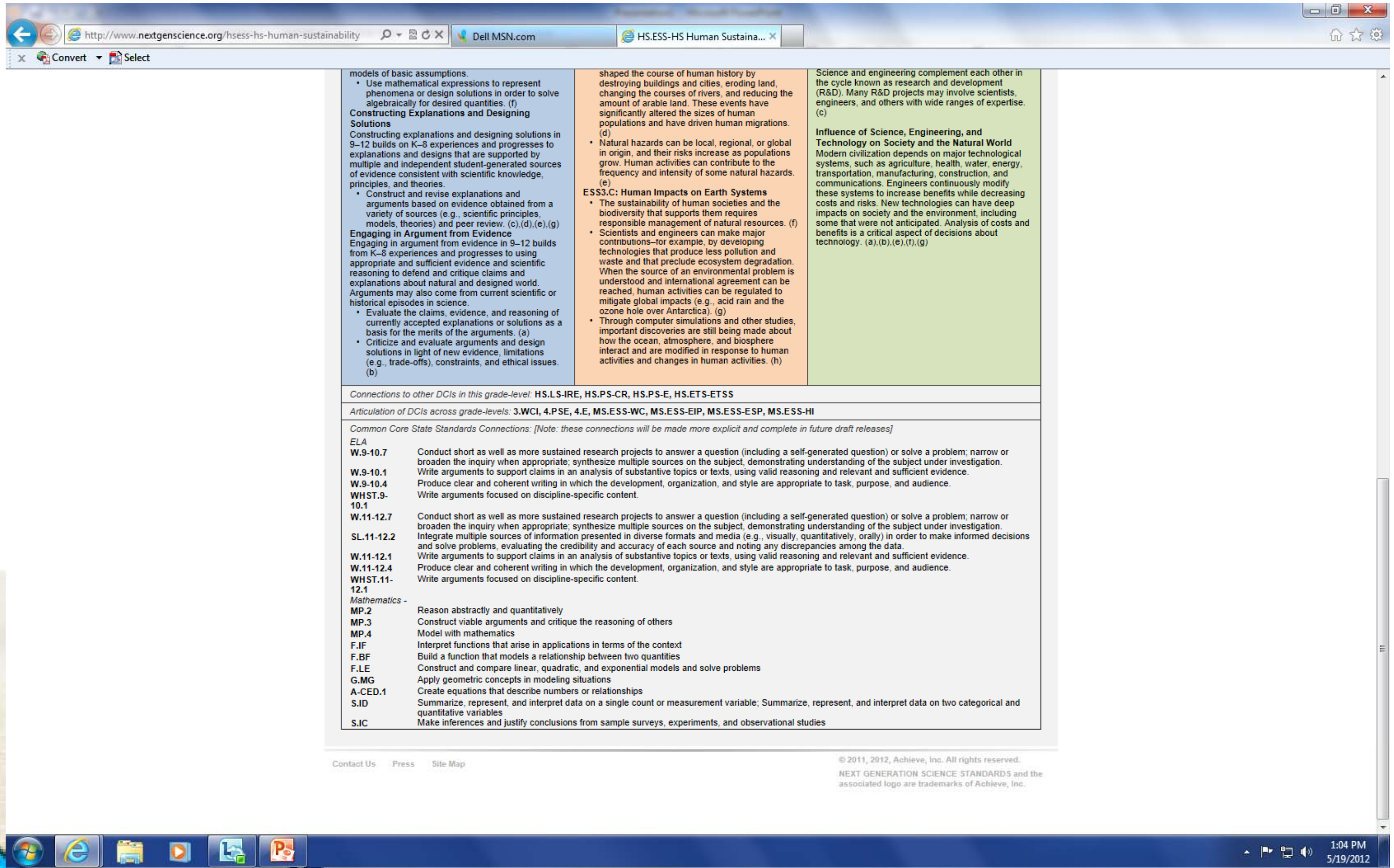
SL.11-12.2	Integrate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, orally) in order to make informed decisions

Next Generation Standards: Connection Boxes



models of basic assumptions.

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SL.11-12.2	Integrate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, orally) in order to make informed decisions and solve problems, evaluating the credibility and accuracy of each source and noting any discrepancies among the data.
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W.11-12.4	Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
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Mathematics -

MP.2	Reason abstractly and quantitatively
MP.3	Construct viable arguments and critique the reasoning of others
MP.4	Model with mathematics
F.IF	Interpret functions that arise in applications in terms of the context
F.BF	Build a function that models a relationship between two quantities
F.LE	Construct and compare linear, quadratic, and exponential models and solve problems
G.MG	Apply geometric concepts in modeling situations
A-CED.1	Create equations that describe numbers or relationships
S.ID	Summarize, represent, and interpret data on a single count or measurement variable; Summarize, represent, and interpret data on two categorical and quantitative variables
S.IC	Make inferences and justify conclusions from sample surveys, experiments, and observational studies

Contact Us Press Site Map

End of Course Exams

- All students must take and End of Course Exam in biology
- It is composed of multiple choice and constructed-response questions
- The content on the test includes: biological processes, biochemistry, cell structure and function, genetics and evolution, animal and plant systems, ecology
- The test counts 20% of a student's grade

UKAg UK

Our Work:
Project-Based Learning

- Investigating Mare Reproductive Loss Syndrome
- Exploring elk in eastern Kentucky
- Researching Asian clams
- Studying native herbs in Appalachia
- Evaluating pasture at Taylor Made Farm
- Assessing Fayette County Parks
- Evaluating water quality and watershed
- Building and assessing wetlands
- Assessing soils and the loss of farmlands

Workshops

NASA- KY EPSCoRE Sponsored 1 ½ Day Workshop, June 2012, College of Agriculture University of Kentucky, and the Tracey Farmer Institute for Sustainability and the Environment.

"HANDS-ON EXPERIMENT-BASED AND INTERNET-BASED, CLIMATE-CHANGE-SCIENCE INSTRUCTION FOR MIDDLE AND HIGH SCHOOL SCIENCE TEACHERS"

OBJECTIVES:

1: Increase middle and high school teachers' content knowledge of climate change (CC) science.

Climate Change Workshop cont.

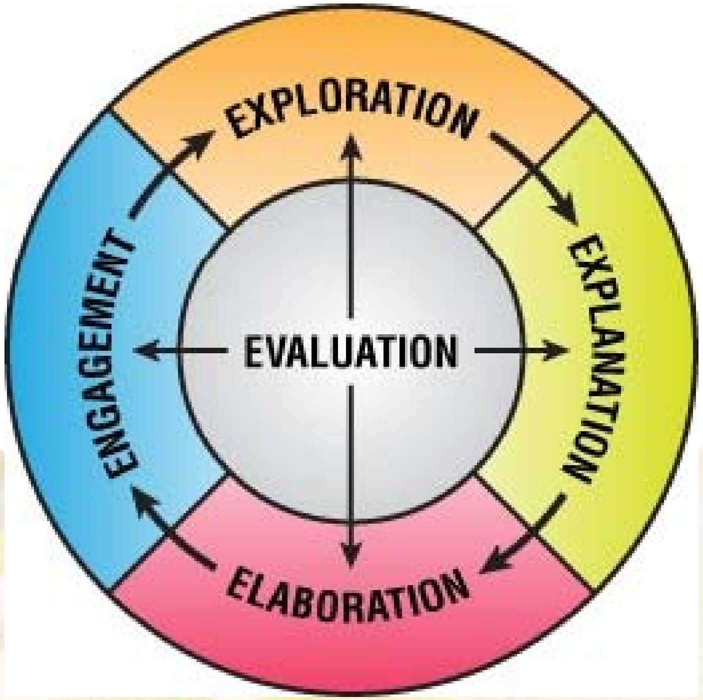
2: Prepare middle and high school teachers to conduct simple and inexpensive CC experiments in their class rooms to illustrate key CC science concepts.

3: Prepare middle and high school teachers to teach students about STEM careers related to CC.

Climate Change Workshop cont.

4: Enhance middle and high school teacher's ability to critically use the Internet in order to find materials on CC concepts, activities and careers (i.e., NASA web sites, NASA's CORE and ERCN sites).

Pedagogy Matters:
A 5-E Learning Cycle



Science in a Box:

Everything you need to teach science

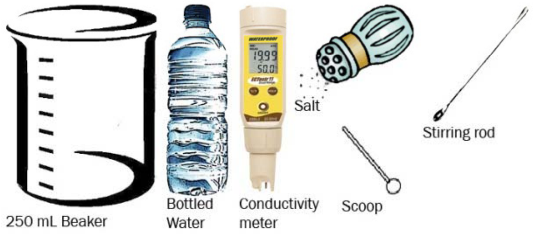
Forces – By Kelly Taylor

Water Quality – By Brian Radcliffe

By special request of Dr. Bujang Rahman

Water: Conductivity

Conductivity Meter.



One of the students can prepare a table to record their data.

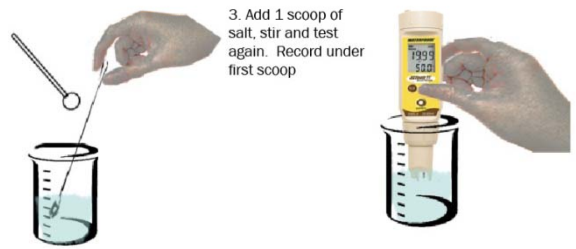
Amount of Substance added	0 scoops	First scoop	Second Scoop	Third Scoop	Fourth Scoop	Fifth Scoop	Sixth Scoop	Seventh Scoop
Conductivity								

Each group of students should have a beaker, a scoop and stirring rod, and the conductivity meter.

Begin by filling the beaker with 200 mL of water. Read and record the conductivity on the table under 0 scoops. This is the control. A control is the set up for the experiment with everything the same except the variable you are testing.

Water: Conductivity

Have students add one scoop of their substance to the beaker and stir. Record the conductivity on the data table.



4. Repeat the procedure by adding one scoop each time until all data has been collected.

After the data are collected, have students describe what they have found. What happened as more of their substance was added to the water? Was the hypothesis supported by the data? Was the change in conductivity equal each time or did it change? Was there a point where conductivity did not change?

Explain: Students should see an increase in conductivity as scoops are added. Explain that the meter measures the ability of water to conduct an electric current. When substances dissolve in water to form ions (particles with a positive or negative charge), the conductivity changes.

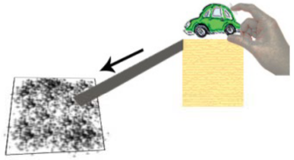
Evaluate / Extend: Ask questions to see if students understand conductivity. What causes conductivity in water? What type of substances change the conductivity of water? Where might these substances come from?

The test can be done again with different substances – some will show a larger change in conductivity and some may show little or no change. The idea is to show that many substances can dissolve in water. In natural waters, such as rivers, streams and lakes some of these dissolved substances may cause problems for people and wildlife.

The conductivity meters can be used to measure the conductivity of natural waters. During a rain event different sources of water could be col-

Forces: Friction

same height as before and measure the rolling distance on the new surface. (If the car rolls past the edge of the surface, be sure to add more of the material so that the car remains on the surface until it stops.) [Discuss]: *Why are all parts of the system unchanged except the surface for the car to roll on?* If the car rolls differently, it must be due to the different surface.



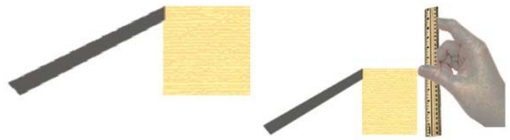
Rolling Distance of Toy Car on Different Surfaces (cm)						
Surface material	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Average
Table top	103	87	98	104	99	98.2
Sandpaper (coarse)	45	47	46	48	48	46.8
Sandpaper (fine)	83	89	95	92	82	88.2
Shelf liner material	33	30	31	32.5	31	31.5

Explain:

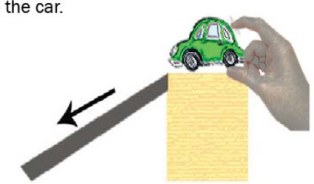
1. Direct students to complete the data table by calculating the average distance the car traveled on each surface.
2. Help them use the data to see which surface allowed the car to travel the farthest distance and which allowed the least distance.
3. Ask students why the car went further on some surfaces than they did on others. Help them identify the force of friction as the influence that caused the car to travel differently on each of the surfaces. The force of friction always acts in a direction that is opposite to the direction of motion. If the motion of the car is to the left, then the friction force is acting from the right.
4. The toy car produces a force due to its motion, which is commonly referred to as kinetic force or momentum. The interaction of these two forces, kinetic and friction, determines the distance that the car moves.

Forces: Friction

will have as it rolls down the ramp. This is a variable that must be constant in our experiment.



2. Place a toy car at the top end of the track and release it to roll down the track and continue across the surface. [Discuss]: *What force is causing the toy car to move down the ramp?* Gravity is pulling the car down the ramp. *How do we know that the force on the toy car is the same each time we release it?* Since the ramp height is not changing, the force of gravity is consistent each time we release the car.



3. Measure the distance from the bottom of the ramp to the stopping point to get the rolling distance for the car. Students may measure to the front end or rear end of the car, but this choice must be the same every time.
4. Repeat the process of releasing the car and measuring the rolling distance for a total of 5 trials. [Discuss]: *Why is it important to release the car without giving it a push?* If we provide a pushing force it will change the speed of the car. *Why do we use the same car in every trial?* Different cars probably do not roll exactly alike. *Why is it important to release the car from the same position on the ramp each time?* The position on the ramp determines the amount of acceleration due to gravity that is acting on the car and, therefore, the speed and kinetic force of the car at the bottom of the ramp.
5. Choose one of the surface materials from the science box and place it at the bottom of the ramp. Release the car from the

Locust Trace Agri-Science Farm

Locust Trace Agri-Science Farm
Barn and Horse Arena

Locust Trace Agri-Science Farm Greenhouse

Locust Trace Agri-Science Farm
Aquaculture

Locust Trace Agri-Science Farm
Getting Ready for Crops

Locust Trace Agri-Science Farm
In-School Veterinary Clinic

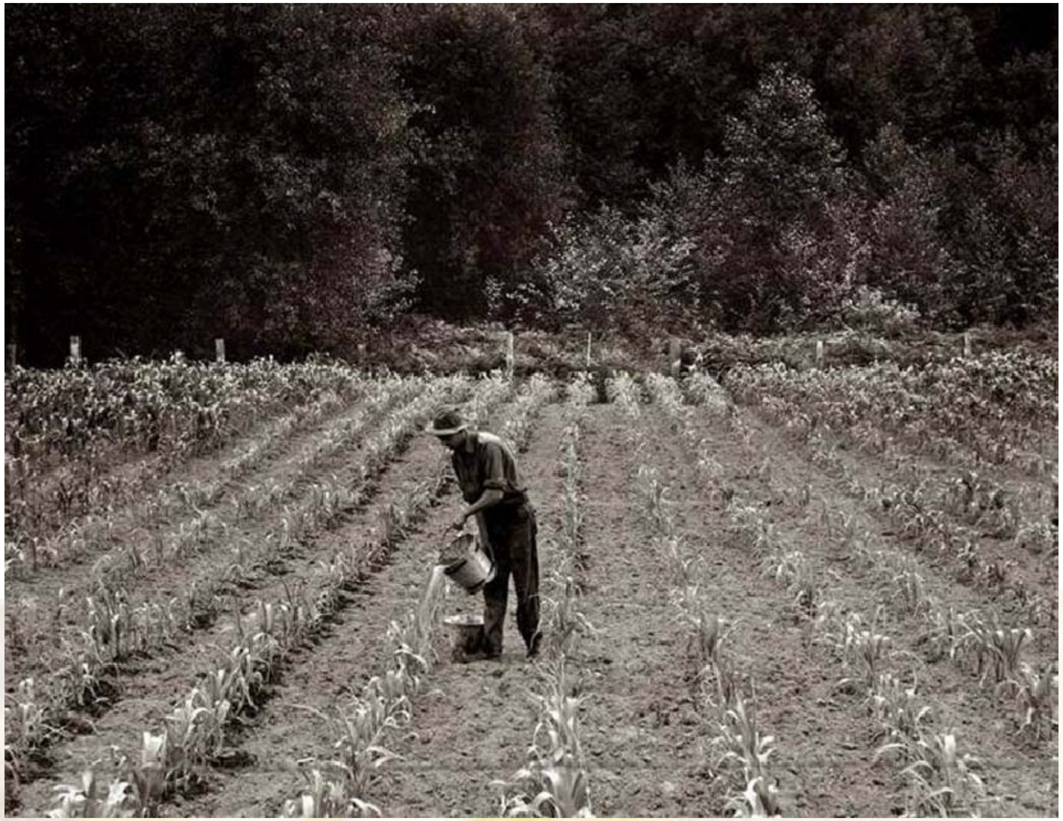
UKAg UK

Henry County, Kentucky

UKAg UK

Livingston County, Kentucky

Knox County, Kentucky



Boone County, Kentucky