STEM & The Three Circle Model

Creating Scientifically Literate Students Through Authentic Agriscience Instruction

By C. Kohn

Michigan State University

2018 National FFA Convention

Welcome!

- **Introductions**
  - Craig: former farm kid, former ag teacher, current researcher, an author of AFNR.
  - Beth: Agriscience Instructor at LHS in Michigan

- **Overview of Today**
  - 1. FACTS Overview (Curric & Research)
  - 2. Firsthand Experiences w/ FACTS
  - 3. Sample Curriculum Activity
  - 4. Future Work on Curric. & Instruction

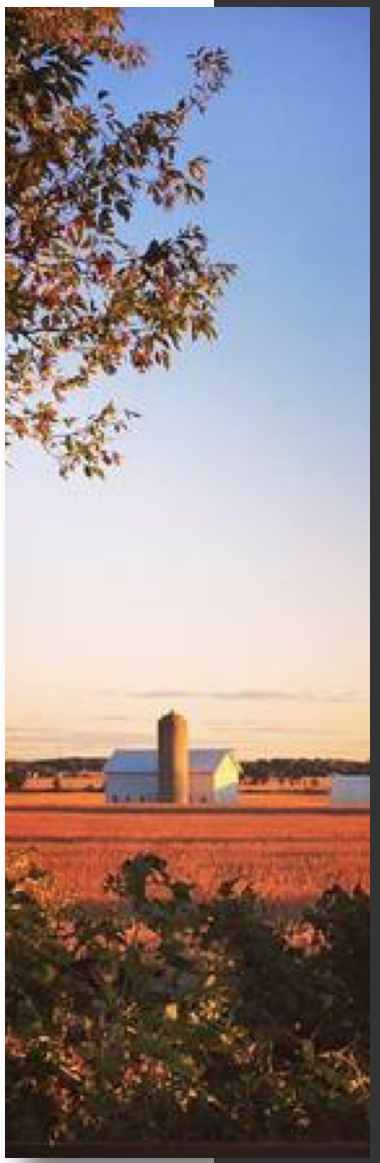
Disclaimers

- **We are not trying to sell you anything!**
  - We are only trying to provide you with examples of options, ideas, and resources that are aligned to national standards and research-based objectives.
- **This is not the only way to do this!**
  - This is *one* approach we are using – other forms of instruction can be effective as well.
- **Ask questions!**
  - Don't be afraid to interrupt us if you need anything.
- **We're going to move quickly in this workshop.**
  - All of these resources are available online for you to access when you have more time (www.factsnsf.org).

Key Concern: Rural Sustainability

- **<u>2050 Challenge</u>: how will we…**
  - produce 70% more food…
  - using fewer acres and less resources…
  - using methods that can be practiced indefinitely…
  - even with a changing climate and a growing population?

- **Success will depend on <u>rural sustainability</u>, which includes:**
  1. Use of resources at rates that do not exceed replenishment.
  2. Prevention of ecosystem degradation.
  3. Development of more secure rural communities.
  4. Improved economic, educational, and social opportunities.

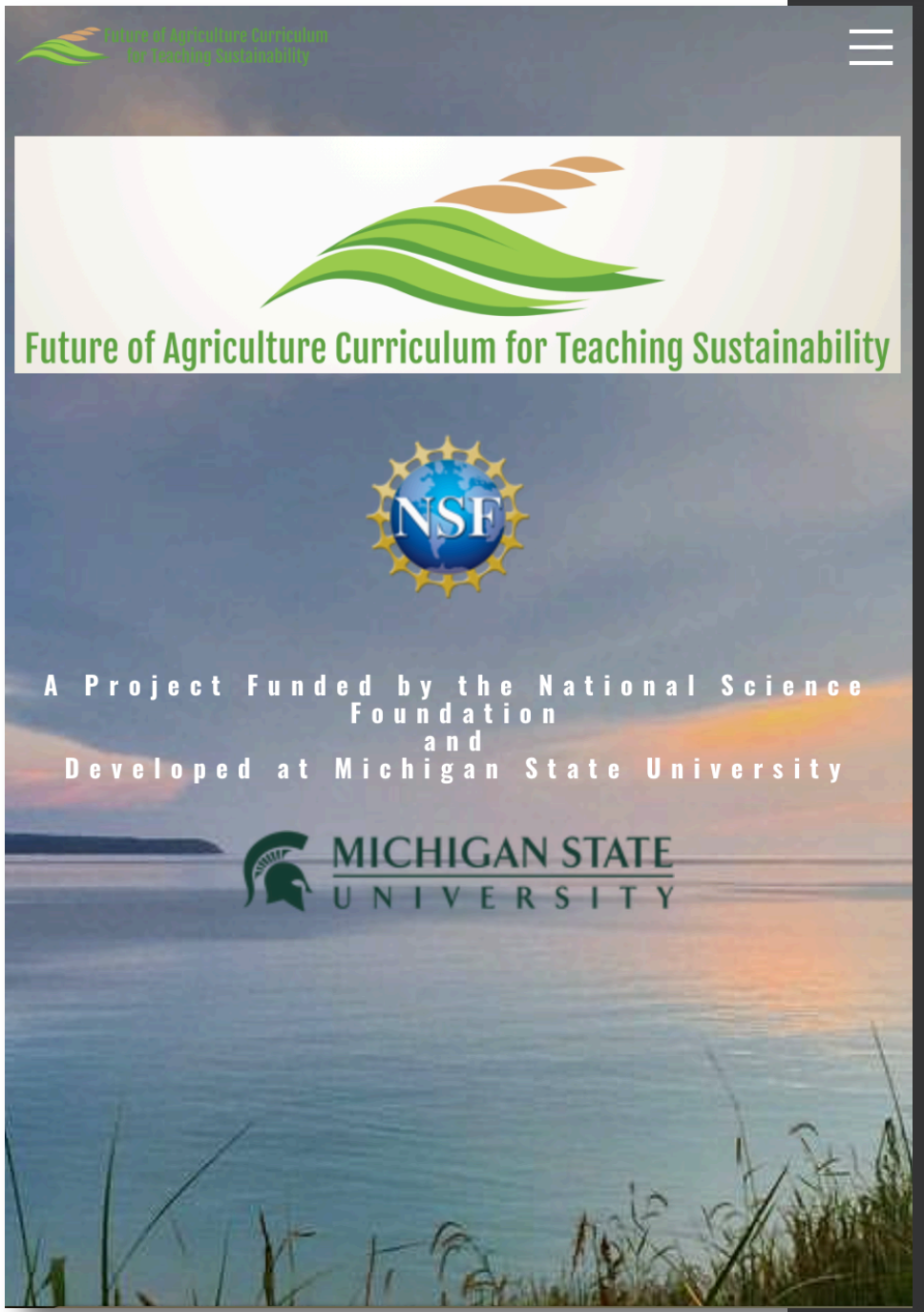


Sustainability & Rural Populations

- **Modern agricultural practices are unlikely to be able to sustain the current level of food production in the long-term.**
  - Current production practices result in **excess soil tillage** (UNL, 2015).
  - This contributes to surface runoff that is the leading cause of **surface water pollution** (CDC, 2016).
  - It also results in rates of **soil erosion** are ten times greater than the rate of soil formation (Trautmann, Porter, & Wagenet, 2012).
  - Adoption of the **Best Management Practices** has been sparse (Mulla, Birr, Kitchen, & David, 2008).

Future of Ag Curriculum for Teaching Sustainability

- **How America will look in 2050 directly depends on how students are being taught today.**
  - How can we teach our students to create a more sustainable future?
- **F.A.C.T.S. reflects one attempt to apply scientific research in order to create a more sustainable generation of agriculturalists.**
  - FACTS is a standards-aligned, multi-semester high school agriscience curriculum.
  - It is freely available online – factsnsf.org



FACTS Courses

- **There are currently three FACTS courses in development.**
  - Natural Resources is currently being tested.
  - Horticulture is entering the development phase.
  - Animal Science will hopefully be completed by 2021.
- **The intent is to eventually develop courses for all career clusters.**
  - …assuming we receive grant funding ;)

FACTS 5-Day Structure

- **Day 1 – Case Study Data & Model Development**
- **Day 2 – Core Ideas & Model Refinement**
- **Day 3 – Inquiry-based Learning & Model Testing**
- **Day 4 – Review & Assessment**
- **Day 5 – Career Connections**

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Week 8 Habitat Loss

Oct 22-26

Monday: Data Dive & Model Development (*Weekly Packet - Word / PDF*)

Tuesday: Notes (PPT / PDF) & Class Discussion

Wednesday: Lab Activity (*see packet*)

Thursday: Assessment

Friday: Career Connections - Cover Letters (*SCE Packet -* Word/PDF)

Week 9 Invasive Species

Oct 29-Nov2

Monday: Data Dive & Model Development (*Weekly Packet - Word / PDF*)

Tuesday: Notes (PPT / PDF) & Class Discussion

Wednesday: Lab Activity (*see packet*)

Thursday: Assessment

Friday: Career Connections - Peer Reviews of Resumes & Cl

(*SCE Packet -* Word/PDF)

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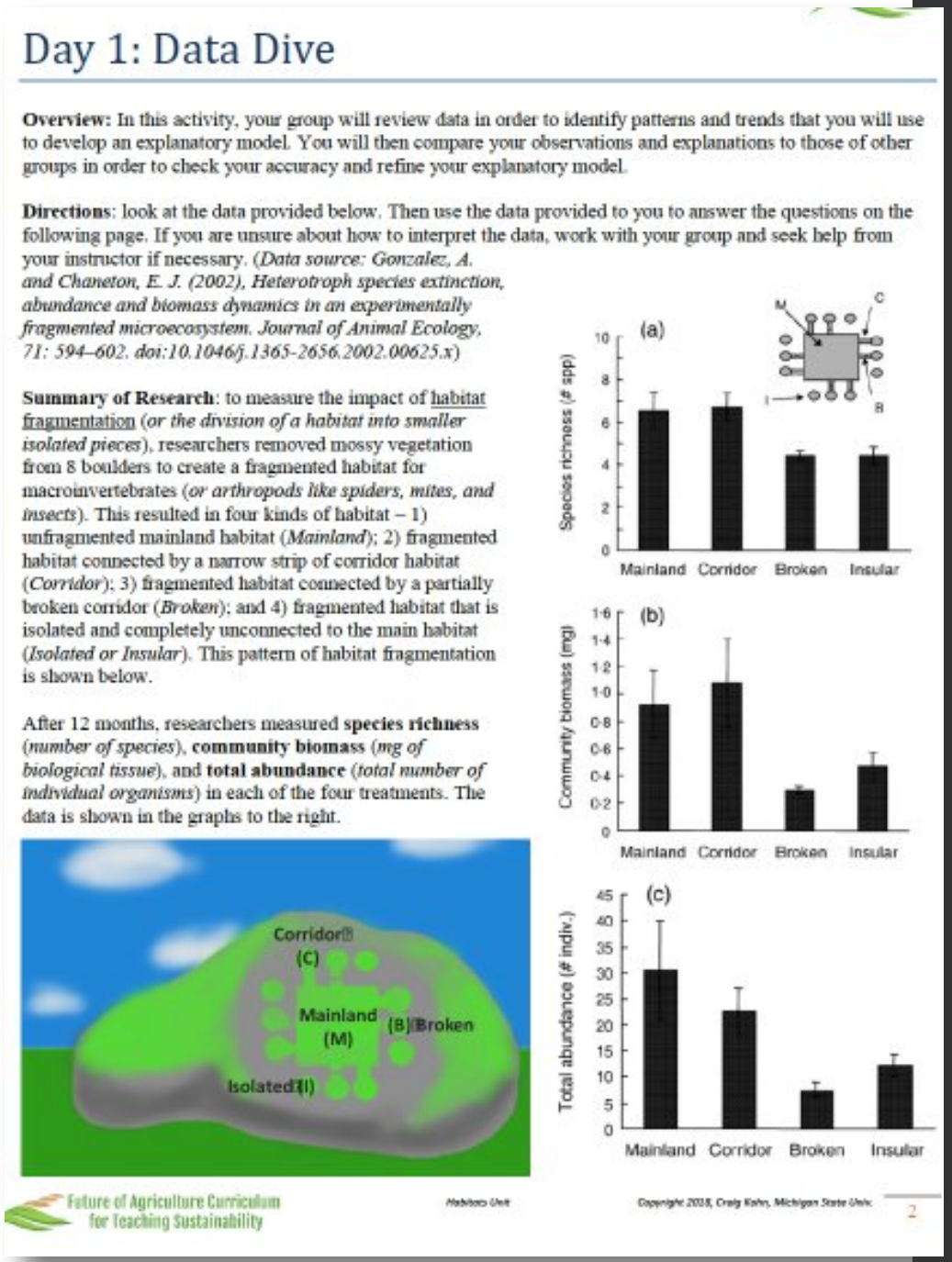
Models & Argumentation

- Each week utilizes case studies featuring actual quantitative data from scientific studies.
- Students are coached in using data to develop explanatory models.
- These models are then connected to specific real-life scenarios.



Day 1: Data Dive

Overview: In this activity, your group will review data in order to identify patterns and trends that you will use to develop an explanatory model. You will then compare your observations and explanations to those of other groups in order to check your accuracy and refine your explanatory model.

Directions: look at the data provided below. Then use the data provided to you to answer the questions on the following page. If you are unsure about how to interpret the data, work with your group and seek help from your instructor if necessary. (*Data source: Gonzalez, A. and Chaneton, E. J. (2002), Heterotroph species extinction, abundance and biomass dynamics in an experimentally fragmented microecosystem. Journal of Animal Ecology, 71: 594–602. doi:10.1046/j.1365-2656.2002.00625.x*)

Summary of Research: to measure the impact of habitat fragmentation (*or the division of a habitat into smaller isolated pieces*), researchers removed mossy vegetation from 8 boulders to create a fragmented habitat for macroinvertebrates (*or arthropods like spiders, mites, and insects*). This resulted in four kinds of habitat – 1) unfragmented mainland habitat (*Mainland*); 2) fragmented habitat connected by a narrow strip of corridor habitat (*Corridor*); 3) fragmented habitat connected by a partially broken corridor (*Broken*); and 4) fragmented habitat that is isolated and completely unconnected to the main habitat (*Isolated or Insular*). This pattern of habitat fragmentation is shown below.

After 12 months, researchers measured **species richness** (*number of species*), **community biomass** (*mg of biological tissue*), and **total abundance** (*total number of individual organisms*) in each of the four treatments. The data is shown in the graphs to the right.

Why Model-based Learning?

- **This form of model-based instruction has two key goals:**
  - **<u>Science Literacy</u>**: ability to understand, judge, and use science in productive and scientifically aligned ways
  - **<u>Sense-making</u>**: the ability to use evidence, logic, and argumentation to reach sound, valid conclusions.

How? Next Generation Science Standards

NEXT GENERATION SCIENCE STANDARDS
For States, By States

Have **broad importance** across multiple sciences or engineering disciplines or be a **key organizing concept** of a single discipline

What scientists do.

Science and Engineering Practices

- Asking questions (for science) and defining problems (for engineering)
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations (for science) and designing solutions (for engineering)
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information.

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

What scientists know.

Disciplinary Core Ideas

Physical Sciences
PS1: Matter and its interactions
PS2: Motion and stability: Forces and interactions
PS3: Energy
PS4: Waves and their applications in technologies for information transfer

Life Science
LS1: From molecules to organisms: Structures and processes
LS2: Ecosystems: Interactions, energy, and dynamics
LS3: Heredity: Inheritance and variation of traits
LS4: Biological evolution: Unity and diversity

Earth and Space Sciences
ESS1: Earth's place in the universe
ESS2: Earth's systems
ESS3: Earth and human activity

Engineering, Technology, and Applications of Science
ETS1: Engineering design
ETS2: Links among engineering, technology, science, and society

How scientists think.

Crosscutting Concepts

- Patterns
- Cause and effect: Mechanism and explanation
- Scale, proportion, and quantity
- Systems and system models
- Energy and matter: Flows, cycles, conservation
- Structure and function
- Stability and change

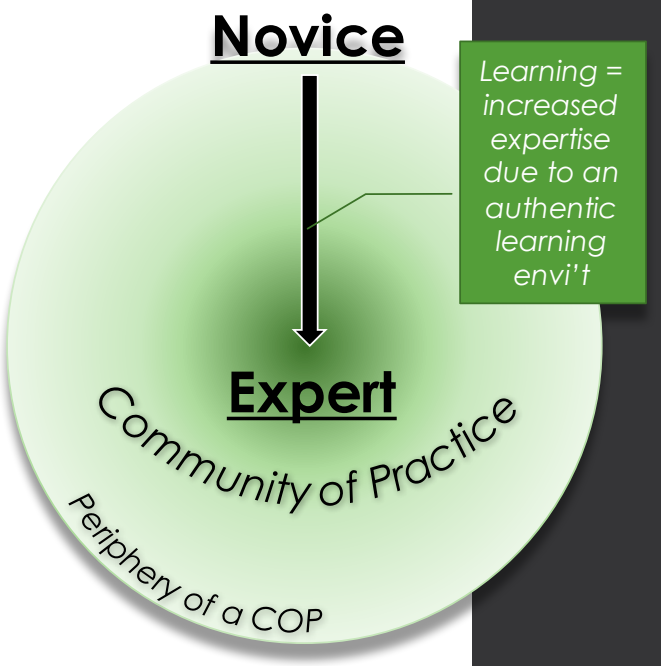
Crosscutting concepts have application across all domains of science

- **NGSS are meant to guide science instruction to increase the development of science literacy and sensemaking.**
  - This is achieved through 3D science learning →

-The National AFNR standards are cross-walked with NGSS.

3-D Science Ed w/ 3 Circle Ag Ed

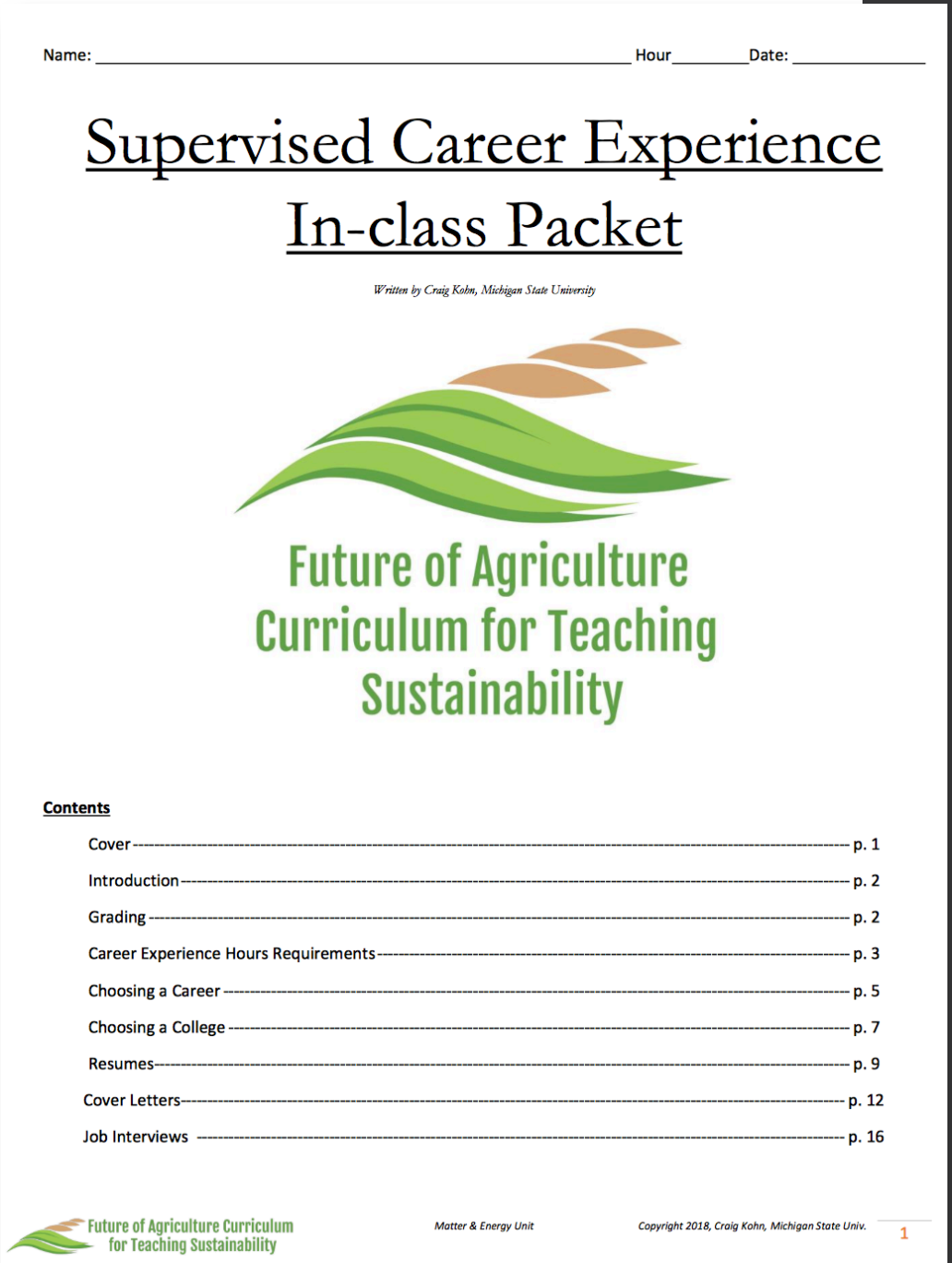
- **Science literacy and sense-making likely depend on more than just classroom instruction.**
  - Lave and Wenger (1991) suggested that most meaningful learning actually happens in authentic informal interactions outside of classrooms.
- **Lave & Wenger define *learning* as:**
  - 1) a change in identity…
  - 2) as a student moves from being a novice to an expert…
  - 3) in a specific community of practice.
- **Ag Ed has a time-tested instructional model reflective of these ideas.**
  - We should consider using this approach for more than just creating new career professionals.



FACTS & SAEs

- **FACTS uses SAEs as a graded component of the instruction.**
  - Science learning must be place-based and authentic to be impactful.
- **FACTS utilizes the Supervised Career Experience packet* to guide students in their SAEs:**
  - Each student shadows community professionals for 15+ hours and develops a college & career portfolio.
  - These experiences also inform classroom discussion on curricular topics.

**A product of the National Council for Ag. Education*



Name: _____ Hour_____ Date: _____

Supervised Career Experience In-class Packet

Written by Craig Kohn, Michigan State University

Future of Agriculture Curriculum for Teaching Sustainability

Contents

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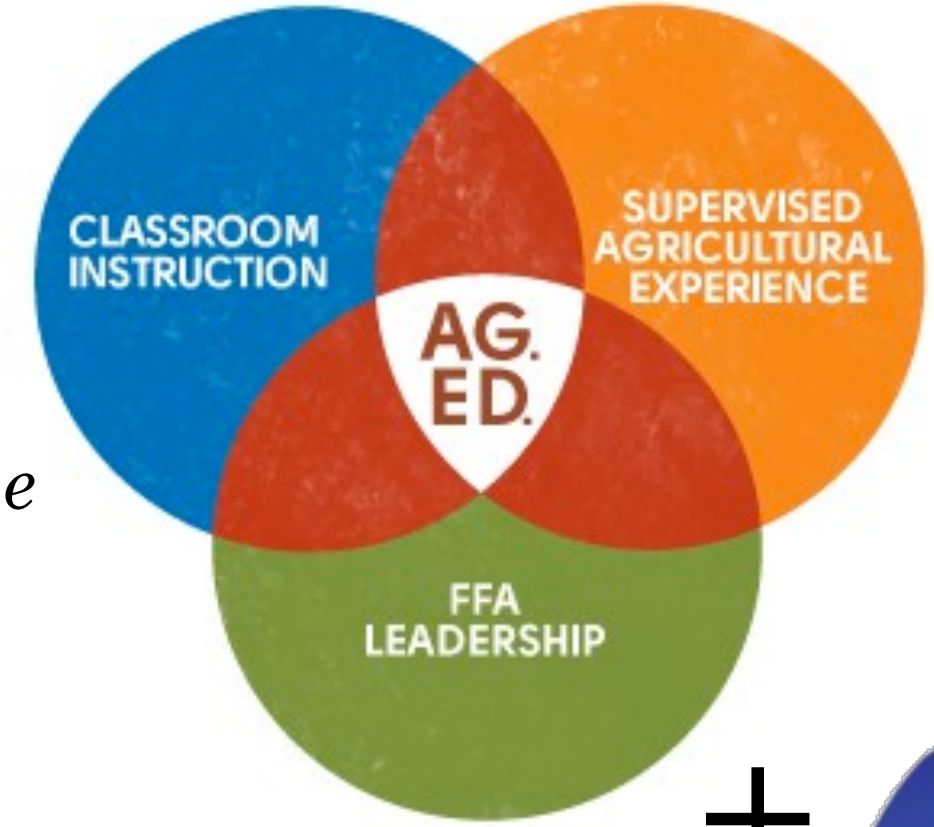
The 3-Circle Model

- **The key question:**

  Can we create a more sustainable and productive generation of agriculturalists by combining 3-D Science Learning w/ the Three Circle Model of Ag Ed?

- **The goal of FACTS research is to provide data on this question.**



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Questions & Discussion

FACTS in Practice: Laingsburg HS, MI

Firsthand reflections of how FACTS worked in a classroom based situation.

FACTS at LHS

- **Preparing to teach FACTS.**
  - *How did you prepare to teach in this way?*
- **Week-by-week experiences.**
  - *How did your experiences change over this semester?*
- **Student reactions.**
  - *How did your students' respond to this kind of instruction?*
- **Changes to student performance.**
  - *What changes did you observe in your students?*
- **Impact on teaching practices.**
  - *What did you learn about teaching and learning from being a part of this research? How did it change your teaching?*

Questions & Discussion

FACTS Curriculum: Hands-on Activity

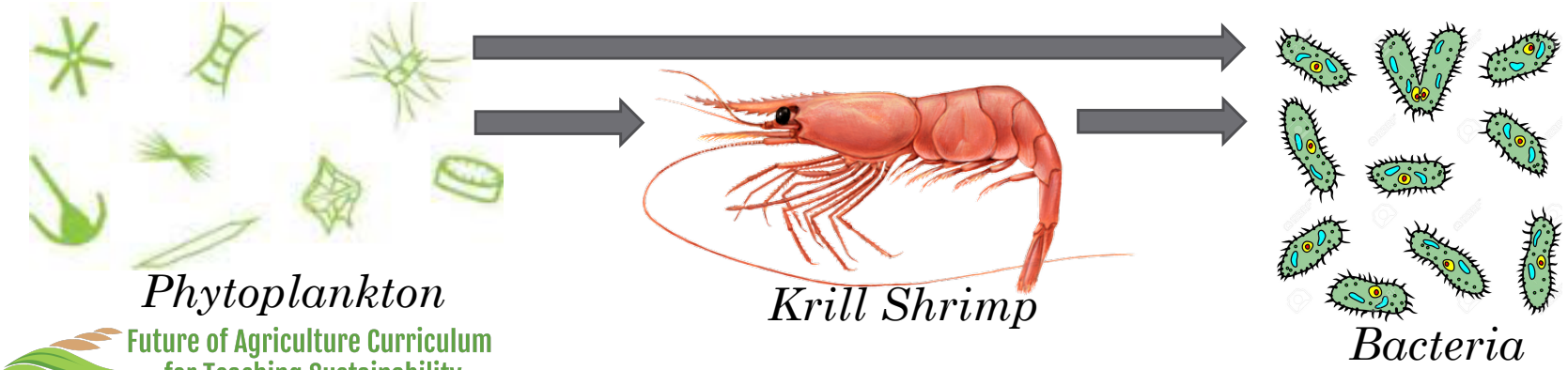
Experiencing Learning in FACTS Firsthand

Activity Overview

- **Section 1: Why Biodiversity Matters**
- **Week 4: Ecosystems & Biodiversity**
- **Schedule:**
  - Monday: Bioreactor Ecosystems & Model Development
  - Tuesday: Core Ideas: Video, Notes, & Model Refinement
  - Wednesday: Revisit Ecosystems, Meadow Simulation
  - Thursday: Review & Assessment
  - Friday: Career Connections

Monday: Case Study & Model Development

- **Overview:** phytoplankton (*producers*), krill shrimp (*consumers*), and bacteria (*decomposers*) are combined in a saltwater ecosystem inside a sealed container.
- Students use this tabletop ecosystem as a simplified model to understand how more complicated ecosystems function.
- Students attempt to understand and explain the relationship between biodiversity, ecosystem services, and ecosystem resilience.



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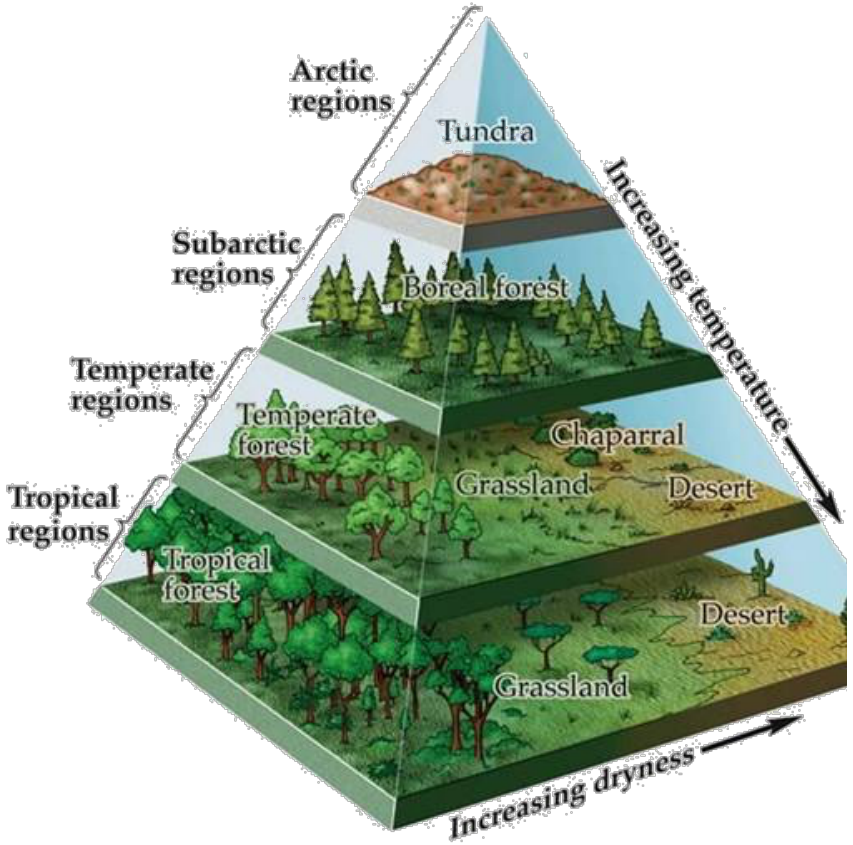
Monday: Case Study & Model Development

- 1) If we permanently sealed this ecosystem, could it keep functioning for a long period of time? Explain.
- 2) Will your sealed ecosystem eventually run out of oxygen or carbon atoms? Explain.
- 3) What is most important in this ecosystem – the phytoplankton, shrimp, or bacteria? Why? Could one exist without the others?
- *4)* Is your bioreactor ecosystem very biodiverse? Explain.
- 5) A *resilient* ecosystem is one that can recover from disturbances. Do you think that this bioreactor ecosystem is resilient? Why or why not?
- *6) Ecosystem services* are the benefits that an ecosystem can provide (*nutrient cycling, water purification, food production, etc.*). How do you think that the level of biodiversity and level of resilience in your ecosystem affects the ability of your ecosystem to provide these services?

Classroom Argumentation & 9 Talk Moves

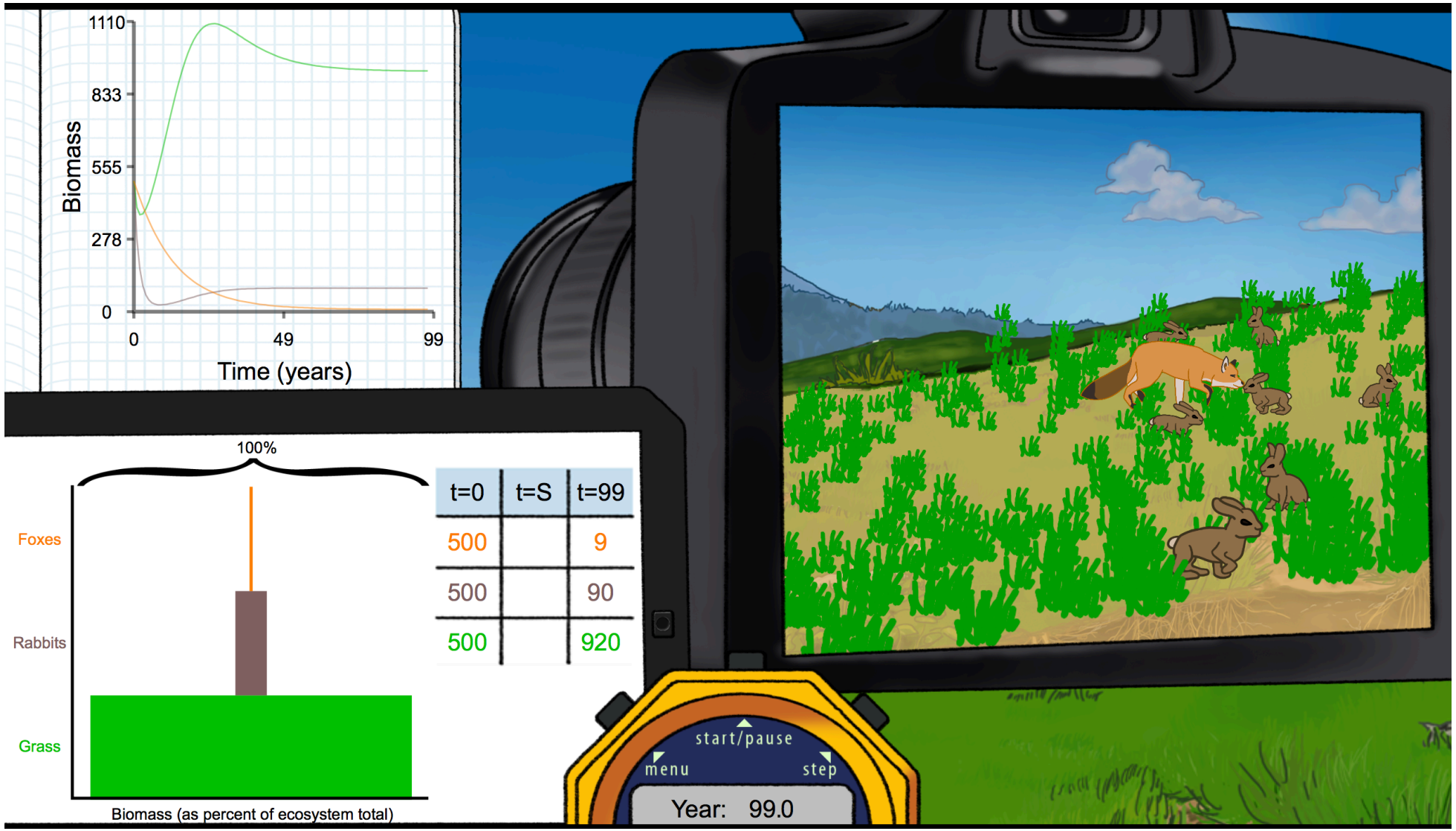
- **Goal: Individual students share, expand and clarify their own thinking**
  - 1. Time to Think: Partner Talk/Writing as Think Time/Wait Time
  - 2. Say More: "Can you say more about that?" "What do you mean?"
  - 3. So, Are You Saying…?: Paraphrasing Student Responses.
- **Goal: Students listen carefully to one another**
  - 4. Who Can Rephrase or Repeat That?
- **Goal: Students deepen their reasoning**
  - 5. Asking for Evidence or Reasoning: "Why do you think that?" "What's your evidence?" "How did you arrive at that conclusion?" "Is there anything that made you think that?"
  - 6. Challenge or Counterexample: "Does it always work that way?" "How does that idea square with Sonia's example?" "What if it had been a copper cube instead?"
- **Goal: Students think with others**
  - 7. Agree/Disagree and Why?: "Do you agree/disagree? (And why?)" "Does anyone want to respond to that idea?"
  - 8. Add On: "Who can add onto the idea that Jamal is building?" "Can anyone take that a little further?"
  - 9. Explaining What Someone Else Means: "Who thinks they could explain in their words why Simon came up with that answer?" "Why do you think he said that?" Source: https://www.nsta.org/conferences/docs/2015SummerInstituteElementary/NineTalkMovesFromTERC.pdf

Tuesday – Core Ideas & Model Refinement



Warm temperatures, sufficient moisture, and adequate levels of sunlight increase rates of photosynthesis.	Greater rates of photosynthesis lead to more production of biomass via biosynthesis.	Increased levels of plant biomass allow for more living organisms to exist.	More living organisms enables more biodiversity to emerge through mutations & natural selection.	More biodiversity results in greater ecosystem function and ecosystem resilience.
During photosynthesis, light energy is used to rearrange H_2O & CO_2 molecules into glucose and oxygen molecules. The light energy is transferred to chemical energy in the molecular bonds of glucose & oxygen. Warmer, wetter, and sunnier conditions allow for greater rates of photosynthesis.	The glucose produced during photosynthesis can serve two purposes. During cellular respiration, glucose and O_2 are formed back into H_2O & CO_2. The chemical energy is moved to ATP. During biosynthesis, the glucose is used to produce more plant tissue (biomass).	Most consumed biomass is converted to H_2O & CO_2 through cell respiration (10% rule). Most energy eventually dissipates into space as heat. Because plants are the original source of all energy & biomass, the greater the plant biomass, the greater the variety of species that can exist (biodiversity).	The proteins in the cells of living organisms give rise to their visible traits. Proteins are assembled based on genes in a cell's DNA. Mutations change genes, proteins and traits. Beneficial mutations improve the survival of some individuals (natural selection) and can jointly result in new species (evolution).	Greater levels of biodiversity enable an ecosystem to provide greater amounts of ecosystem services, which increases ecosystem function. More biodiversity also increases the resilience of an ecosystem. Losses to biodiversity reduce ecosystem function and resilience.

Wednesday- Inquiry-Based Investigations



Thursday – Review & Assessment

1. **How does the rate of biomass production relate to biodiversity and to ecosystem function?**
2. **How does biodiversity affect the resilience or fragility of an ecosystem?**
3. **What are ecosystem services and why are they vital to the existence of humans and other species?**
4. **Where does biodiversity come from? How do new species form?**
5. **How do the genes, proteins, and mutations relate to the adaptation or extinction of a species?**

Friday – Career Connections

- **Directions:**
  - Form groups based on similar career interests.
  - Address the following questions as a group
  - Be prepared to discuss as a class.
- **Questions:**
  1. Summarize what we learned this week (*in your own words*). What questions do you still have?
  2. What were the most important things to remember from this week?
  3. How might your daily activities in this future career be affected by these concepts?
  4. How might the decisions you make as part of this career be influenced by these ideas?
  5. How might your future career increase or decrease biodiversity?

Next Steps

- **All curricular materials are available for free – visit www.factsnsf.org.**
  - Email me to get a copy of the answer keys – kohncrai@msu.edu.
- **Volunteers will be needed to test the FACTS curriculum next year (and get paid for it!)– if interested, sign up at www.factsnsf.org**
  - Publication opportunities are also available if you would like to collaborate on writing for research journals.
- **Additional courses and materials are coming. Stay tuned for more details!**

Please visit our website:

www.factsnsf.org

Questions? Email me – kohncrai@msu.edu

Thank you for coming! Please complete a workshop review!

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