The ESA’s Four-Dimensional Ecology Education Framework (4DEE):
Opportunities and Challenges
January 24, 2019
Our Vision for the Webinar

• Leadership in the field of ecology education
  • ESA endorsement of the 4DEE Framework
  • Dissemination of the Framework

• Building on, extending and celebrating the Framework
Importance of ESA-Endorsed Curricular Framework

- ESA: largest professional society in ecology
- Excellent ecology teaching essential for ...  
  - effective and diverse ecology workforce  
  - environmental decision-making
- Help ESA members incorporate society-relevant content
- Fill gap in college-level resources for ecology teaching
- ESA endorsement validates program enhancement

4DEE Framework can help with all of these goals
Schedule of the Webinar

• Introducing the 4DEE – Alan Berkowitz

• Engaging non-majors in ecology: Aligning lesson plans using 4DEE – Luanna Prevost

• 4DEE and Course-Based Undergraduate Research Experiences (CUREs) – Amanda Sorensen

• How do we assess multiple dimensions of student learning? - Diane Ebert-May

• Wrap up and next steps – Pam Templer
Alan Berkowitz –
Introducing the 4DEE
Various attempts to define ecological literacy.

Klemow – 1991

Orr – 1992

Berkowitz et al. 2005

Jordan et al. 2009

McBride 2011

McBride et al. 2013
What should people know, feel or be able to do to be ecologically literate?

- Science Process, Thinking Skills, 728
- Identification, Natural History, 178
- Attitudes, Feelings, 288
- Human Ecology Concepts, 2937
- Ecology Concepts (not humans), 3509

Number of Coded Elements in Major Categories (n total = 7656)

ESA 2007 Member Survey (n = 1032)
ESA 2015 Fundamental Concepts / 4DEE Task Force

• George Middendorf, Howard University
• Bob Pohlad, Ferrum College

• Alan Berkowitz, Cary Institute of Ecosystem Studies
• Carmen Cid, Eastern Connecticut State University
• Jennifer Doherty, University of Washington
• Ken Klemow, Wilkes University
• Diane Ebert-May, Michigan State University
• Teresa Mourad, Ecological Society of America
Three Dimensions:
1. Disciplinary Core Concepts
2. Crosscutting Concepts
3. Science Practices
4DEE Ecology Education Framework

Core Ecology Concepts
classical ecological hierarchy
e.g., population, ecosystem

Ecology Practices
doing and critiquing ecology
e.g., fieldwork, modeling

Human-Environment Interactions
human dependency and impact
e.g., climate change, services, ethics

Cross-Cutting Themes
ways-of-thinking, unifying ideas
e.g., evolution, space, structure/function
Many Challenges for Scientists and Educators

Defining learning outcomes – for each sub-element, and for integration across dimensions.

Exploring effective teaching strategies and course sequences.

Developing useful tools for measuring student progress and attainment.
Luanna Prevost –
Engaging non-majors in ecology:
Aligning lesson plans using 4DEE
Engaging non-majors in ecology: Aligning lesson plans using 4DEE

Causes and Impacts of Declines in Bee Diversity
Course Context

- Non majors introductory biology course
- ~180 students each semester
- Meets in an auditorium with fixed seating

Activities
- Small group work
- Clickers
- Worksheets
- Online homework

<table>
<thead>
<tr>
<th>Major</th>
<th>% enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arts &amp; Humanities</td>
<td>4</td>
</tr>
<tr>
<td>Biomedical &amp; Health Sciences</td>
<td>14</td>
</tr>
<tr>
<td>Business</td>
<td>29</td>
</tr>
<tr>
<td>Education</td>
<td>5</td>
</tr>
<tr>
<td>Engineering</td>
<td>2</td>
</tr>
<tr>
<td>Social &amp; Behavioral Sciences</td>
<td>22</td>
</tr>
<tr>
<td>Other</td>
<td>23</td>
</tr>
</tbody>
</table>
Causes and Impacts of Declines in Bee Diversity

Case overview

• Students examine causes and impacts of bee decline on the environment and implications for society

• Based on literature: article in *Frontiers in Ecology and the Environment*

• Activities: Worksheets, Clicker questions

• Assessments
  • In Class: Open-ended questions and clicker question
  • Homework: Multiple-choice questions
  • Exam: Multiple-choice questions
Aligning the lesson plan using 4DEE

- Alignment improves learning outcomes

Fink 2003; Wiggins and McTighe 2005; Momsen et al. 2010; Jensen et al. 2014
4DEE approach to understanding causes and impacts of a decline in bee diversity
Learning Objectives

• Identify, explain, give examples ecological interactions between organisms

• Interpret data to deduce ecological interactions

• Interpret food webs to determine energy flow with an ecosystem

• Apply the skills and concepts above to describe potentials causes and impacts of a decline in bee diversity
Instructional Activities: Small groups with reporting out

1. Brainstorming
   Setting the Context and Real World Challenge
   • Why are bees important to people?
   • What are potential causes of bee declines?
   • What are potential impacts?
   • How can we reduce or stop this decline?

2. Data interpretation

3. Integration of data

4. Making predictions and recommends (using content knowledge and data)
2. Interpret data from primary literature

What does the map tell you about the distribution of *Bombus affinis*?

How do pesticides affect queen bee production? What impact can this have on bee populations?

Dave Goulson et al. Science 2015;347:1255957

3. Integration of data:

Small group discussion: What happens when bees face multiple stressors?

Clicker question: Bee mortality when both fungus and pesticides are present is ______ than when either fungus or pesticide alone is present.

A. lower than
A. higher than
A. the same as

4. Making predictions and recommendations (using content knowledge and data)

Based on your readings, can you describe the interaction between bees and
a) spiders?
b) birds?
C) coffee plants?

Describe the impact of the removal of bees on
a) spider populations?
b) lizard populations?
C) coffee plant populations?
Assessment

• Assessments directly related to bee diversity
  • Open ended responses
  • Clicker questions
  • Exam multiple-choice questions

• Application to a similar context – Coral Diversity
  • Homework and Exam multiple-choice questions
A study published in 2018 examined the effects of glyphosate on bees. Glyphosate is one of the main herbicide used for weed control around the world. It works by inhibiting the function of some enzymes found in plants and microorganisms, like bacteria.

Thus, glyphosate has the potential to affect the microbes that live in the guts of bees.

Scientist wanted to find out the effect of glyphosate on the bacteria in young worker bees. They treated one group of bees with glyphosate (T) but did not treat the other group (T).

One of the bacteria studied was S. alvi (Figure 1). Which statement best describes the change in relative abundance of S. alvi?

A. S. alvi bacteria became less resistant
B. There was less S. alvi bacteria compare to other types of bacteria found.
C. The total number of S. alvi bacteria decreased.
D. There were fewer species of S. alvi bacteria.

Figure 1. Abundance of S. alvi bacteria
Outcomes

5 multiple-choice questions on ecological interactions and food webs

Effect size:
Cohen's d = 0.4

“I have NEVER understood science and have always done poorly in science classes until this semester”

“..relates to my every day life in the food i eat”
Amanda Sorensen –
4DEE and Course-Based
Undergraduate Research Experiences (CUREs)
Context

• Fall 2017
  • 4 class sessions (3 hours each)
  • 4 week independent research time
• 30 Students
  • Freshman-Senior level
• Majority Natural Resource Majors
  • Mathematics, Hospitality, English

Photo credit: World Wildlife Fund
CURE-Auchincloss et al. 2014
Learning Objectives

• Identify and explain human influence in prairie canid communities
• Develop and implement research protocol
• Interpret data to inform model of prairie system
• Generate and use model to explain impact of canid + human interactions on swift fox
Models as Classroom Supports

PMC-2E Conceptual Framework:
P- Phenomenon
M- Mechanism
C- Components
E- Evidence
E- Explanation

*Based on SBF Models

Gray et al. 2013
Jordan et al. 2014
Models as Assessments

1. Open-ended reflection
   – Explain relationships (mechanisms) between components in their models
   – Describe predicted impact on system before running a scenario
Models as Assessments

1. Open-ended reflection
   – Explain relationships (mechanisms) between components
   – Describe predicted impact on system before running a scenario
Models as Assessments

1. Open-ended reflection
   - Explain relationships (mechanisms) between components
   - Describe predicted impact on system before running a scenario
2. Run a scenario
Models as Assessments

1. Open-ended reflection
   - Explain relationships (mechanisms) between components
   - Describe predicted impact on system before running a scenario

2. Run a scenario

3. Open-ended reflection
   - Identify direct and indirect relationships
   - Justify scenario output
Models as Assessments

Student Individual + Group Models

Wildlife Biologists Model
Class 1

<table>
<thead>
<tr>
<th>Topic</th>
<th>Activity</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community Ecology- prairie systems</td>
<td>-Lecture</td>
<td>-Multiple Choice Quiz</td>
</tr>
<tr>
<td></td>
<td>-Model Building</td>
<td>-Student Models</td>
</tr>
</tbody>
</table>
# Class 2

## Topic

<table>
<thead>
<tr>
<th>Anthropogenic Influences</th>
</tr>
</thead>
</table>

## Activity

- Primary Literature
- Group Discussion
- Model Revisions

## Assessment

- Open-Ended Reflection
- Student Models

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Student Research

-supported by literature and models
-reviewed by professional ecologist
-revisions + justification

<table>
<thead>
<tr>
<th>Topic</th>
<th>Activity</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Planning and Data Collection</td>
<td>-Research Planning Framework</td>
<td>-Data collection</td>
</tr>
<tr>
<td></td>
<td>-Discussion with professional ecologist</td>
<td>-Research Plan</td>
</tr>
<tr>
<td></td>
<td>-Camera Trapping</td>
<td>Justification</td>
</tr>
</tbody>
</table>

Plan for camera trap deployment and data collection.
5 points - due at the beginning of class, Sept 25th for Monday section or 27th for Wednesday section
Name: __________________________

1) Cameras should be deployed between September 29th and November 26th, 2017. Cameras should be deployed for at least 10 nights, but can be out for 14 days.

Dates of camera trap deployment: __________________________

Date to obtain the cameras: __________________________

Date to return the cameras: __________________________

Before you pick up the cameras, please email Jessie Hall, halljr93@gmail.com, to confirm the camera pick up. Cameras will be picked up and dropped off in 200 Hardin Hall.

2) Location of camera trap deployment: __________________________

Please be as specific as you can.

GPS coordinates of the property: __________________________
(You can use Google Maps to find coordinates http://www.gps-coordinates.net/ or the “compass” app on an iPhone, or other similar app, when you are on the property.)

3) Draw a map of your property. Use Google Maps in “map” view and “earth” view to sketch out the property. Label each section of the property with the associated land cover (tall grass, mowed grass, short grass, grass & shrubs, tree cover, corn crop etc), being as specific as you can. Label any road, structure or waterway. Draw in any fences, telephone or electric posts or any structures present that you could attach the camera to. Add an indicator of scale. See the back of the page for an example. When you visit the land, “prove” the map by validating that the vegetation cover that exists in various locations on your map. (When you are collecting the camera trap data, you will need to be more specific about the vegetation around the camera trap.)

4) A. Decide where to place the camera traps. Where do you think canid species might be found on your property (your hypothesis)? Why?
### CAMERA TRAP STATION RECORD FORM

<table>
<thead>
<tr>
<th>Date:</th>
<th>Data collector(s) name(s):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station ID:</td>
<td>Start date:</td>
</tr>
<tr>
<td>Camera ID:</td>
<td>End date:</td>
</tr>
<tr>
<td>UTM Coordinates:</td>
<td>Easting</td>
</tr>
<tr>
<td>Proximity to road/trail (m):</td>
<td>Type of road:</td>
</tr>
<tr>
<td>Vegetation height (average height in 5 m circle around the camera):</td>
<td>□ &lt; 30 cm (12 in)</td>
</tr>
<tr>
<td>Vegetation type or dominant cover 5 m (~16 ft) around the camera:</td>
<td>Grass: □ Mixed grass □ Shortgrass □ Tallgrass</td>
</tr>
<tr>
<td>Dominant cover ~ 0.5 mi around the camera station:</td>
<td>□ Crop □ Grass □ Other:</td>
</tr>
<tr>
<td>Comments/Observations:</td>
<td></td>
</tr>
</tbody>
</table>

38
<table>
<thead>
<tr>
<th>Topic</th>
<th>Activity</th>
<th>Assessment</th>
</tr>
</thead>
</table>
| Data Analysis | -Data crunching session with wildlife biologist  
              | -Model Revisions             | -Brief report on findings from research  
              |                                | -Open-Ended Reflection        |
|               |                                 | -Student Models             |

### Student Data -> Swift Fox Distribution Model

![Data Analysis Spreadsheet](image1)

![Fox Distribution Map](image2)
Class 4

<table>
<thead>
<tr>
<th>Topic</th>
<th>Activity</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group Consensus Model</td>
<td>-Model Building</td>
<td>-Open-Ended Reflection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Student Models</td>
</tr>
</tbody>
</table>

[Diagram showing interactions between various elements such as Road Developments, Developing Towns, Agriculture, Swift Fox Population, Habitat, Predation, Prairie Dog, Road traffic, Prairie Dogs, Coyote, Dens, Humans, Grassland habitat, Land use change, Coyote population, Number of Roads, Coyote population, Competition, Greenhouse Gas Emissions, Insects and other prey population, Urbanization, Prairie dog population, Coyotes, Roadways, and Swift Fox Population].
How much did you GAIN in the following areas as a result of your most recent research experience?

<table>
<thead>
<tr>
<th>Area</th>
<th>No gains</th>
<th>A little gain</th>
<th>Moderate gain</th>
<th>Good gain</th>
<th>Great gain</th>
<th>Not applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analyzing data for patterns</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Figuring out the next step in a research project</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Problem-solving in general</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Using a model to develop a hypothesis or prediction</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Formulating a research question that could be answered with data</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Identifying limitations of research methods and designs</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Understanding the theory and concepts guiding my research project</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Understanding the connections among scientific disciplines</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Understanding the relevance of research to my coursework</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

Undergraduate Research Student Self-Assessment (URSSA) (Weston and Laursen 2015)
How do we assess multiple dimensions of student learning?
How do we assess multiple dimensions of student learning?

Diane Ebert-May
Department of Plant Biology
Michigan State University

24 January 2019
4-Dimensional Ecology Education

- Ecology Practices
- Human-Environment Interactions
- Ecology Concepts
- Cross-Cutting Themes
Where do we start?
Core Concept in Ecology
Energy Flow – Nutrient Cycling

Carbon Cycle

- Burning fossil fuels
- Plants, animals respiring
- Dissolved CO2 from ocean released
- Plants photosynthesize

Carbon stored in
- Atmosphere
- Vegetation
- Soil
- Old carbon (old vegetation)
- Storms bury carbon in sediment in ocean

Bacteria, fungi breakdown dead plants, animals
What should students do with this Big Idea?
Create Learning Objectives that Use Science Practices and Core Concepts
Model the flow of carbon through an ecosystem and use the model to predict the consequences of increased temperature on primary productivity.
Three-Dimensional Learning Assessment Protocol: 3D – LAP

Three-Dimensional Learning Assessment Protocol: 3D – LAP

1. Characterize assessment questions
2. Develop/modify assessments
3D-LAP Developing and Using Models: *Constructed Response*

1. Question gives an event, observation, or phenomenon for the student to explain or make a prediction about.

2. Question gives a representation or asks student to construct a representation.

3. Question asks student to explain or make a prediction about the event, observation, or phenomenon.

4. Question asks student to provide the reasoning that links the representation to their explanation or prediction.
The Arctic Ocean is home to a diverse community of organisms, supported by primary producers - algae – that use sunlight (energy) and carbon dioxide to produce carbohydrates (matter) through photosynthesis, just like plants. This ecosystem is seasonal, with high levels of primary productivity (NPP) during the summer, when sea ice melts and liquid ocean water is exposed to the air, and low NPP during the rest of the year, when the ocean surface is frozen as sea ice....
What do we know about students’ thinking from these two questions?

1a. Draw a species interaction model for the Arctic ocean food web described in this case. Connect names of species that interact directly with each other using lines and indicate on the lines how each species' fitness is impacted, with +/-/0 next to the species name. Be sure to include all appropriate primary producers, competitors, predators in the case.
Q1b. Now, draw another species interaction model for this Arctic Ocean food web following extinction of polar bears. Predict how primary productivity may be affected and explain your reasoning.
3-DLAP Tool to Assess 4DEE

• The 3D-LAP can help us create and modify assessments.
• The 3D-LAP can help us characterize assessments for “what” is assessed.
Pam Templer –
Discussion, Next Steps and Wrap-up
Next Steps for 4DEE: How Can ESA Help You?

- Course syllabi examples
- Lesson plans
- Lecture (powerpoint) examples
- Assessment tools and sample exam questions
- Workshops at ESA meetings
- Workshops at Life Discovery Conference
- Research publications showing that utilization of 4DEE improves learning outcomes
For more information or to get involved with 4DEE

Website:  https://www.esa.org/4DEE/

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• Teresa Mourad – Teresa@esa.org
• Pam Templer  - ptempler@bu.edu
Thank you!