I predict that a “perfect storm” is approaching livestock production

Warning: My “Crystal” Ball is a Brunswick
And I may well be sawing my limb off

Who to trust on emerging social issues impact livestock agriculture?

Vaclav Smil
http://www.philiplymbery.com/farmageddon-facts/

Are humans contributing to global warming?

DamIfINo
(but Probably)

Do Livestock contribute to global warming?

Are you out of your mind?

http://m.beefmagazine.com/cow-calf/15-best-winter-ranch-photos

Public (consumer) understanding is neither straightforward nor necessarily rational!

Which are the jackhammers and which are the cigarettes?

Emotional perception trumps rational science every time

http://www.snopes.com/photos/signs/pregnant.asp
**Exploiting our biases is a profitable media industry**

The Outrage Industry  
JM Berry & S Sobieraj, 2014  

**Public issues are framed to maximize emotional impact (System I thinking)**

Opposite spin label pairs:
- Washington : government  
- tax simplification : tax reform  
- the death tax : inheritance / estate tax  
- illegal aliens : undocumented workers  
- international trade : foreign trade  
- exploring for energy : drilling for oil  
- lawsuit abuse reform : tort reform  
- personal injury lawyer : trial lawyer  
- corporate accountability : corporate transparency  
- the right to choose : healthcare choice  
- parental choice : school choice

**We need science-based answers on two scales**

Broad scale (circle of concern):  
- What is “global warming”?  
- Is it occurring? How fast?  
- What are potential risks from it? How likely are each? When?  
- What are societies and their governments doing about these?  
- What could they do? Likely to do? When?  

Science (facts) should lead Technology (actions)  
What level of certainty do we need or should we have before acting?

Individual scale (circle of influence):  
- If it is occurring, how might it impact my operation?  
- How likely? When?  
- How might customer concerns impact my operation? Social?  
- How might it impact my kids?  
- What can I do about any of these?  
- When?

**What does having an informed opinion require?**

MITx 12.340x Global Warming Science  
- Introduction to the physics of the climate system and the basic science of anthropogenic climate change  
  - basic science of the climate system, how it has changed in the past, and how it may change  
  - fundamental energy balance between incoming solar radiation and outgoing infrared radiation, and how this balance is affected by greenhouse gases  
  - physical processes that shape climate, such as atmospheric and oceanic convection and large-scale circulation, solar variability, orbital mechanics, and aerosols  
- Doesn’t cover policy issues  
- Campus equivalent – 3 credit 14 week class, prerequisites calculus, physics, thermodynamics  
- ~40+ hours of concentrated work on the topic

**Most curriculum is taught as dogma**

- Beliefs put forth authoritatively without supporting empirical evidence or the information required to judge evidence strength  
  - Not primary refereed scientific papers (reproducible “materials and methods” required)  
  - No information on degree of uncertainty  
  - Hypotheses or uncontrolled observations presented without assessing the effects of chance, biological variation and observer bias (authoritative or established opinion)  
  - Done for presentation efficiency (textbooks, class notes)  
- Repetition across sources or people, whatever their qualifications, does not change the status of dogma

**“Framing” is repeatedly using the most positive or negative label to “spin” a concept**

Liberal – George Lakoff  
Conservative – Frank Luntz

Some dogma is right, some dogma is wrong; the problem is which is which?
Opinion (belief) outsourcing is risky

- With secondary sources (review papers), you’ve "outsourced" the responsibility for critical evidence evaluation
  - At least authors usually provide citations to the primary literature that they used
- With tertiary sources (textbooks, encyclopedias, wikipedia, webpages), you’ve outsourced that responsibility another level!
  - Authors don’t even provide citations

How do you know you have an informed opinion?

Evaluate yourself for IOED – the "Illusion of Explanatory Depth"
- Spend 10+ minutes explaining the key concepts and their relationships to someone
- Starting with a blank sheet of paper, spend 30 minutes mapping out everything you know and identifying your knowledge gaps

Don’t fall victim to the Dunning-Kruger Effect

Two books on knowledge mastery strategies

A Markman

smart thinking

Chap 4: Understanding How Things Work

EB Burger, M Starbird

The 5 Elements of Effective Thinking

Chap 1: Understand Deeply

Gaining perspective is most important

View from Space Shuttle at altitude of 250 miles

Practical terrestrial biosphere (zone of life) thickness = 0.0005 of earth’s radius

Look up; airliners fly at the upper biosphere boundary

Jetstream from Space Shuttle

Upper biosphere boundary ~ 4 – 10 miles up horizontally the length of Pullman-Moscow highway!

Jetstream altitude is 23,000 to 52,000 feet

https://www.youtube.com/watch?v=xF27e59QU44

We humans tend to perceive things best in our scale of size, distance, mass, and time

- We use technology to extend our perception to the telescopic, microscopic, in distance, and in time
  - Powers of Ten - https://www.youtube.com/watch?v=0fKBhvDjuy0
- Our perception is easily deceived, particularly in un-natural scales
- Comprehension is difficult for us in un-natural scales
Life dramatically affected the earth’s history

<table>
<thead>
<tr>
<th>Stages</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<td>3.8–2.4 Ga</td>
<td>~5,000 new of ~4,500 minerals appeared</td>
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<tr>
<td>No atmospheric O₂</td>
<td>Cyanobacteria began photosynthesis</td>
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</table>

Great Oxygenation Event

Historical Earth Temperature

Agriculture developed during a period of unusual climate stability

Historical Earth Temperature

Stage 1

Great Oxygenation Event

Biogeochemistry

We are dealing with very complex systems interacting across wide scales including time

Sulfur Cycles

The surface temperature key is the atmospheric energy balance, Wm⁻² in = out

Atmospheric CO₂ level is the primary focus of concern and for mitigation

Atmospheric components block outbound long wave radiation

Sunlight Energy In

Infrared Energy Out

Atmospheric Carbon Dioxide

Keeling Curve

Agriculture began in ~7 places around world 7-10 K yrs ago
The CO₂ change contribution is physically small

Equivalent to a small flashlight bulb per square meter!

From the global perspective, the big factors driving change are:

- Global Climate Variability, Change
- Increasing regional Fresh Water Scarcity
- Regional Soil Depletion and Salinization
- Emerging Infectious Agents – Virus, Bacteria, Parasites
- Regional Human Population Expansion
- Genetic Diversity Threats - Invasive, Extinction
- Increasing Petroleum Scarcity and declining EROEI
- Economic Globalization

These factors interrelate in very complex ways

Solutions to one problem often increase another problem

During your career, population will grow ~50%

Where will that additional food come from?

During your career, population will grow ~50%

World map adjusted for population

Livestock are concentrated in regions

Domestic mammals far outweigh wild mammals

http://xkcd.com/1338/
Highest poultry densities are in the Pacific Rim

Avian influenza H5N1 remains endemic here

40% of global poultry production

Livestock population density mirrors Human population

Disease density mirrors population density

Global arable (cultivable) land is declining

Arable land:
- 1.5 billion hectares
- Takes 0.25 hectares to feed each person
- Maximum in early 1980’s, now declining
  - erosion
  - salinization
  - desertification
  - diversion

Google “Outgrowing the Earth” to read the on-line version

http://www.earth-policy.org/books/out/out_table_of_contents

Crop agriculture is not sustainable without re-integrating livestock, particularly ruminants

David Montgomery
- Professor of Geomorphology, U Washington
- 2008 MacArthur Fellow, $500,000 “genius” award
- Viewing soil as a biological rather than as a chemical system

We are currently using arable soil 20 to 100 times faster than natural processes produce it

The future of livestock agriculture is excellent; how and where we do it will change

Human population growth rates are highest in LDC’s

Rule of 72: Population doubles in ~72 / (%rate)

Qatar ~ 4.9%
Zimbabwe ~ 16 years, 3% ~ 24 years
Livestock producer education is poor in LDC’s

<table>
<thead>
<tr>
<th>Education Level</th>
<th>Number</th>
<th>Percentage</th>
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<tr>
<td>no education</td>
<td>1,449</td>
<td>26.5</td>
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<tr>
<td>not completed primary</td>
<td>1,833</td>
<td>34.0</td>
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<tr>
<td>primary school</td>
<td>1,874</td>
<td>36.5</td>
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<tr>
<td>junior high</td>
<td>300</td>
<td>6.0</td>
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<tr>
<td>senior high</td>
<td>200</td>
<td>3.9</td>
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<tr>
<td>illiterate</td>
<td>22</td>
<td>0.4</td>
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</table>

• 90% have a primary school education or less

Can LDC producers understand the “how” and “why” of climate change mitigation sufficiently to optimize food production?

Global water situation is tight in some areas

Map 2. Areas of physical and economic water scarcity

- > 75% of flows allocated to agriculture, industry, domestic use
- Unmet water needs due to lack of infrastructure (dams, piping)

Projected global climate change by season

Dec, Jan, Feb: 20% precipitation increase, no precipitation change, 20% precipitation decrease

Jun, Jul, Aug: 20% precipitation change

The dairy cow has the highest per lb water requirement of land mammals.

Climate change consequences are already apparent in the Pacific Northwest

- More winter precipitation falling as rain instead of snow
- Increased winter streamflows
- Increased winter flood risks in transient (rain/snow mix) basins
- Reduced snow water storage, particularly in mid-elevations
- Earlier snow melt and peak runoff (10 to 30 days)
- Decreased late spring and summer streamflows

The Result: The paradox of more winter flooding and more summer drought

From my limb I predict that climate change will have the biggest impact on livestock through disease

Vector-borne diseases will provide the nastiest surprises for livestock production
Climate change will likely expand many vector-borne disease ranges

Small climate changes can:
- Markedly shift ranges of tick species
  - Ticks are vectors of nasty bovine disease agents
- Markedly alter mosquito populations and their range
- Reduce keystone species, destabilizing vulnerable ecosystems
  - Allows proliferation of invasive species

However, due to the many factors involved vector-borne disease ecology is very complex, making prediction difficult and uncertain!

The dynamics of complex systems are difficult to comprehend

Big factors driving change:
- Human Population Expansion
- Fresh Water Scarcity
- Soil Depletion
- Fossil Fuel Scarcity
- Globalization
- Emerging Infectious Agents
- Global Climate Change
- Genetic Diversity Decrease

Tough positive and negative feedback loops with time lags link all of these factors and problem solutions

Understanding and mitigating climate change effects requires a systems thinking approach

Careful critical thinking that:
- Is based on empirical scientific evidence
- Allows for the occurrence of unintended consequences
- Avoids the “silo effect”
- Avoids “framing”
  - [http://en.wikipedia.org/wiki/Framing_(social_sciences)]
- Detects “illusions of explanatory depth” (IOED)
- Includes all the relevant systems

Cognitive biases hardwired into our brain by our evolution distort our thinking

“Human nature” is to:
- Weigh information consistent with current belief heavier
- Overly commit and to ignore or discount discordant information
- Search for belief-confirming data rather than belief-refuting data
- Be overly optimistic about outcomes
- Recall the most recent, the most notable, . . .
- Stop searching prematurely

Prior biases observation by subtly changing perception, particularly of the vague or ambiguous
  - Interpretation of vague patterns

Critical Lessons:
- Cognitive biases occur unconsciously and despite the observer’s best intentions!
- Cognitive biased thinking is detectable by external observers but not by the thinker
- Knowledge of cognitive biases is not protective!
- To avoid cognitive biases, we have to follow specific procedures
  - This is why the scientific method, strong experimental design, and evidence-based medicine have developed

My webpage has materials and links on global climate change and livestock

Google “WSU jmgay”
Index page - [http://people.vetmed.wsu.edu/jmgay/courses/]

Presentations:
- Increasing Climate Variability and Livestock Production: The Perfect Storm?
proceedings updated pdf
“Identifying Climate Change Information That You Trust”