# GPSA Poster Session

**"Sustainability in the 21st Century: From Greening to Resilience"**

Presented at the
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# Our Modern, Industrial, Agriculture Paradigm

- Beginning around 1930 we decided that the best way to maximize productivity and achieve short term economic returns in our food and agriculture system was to apply industrial principles—specialization, simplification and economies of scale. — Based on Frederick Taylor's *The Principles of Scientific Management*, 1911

- Adoption of industrialization on a large scale in *agriculture* began after World War II.

# The Modern Farm

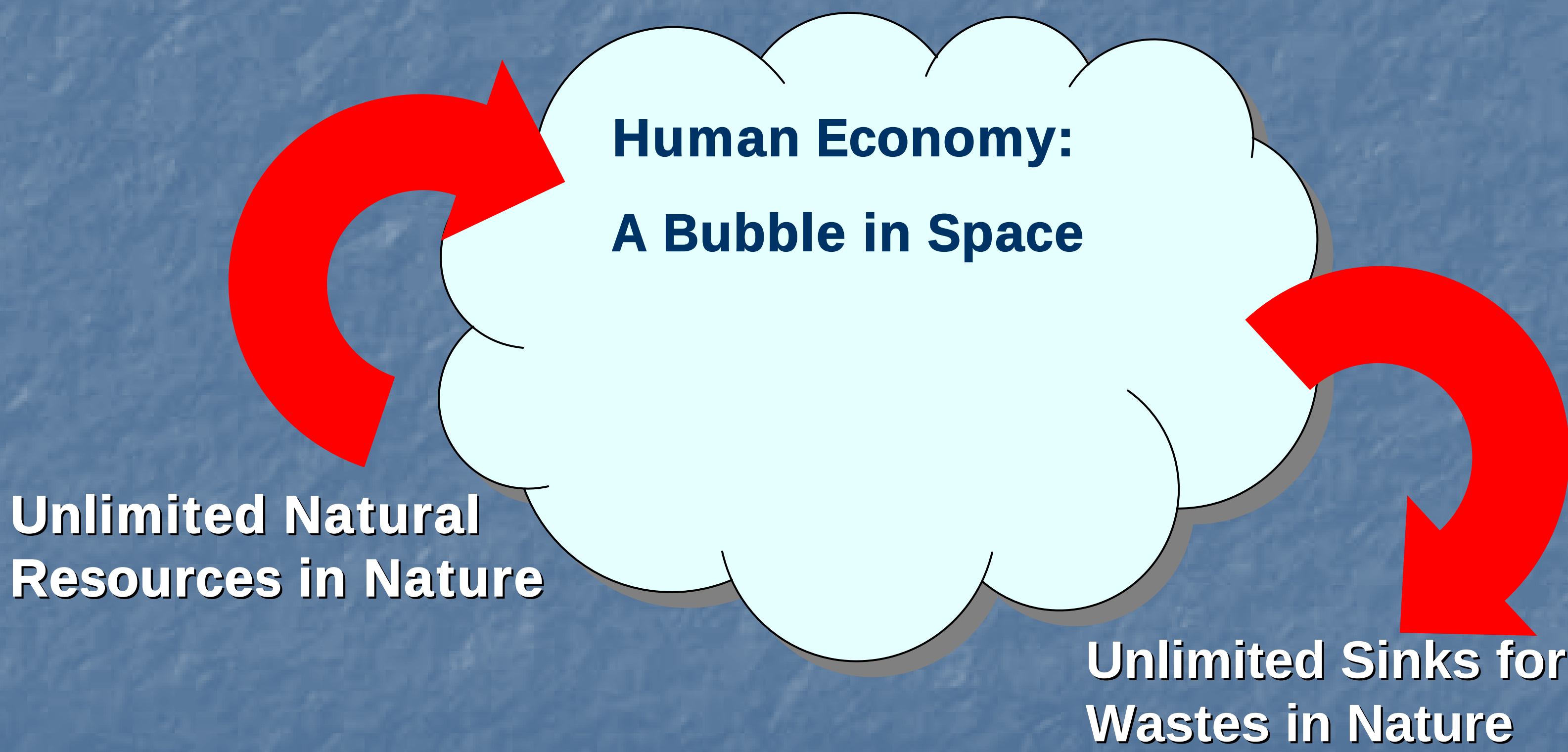
- So now a farm is similar to a factory—a mechanistic arrangement designed to maximize the production of raw materials for food stuff, with little attention to ecological context or function.
- And it has been largely successful in achieving its singular goal—*maximizing production within specialized mono-cultures.*

Hansen, MN Exp Station

# Success of any Industrial Economy is Dependent on Two Resources

1. Abundant natural inputs:
   - Cheap energy
   - Fresh water
   - Stable climates
   - Free ecosystem services
2. Natural sinks to absorb waste

# Key Assumptions of the Industrial Economy



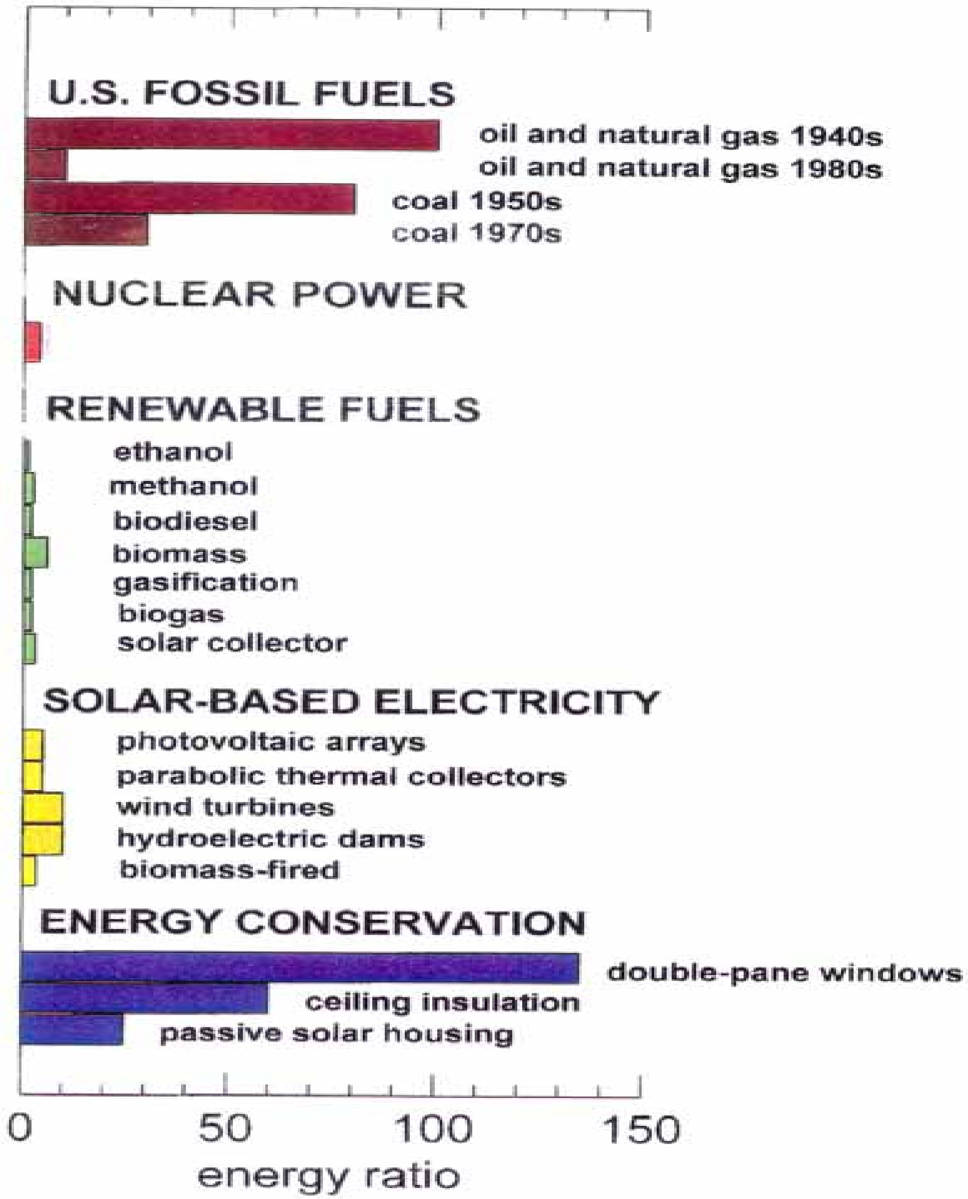

—Herman Daly

# Challenges on the Horizon

- The end of cheap energy
- Global depletion of fresh water resources
- Evolution of unstable climates
- Ecological degradation, especially loss of soil and biodiversity

# Energy

- The end of “cheap” energy will likely bring about a major energy transformation
- Critical issue is EROEI—Energy Return On Energy Invested




—Marty Bender, The Land Institute

# First and Second Laws of Thermodynamics

- First Law: Energy can neither be created nor destroyed.
- Second Law: The Law of entropy. Energy can be transformed from one form to another and energy tends to leave a system as it is transformed.

# Lessons to be Learned

- Lesson #1. Energy cannot be fully recycled so perpetual motion machines are impossible.
- Therefore, we should be skeptical of any hypothesis suggesting that we can invent a new miraculous energy technology that will solve the "end of cheap energy" problem.
- Jevons Paradox: Technological progress that increases the efficiency with which a resource is used tends to *increase* the rate of consumption of that resource.

# Lessons to be Learned

- Lesson # 2. When we use energy to move from a state of complexity toward *simplicity* or from concentration to diffusion, we experience a high degree of entropy.
- Conversely, *complex* systems can *take in* energy from the systems in which they are nested and have a greater tendency to hold energy in the system. —Tom Wessels, *The Myth of Progress*

# Lessons to be Learned

- Lesson # 3. Biospheric entropy is now a reality. "For the first time in earth's history, a single species is responsible for the entropic degradation of the biosphere by releasing more energy through transformation than is being replaced by global photosynthesis."

—Tom Wessels, *The Myth of Progress*

# Water

- Our industrial food system consumes inordinate amounts of fresh water.
- We each require only 4 liters of water to meet our daily liquid requirements.
- The water required to produce our daily food needs totals at least 2,000 liters.

—Lester Brown, *Plan B 2.0*

# Irrigation

- Seventy percent of all fresh water use is for one purpose—*agricultural irrigation.*

- Irrigation water is being depleted in many of the world's grain-producing regions:
  **China**: *Four-fifths* of China's grain production is dependent on irrigation water
  **India**: *Three-fifths* of India's grain production is dependent on irrigation water
  **United States**: *One-fifth* of U.S. grain production is dependent on irrigation water

# Irrigation

- Aquifers in some parts of China are dropping at the rate of 10 feet per year.  Some farmers are now pumping from a depth of 1,000 feet.
- Aquifers in some parts of India are dropping at the rate of 20 feet per year.  Some farmers are now pumping from a depth of 3,000 feet.
- The Ogallala Aquifer in some regions of the Southwest (Texas, Oklahoma, Kansas) water tables have dropped more than 30 feet, causing some irrigation wells to go dry.

—Lester R. Brown, *Plan B 2.0*

# Climate

- Climate on our planet has seldom been as “stable” as it has been the past century.
- And it is in the process of unraveling—which could fundamentally change the climate for the next 100,000 years.
- And we are already seeing its effects on agriculture.

# News Media Articles February 2009

- Serious Drought Strikes Farming Regions in China

  The Associated Press
  Wednesday, February 4, 2009; 11:42 PM

  BEIJING—A serious drought in at least eight Chinese provinces is threatening large crop-growing areas and leaving nearly 4 million people without proper drinking water, the government said Thursday.

# More Headlines

- Australia is in a Ten-Year Drought
- Texas Ranchers and Farmers Struggle in Drought

# More Headlines

- Federal Water May be Cut Off from California Farms; If Drought Deepens, State to Make Drastic Move; Revenue, Jobs Affected

  MENDOTA—Shawn Coburn and his foreman, Juan Guadian, inspect an almond orchard in Mendota, Calif. Farms in the state have been hurt by a lack of rain and they could suffer another blow if federal water managers follow through with plans to cut water due to the deepening drought.

# Meanwhile, Flooding in Iowa June 2008

- In some parts of Iowa 16 inches of rain fell in 24 hours.
- Some climatologists suggest that we may now see a "500-year flood" every 15 years.

# April Snow and Flooding in North Dakota

- Red River crests at all-time high in Fargo.
- Valley City evacuated due to flooding.

# Ecological Degradation

- Has our method of maximizing production jeopardized our potential for future productivity?

# United Nations “Millennium Ecosystem Assessment Synthesis Report, 2005”

- Over the last half century, humans have polluted or over-exploited two-thirds of the earth’s ecological systems on which life depends, dramatically increasing the potential for unprecedented and abrupt ecological collapses.

- Approximately 60 percent of the ecosystem services evaluated are being degraded or used unsustainably.
*Most ecosystem changes were the direct or indirect result of changes made to meet growing demands for ecosystem services—in particular the growing demands for food, water, timber, fiber and fuel*.

# Millennium Report continued . . .

- Solutions will be complex: There is no simple fix to these problems since they arise from the interaction of many recognized challenges including climate change, biodiversity loss and land degradation.

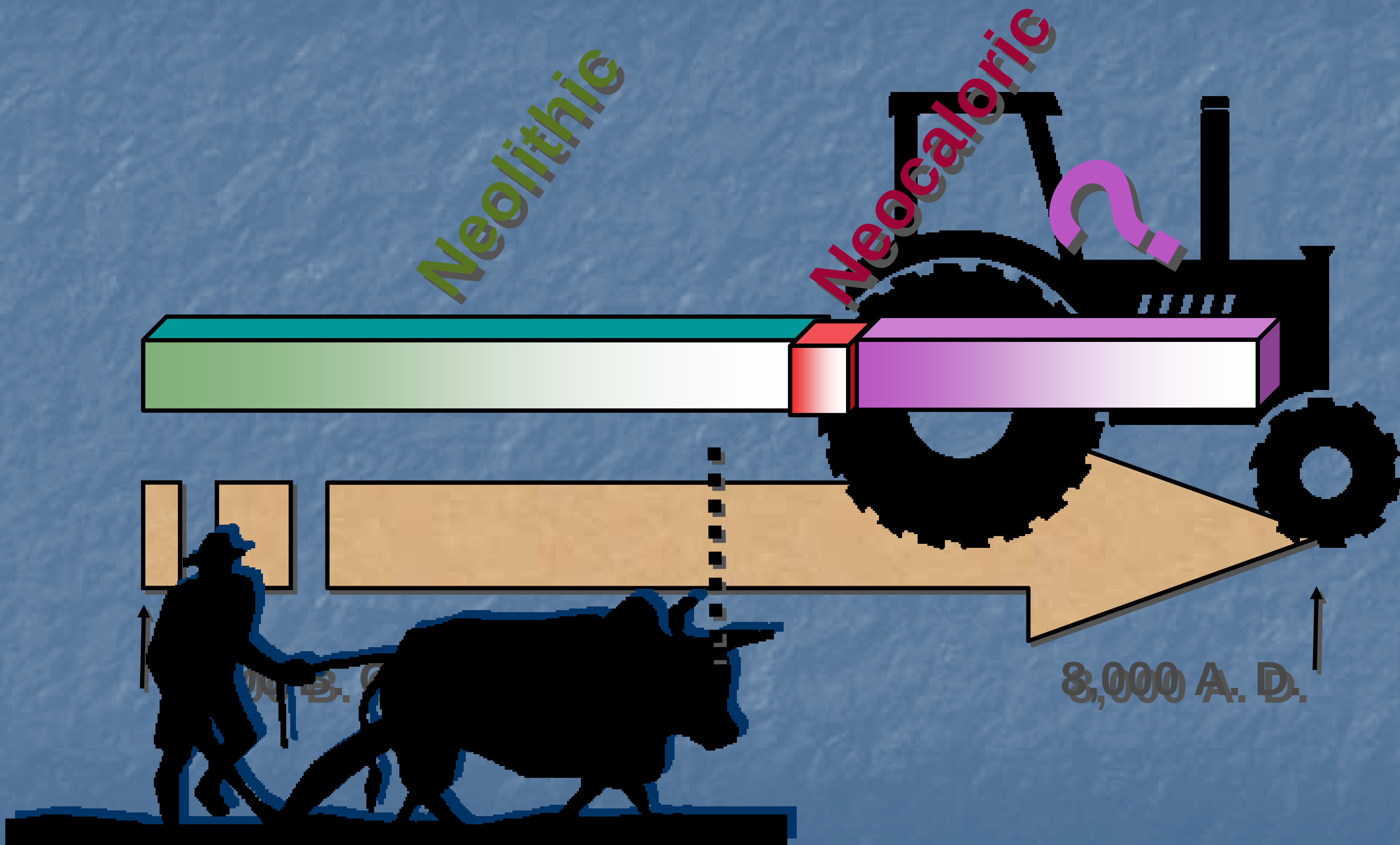
- *Furthermore, the loss of species and genetic diversity decreases the resilience of ecosystems—the level of disturbance that an ecosystem can undergo without crossing a threshold to a different structure or functioning.*

# It Might have Been Different

- 1859 may have been pivotal year
  - First producing oil well in the U.S.
  - Publication of Darwin's *On the Origin of Species*
  - We could have selected *ecology* rather than *oil.*
- But having all that cheap, stored, concentrated energy available to us was too seductive.

We selected *oil.*

# For How Long?




Source: Richardo J. Salvador, Iowa State University, Ames, 2004 (based on Ernest Schusky, *Culture and Agriculture)*

# How Shall We Now Approach the Future?

- "Is it possible to replace current technologies based on fossil energy with Proper interactions operating between crop/livestock and other organisms to enhance agricultural production?"

- If the answer is yes, then modern agriculture, which uses only the simplest biotic responses, can be transformed into an alternative system of agriculture, in which the use of complex biotic interactions Becomes the key technology."

—Masae Shiyomi and Hiroshi Koizumi, *Structure and Function in Agroecosystem Design and Management, 2001*

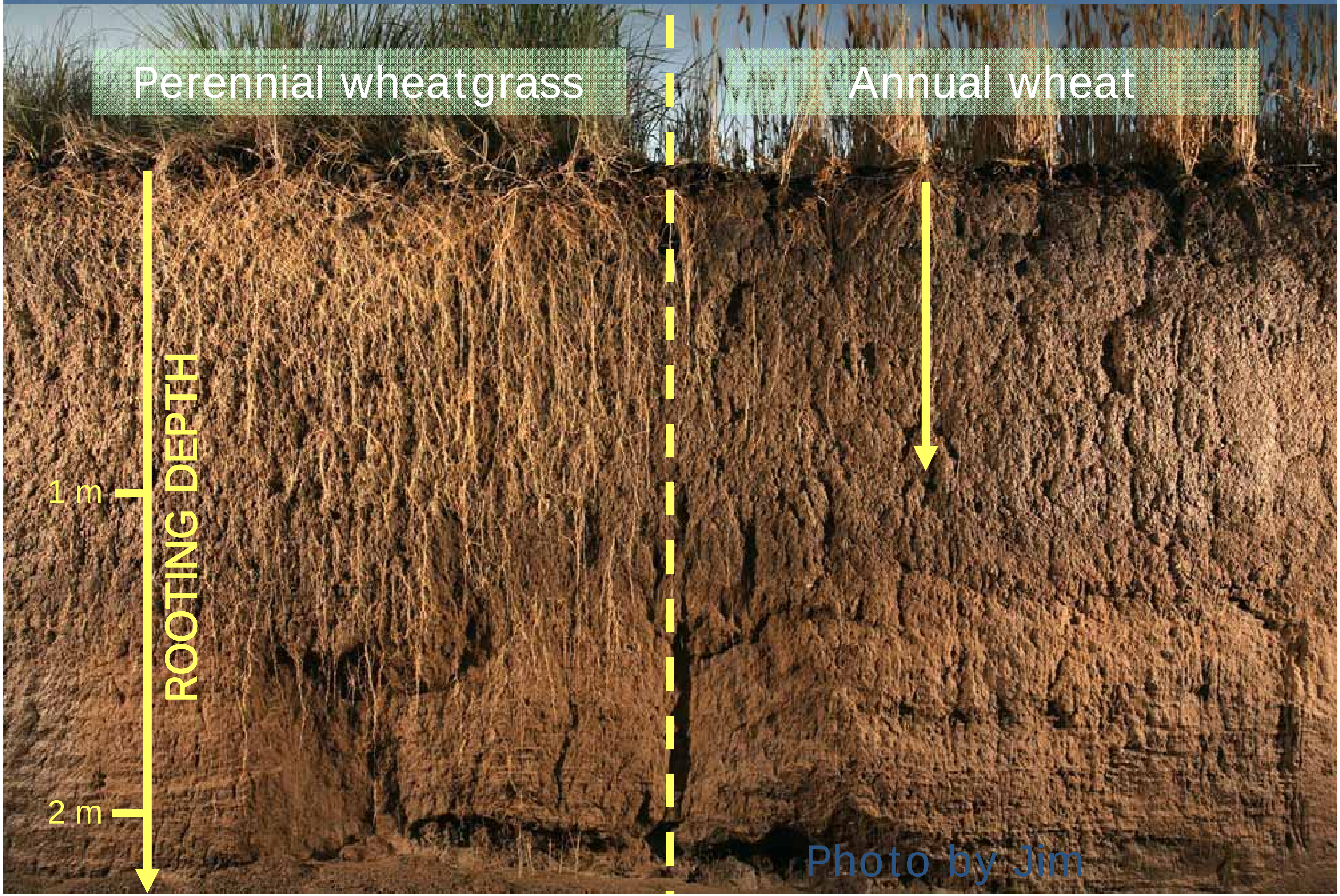
# A New Paradigm for a New Sustainable Agriculture

- Old paradigm: Steady State Sustainability or "Engineering resilience"—greening a system and/or using command and control strategies to return a system to a steady state as quickly as possible after a perturbation.
- New paradigm: Resilient Sustainability or "Ecological resilience"—adaptive capacity, designing systems that can absorb perturbations and/or transform to another desirable domain.

—Holling, Gunderson, Walker, Salt

# The Role of Perennials

- “Look to nature”
- “Mixtures of Perennial plants rule”
- “Perennials hold on for the long haul, protect the soil, and manage nutrients and water to fine degree” —Wes Jackson, *Conservation Biology*
- “Putting 10 percent of row crops into perennials could reduce erosion by 80 percent, even in flood years like 2008.” —Kendall Lamkey, ISU


Perennial wheatgrass
Annual wheat
ROOTING DEPTH
1 m
2 m
Photo by Jim

# More Immediate Agenda

- Increase the acreage of perennial grasslands: Put animals back on pasture, mixed cropping and livestock operations on individual farms or in neighborhood consortia
- Pasture/annual crop rotations

  Dick Thompson – Boone County, Iowa

  Argentina

# How should we now think about food?

- “What would happen, for example, if we were to start thinking about food as less of a *thing* and more of a *relationship*?”

  —Michael Pollan, “Unhappy Meals” *NYT Magazine*, 1/28/07

# Emerging New Systems

- While new, integrated, crop/livestock systems are far from the whole answer to the challenges ahead—they can play a significant role.
- Specialized, simplified systems require large infusions of energy, and consequently increased entropy and ecological degradation; conversely, complex systems can take *in* energy from the larger system in which they are nested and can enhance the capacity for self-renewal.
- Small-scale examples already exist on the landscape.

"The concept is to produce a variety of products within a limited space to achieve maximum overall productivity. But this does not consist of merely assembling all of the components; it consists of allowing all components to influence each other positively in a relationship of symbiotic production."

—Takao Furuno, *The Power of Duck, 2001*

# Poultry, Grapes and Sweet Corn SARE Project

Jeff and Greg Kuntz
assisted by William Kuntz

# Potential Profit .17 acre

<u>Estimated Year Three</u>

- 228 Pheasants X $5 = $1,140
- 125 doz. Sweet Corn X $3 = $375
- 60 vines X 8# = 480# X .50 = $240

$1,755 Total

Per acre equiv. = $10,323

# Confirmed by research: Indonesian Rice/Fish Farms

- Research conducted on 5 rice/fish systems involving 217 farmers
- Net revenue increased an average of over 56% over rice monocultures.
- "Rice/fish systems proved that an agricultural system could be more productive, profitable and technically efficient. Moreover, it could pave the way to an ecology-sound rice farming due to the reduced or zero use of pesticides."

**Erwin Dwiyanna, et.al., *Journal of Sustainable Agriculture*, Vo 29, No 1, 2006**

# Example from Africa: Alley Farming

- Crop yields increased, adequate nitrogen was fixed and hedgerows reduced erosion
- Prunings from the hedgerows were fed to ruminants increasing survival and body weight and increased milk production
- Proved economically profitable because of higher crop yields at lower costs

**E Ogunlana, *Journal of Sustainable Agriculture*, Vol 29, No 1, 2006**

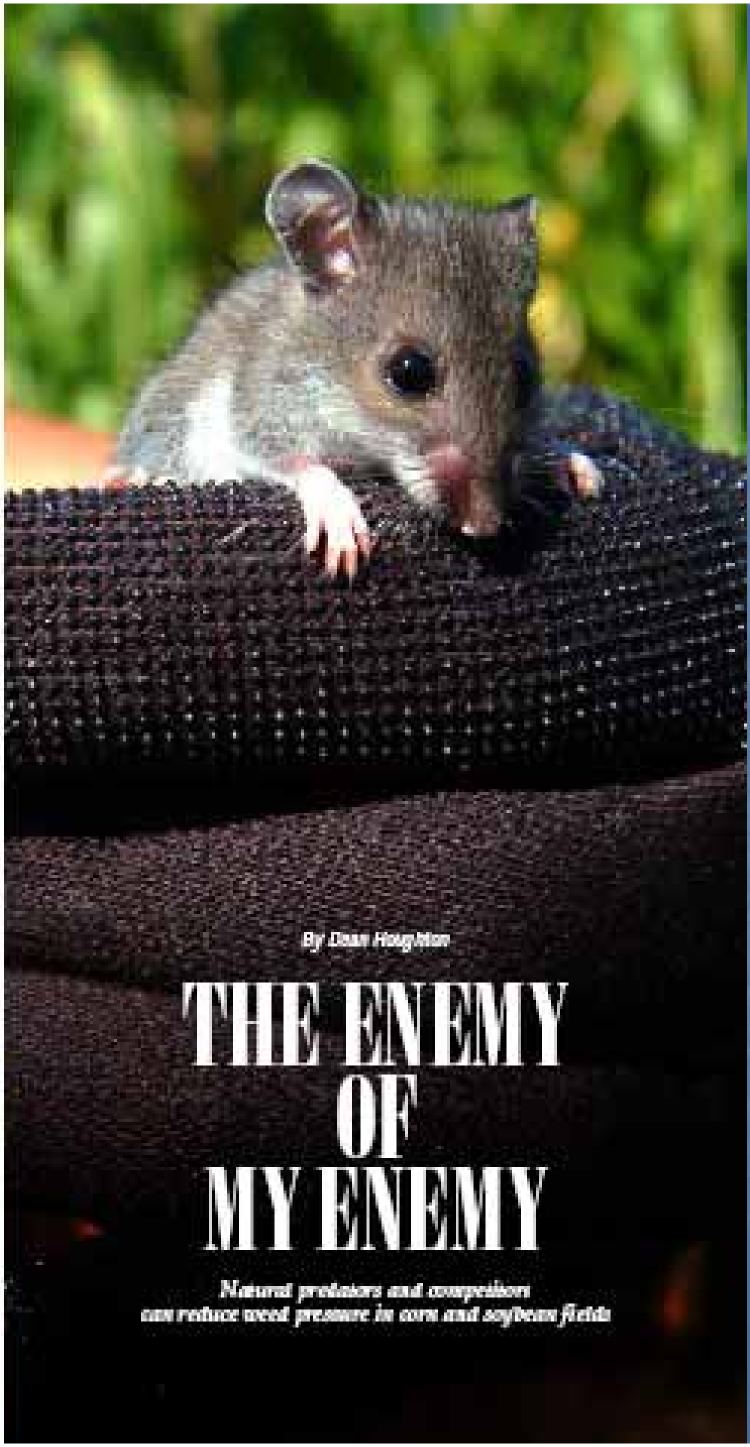
# What other Biological Synergies are available in Nature?

There probably isn't a farmer out there who hasn't wished for a bigger hammer to use in fighting weeds. You can't blame a guy for wanting a more effective herbicide or a wider cultivator to balance the odds when just one person is protecting all those acres against tough weeds.

But maybe you're not as alone as you think. You might not be cozy with crickets or mice, but if the enemy of your enemy is your friend, these little fellows can provide hundreds of thousands of allies per acre in the weed war.

**Little hammers.** These two weed seed predators are part of what Iowa State University scientists call the "little hammers" approach to weed control. "We believe that a combination of weed management techniques and ecological processes can help a farmer maintain effective weed control with a lighter touch," says Matt Liebman, an Iowa State agronomist. "That approach can help slow down evolutionary resistance to herbicides, protect soils from erosion due to excessive cultivation, and protect

▸**Right:** The white-footed mouse and its cousin, the prairie deer mouse, are tireless seed predators, eating or burying weed seeds deep below the surface. ▸**Below:** Scientists offered velvetleaf seeds on test cards in plots and predators removed one-third of seeds within 48 hours.



*By Dan Houghton*

# THE ENEMY OF MY ENEMY

***Natural predators and competitors can reduce weed pressure in corn and soybean fields***

# Rabbits Calm Farrowing Sows

Kathrin Buettner pulled a rabbit out of her repertoire when she spoke to hog farmers at the Shakespeare Seminar in Shakespeare, Ont., recently.

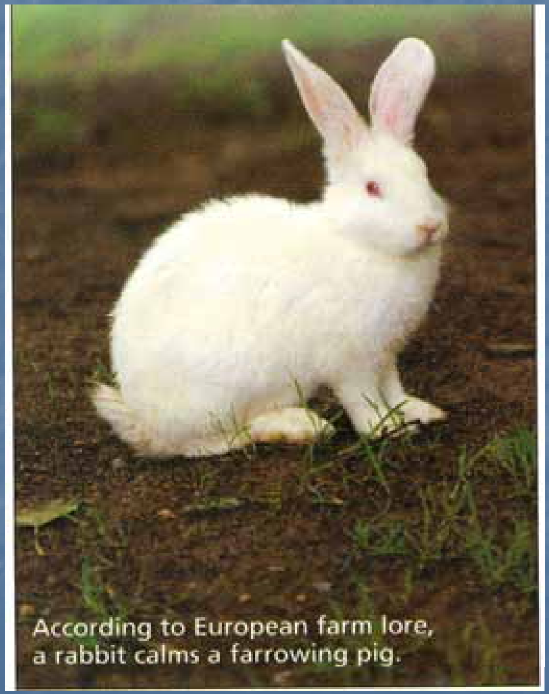
And she put the rabbit into the farrowing pen.

Buettner, who is a researcher from the University of Goettingen in Germany, said it's an old European practice that is gaining renewed interest because a rabbit seems to calm gilts.

The rabbit is set in the pen about an hour before farrowing, when the gilt is beginning to experience extreme pain, she said, and the sow "gets used to seeing something small jumping around."

Then when piglets are born, the gilt is less likely to blame the piglet for her pain because something small was running around before the birth, Buettner said.

The result is that gilts are less likely to attack and bite their newborns, she said. "At least that's the theory and psychology and it seems to work."


According to European farm lore, a rabbit calms a farrowing pig.

—*Small Farm* magazine, January/February, 2006

# Are such Paradigm Changes Possible?

- "Only a crisis—actual or perceived—produces real change. When that crisis occurs, the actions that are taken depend on the ideas that are lying around."
  —Milton Friedman
- "A crisis is a terrible thing to waste"
  —Hazel Henderson

# But what about Food Safety??

- Today, food safety is approached almost entirely from the perspective of isolation and control management.
- Goal appears to be creating a sterile environment in which to produce our food.


WARNING
ABSOLUTELY NO
ANIMALS ALLOWED
DUE TO FOOD
SAFETY ISSUES

# Could the problem be nested in concentration and density?

- "Chronic disease and catastrophic epidemics are the expected result of high densities and low diversity." —David Tilman
- "The trend in animal ecology, shows with increasing clarity, that all animal behavior-patterns, as well as most environmental and social relationships, are conditioned and controlled by density. " —Aldo Leopold

# Could we be Targeting the Wrong Arena?

- What about the way we process our food?

# U.S. Foodborne Illnesses

- More than 75 million cases annually
- 325,000 require hospital care
- 5,000 deaths each year
- 1/3 are from tainted meat

Source:
cdc.gov/ncidod/eid/vol5no5/mead.
htn

# But what about more diverse Production Systems?

- Could mixed crop/livestock systems *increase* food safety problems?
- Can we appropriate insights from Charles Perrow: *Normal Accidents* 1984, revised 1999?

# Is the problem always in the farm or field?

- "Most high-risk systems have some special characteristics, beyond their toxic or explosive or genetic dangers, that make accidents in them inevitable, even 'normal.' This has to do with the way failures can interact and the way the system is tied together. . . . Risk will never be eliminated from high-risk systems."

—Charles Perrow, *Normal Accidents*

- “The odd term *normal accidents* is meant to signal that, given the system characteristics [tightly coupled] multiple and unexpected interactions of failures are inevitable.”

- "At the very least, however, we might stop blaming the wrong people and the wrong factors, and stop trying to fix the systems in ways that only make them riskier."
- "The argument is basically very simple. We start with a plant, airplane, ship, biology laboratory or other setting with a lot of components. Then we need two or more failures among components that interact in some unexpected way . . . The problem is just something that never occurred to the designers." —Charles Perrow

- “For some systems that have this kind of complexity, such as universities or research and development labs, the accident will not spread and be serious because there is a lot of slack available . . . But suppose the system is also ‘tightly coupled,’ that is, processes happen very fast and can’t be turned off, the failed parts cannot be isolated from other parts . . . For most systems . . . *Neither better organization nor technological innovations appear to make them any less prone to system accidents.”*

—Charles Perrow

# And not just meat

- **The Maggots in Your Mushrooms**
  By E. J. LEVY
  Published: February 12, 2009
- Peanut butter—that culinary cause célèbre—may contain approximately 145 bug parts for an 18-ounce jar; or five or more rodent hairs for that same jar; or more than 125 milligrams of grit.
- In case you're curious: you're probably ingesting one to two pounds of flies, maggots and mites each year without knowing it, a quantity of insects that clearly does not cut the mustard, even as insects may well be in the mustard.

# Problem may be exacerbated by economic pressures

- The F.D.A. considers the significance of these defects to be "aesthetic" or "offensive to the senses," which is to say, merely icky as opposed to the "mouth/tooth injury" one risks with, for example, insufficiently pitted prunes. FDA says this policy is justified on economic grounds, stating that it is "*impractical to grow, harvest or process raw products that are totally free of non-hazardous, naturally occurring, unavoidable defects.*" —E.J. Levy

# A New Food Safety Paradigm

- A lot can be learned by studying the genetics of viruses and the structure of human cells, but the questions facing the world are bigger.
- Where does a pandemic come from? Can it be predicted or prevented, and, if not, what is the best way to respond and adapt? How can people live in healthy peace with nature on this planet?
- These questions require a combination of the best laboratory science with an understanding of ecology, culture, social change, and ethics.

—David Waltner-Toews, *The Chickens Fight Back*

# New Design Principles

- Replace single-tactic therapeutic intervention with eco-system management.
- Follow 'Nature as Measure' as a general rule.
- Marry the wisdom of the past with the best science available.
- Consider adopting "ecological eating."
- Engage the current UN debate: Replace technology, trade and aid with fpod democracy, food justice and food sovereignty to make the global food system a global network of foodsheds, rather than a one-size-fits all consolidated, "tightly coupled" food system.

# Shifting from Control Management to Adaptive Management

- The solution for humanity is NOT in a radical return to being "children of nature"
- ". . . [adaptive management] is the heart of sustainable development.  It requires flexible, diverse and redundant regulation; monitoring that leads to corrective responses; and experimental probing of the continually changing reality of the external world."

—C.S. Holling, *Barriers and Bridges to the Renewal of Ecosystems and Institutions,* 1995

# Additional Information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