Hot Science Cool Talks

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Life on a Human-Dominated Earth: The Challenges Ahead

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Ecosystem Services and Life on a Human-Dominated Earth

The Challenges and Opportunities Ahead

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What Are Ecosystem Services?

Services of value to humans provided by natural and managed ecosystems

Purification of air and water

Generation and Renewal of Soil Fertility

Prairie grasslands and savannas of North America generated the fertile soils that feed 200,000,000 people.


Humans Have Benefited From The Vast Diversity of Potential Food Plants
Potato Varieties
USDA-ARS

When we want food, we go to nature

Fine Dining on Whilshire Boulevard, Los Angeles, 9000 BC

(copyrighted image of mastodon in tar pit could not be included on this CD)

Dining at the La Brea Tar Pits, 9000 BC

Earth's Biodiversity is also the Major Source of Human Medicines

More than 60% of the 50 best selling medicines are derived from nature. So are the two most important medicines ever discovered, Aspirin and ….

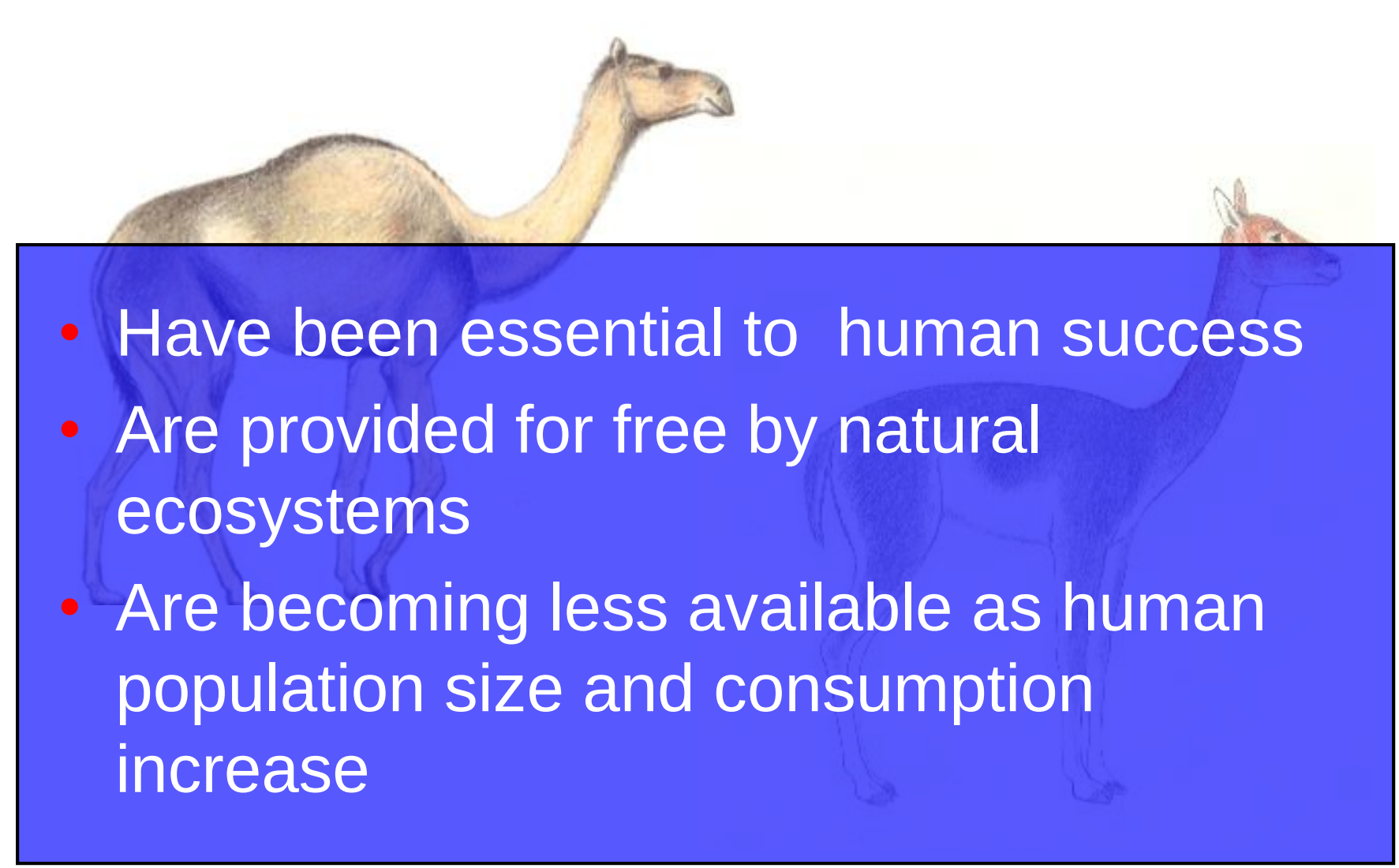
Caffeine

and I thought it was wine

Other Ecosystem Services Include:

- Detoxification and decomposition of wastes
- Pollination of crops
- Control of many agricultural pests
- Moderation of climate
- Natural production of fish, forage, biomass fuels, and industrial products
- Amelioration of flooding
- Maintenance of genetic resources
- Aesthetic beauty

Ecosystem Services



- Have been essential to human success
- Are provided for free by natural ecosystems
- Are becoming less available as human population size and consumption increase


The two largest global human impacts
come from our need for
Food and Energy
USDA-ARS

Human Global Ecosystem Domination

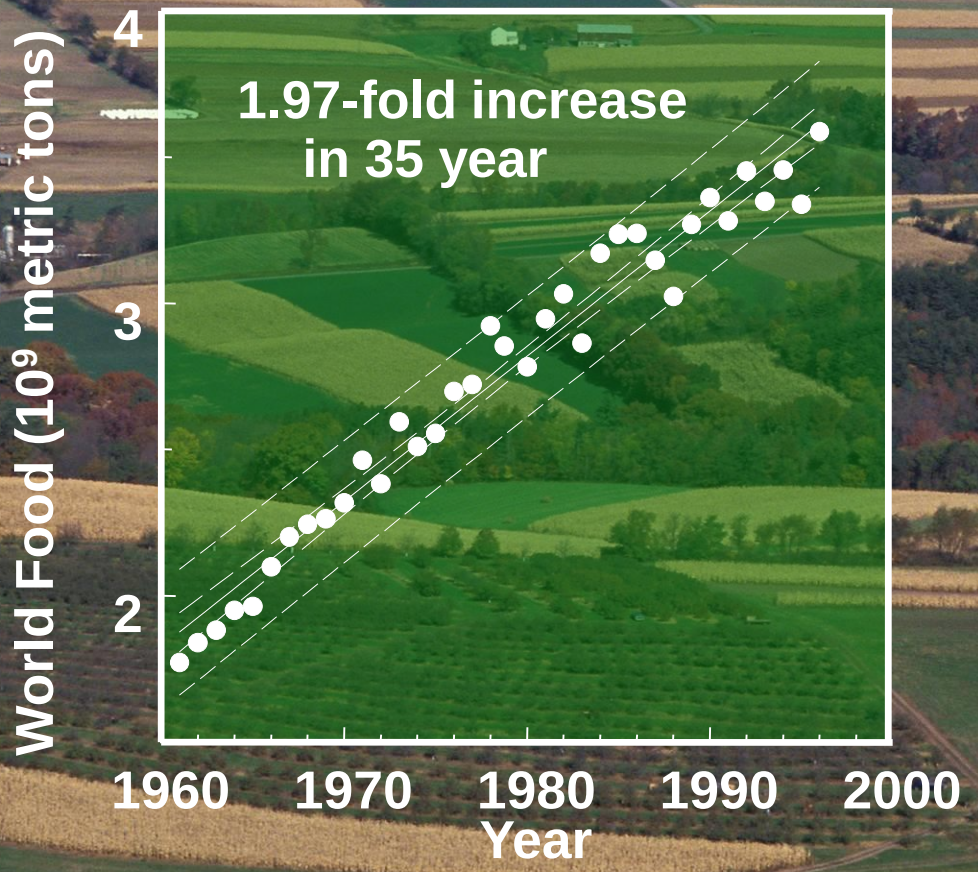
- 45% of terrestrial ecosystem production is appropriated by humans
- Half of useable freshwaters is appropriated by humans (irrigation, hydroelectric power)
- Doubled rates of nitrogen fixation and of phosphorus liberation
- Unprecedented extinctions via habitat destruction and invasions by exotic species
- Elevated pesticide levels in humans
- Elevated greenhouse gases (CO_2, methane)

Final Period of Rapidly Expanding Human Environmental Impacts?

In the next 50 years

- Population is projected to increase from 6 to 9 or 10 billion – a 50% increase
- Global per capita GDP is projected to increase 140%
- Global population and consumption drive agricultural demand – which could double if demand for meat continues to increase globally

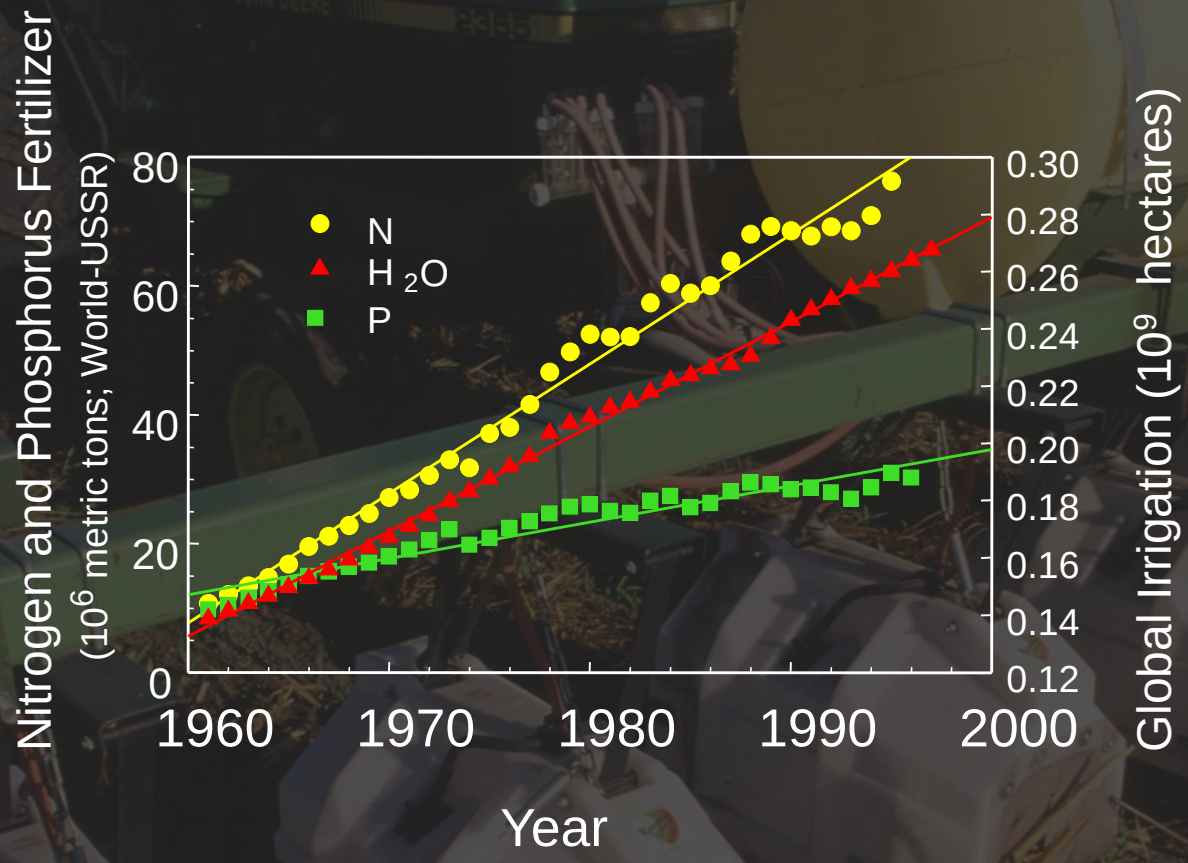
Benefits of the Green Revolution



Global food production doubled in 35 years.

photo credit: USDA-ARS

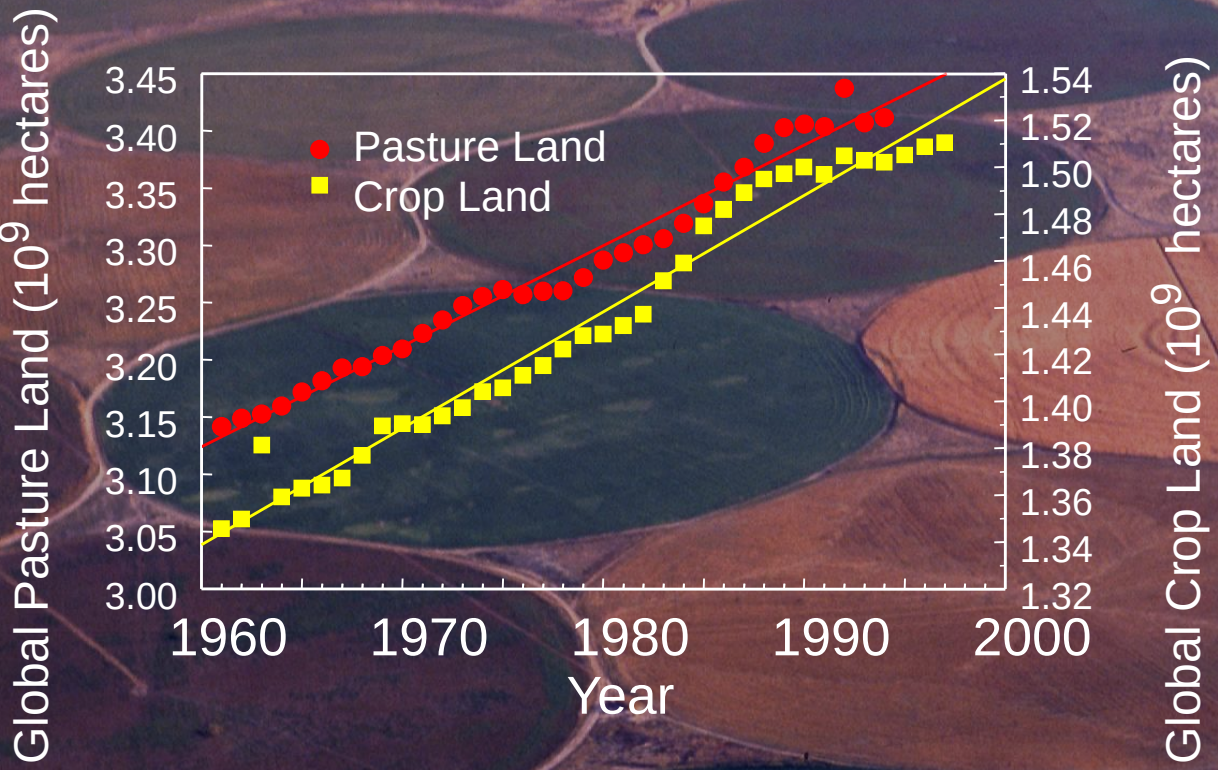
Costs of the Green Revolution



- 7-fold Increase In N Fertilization
- Doubling The N Economy Of the Earth

(from Tilman, Fargione, Wolf et al *Science*)

Costs of the Green Revolution



- Destruction Of Natural Habitats For Agriculture
- Contributing To a major Extinction Event

(from Tilman, Fargione, Wolf et al *Science*)

If We Stay on the Course Set in the Past 35 years:

Environmental Variable	*Increase by 2050*
Global N Fertilizer	210%
Global P Fertilizer	140%
Global Pesticide Production	170%
Global Agricultural Land	20% (Area of USA)

(27% of usable land still in nature)

(from Tilman, Fargione, Wolf et al *Science 2001*)

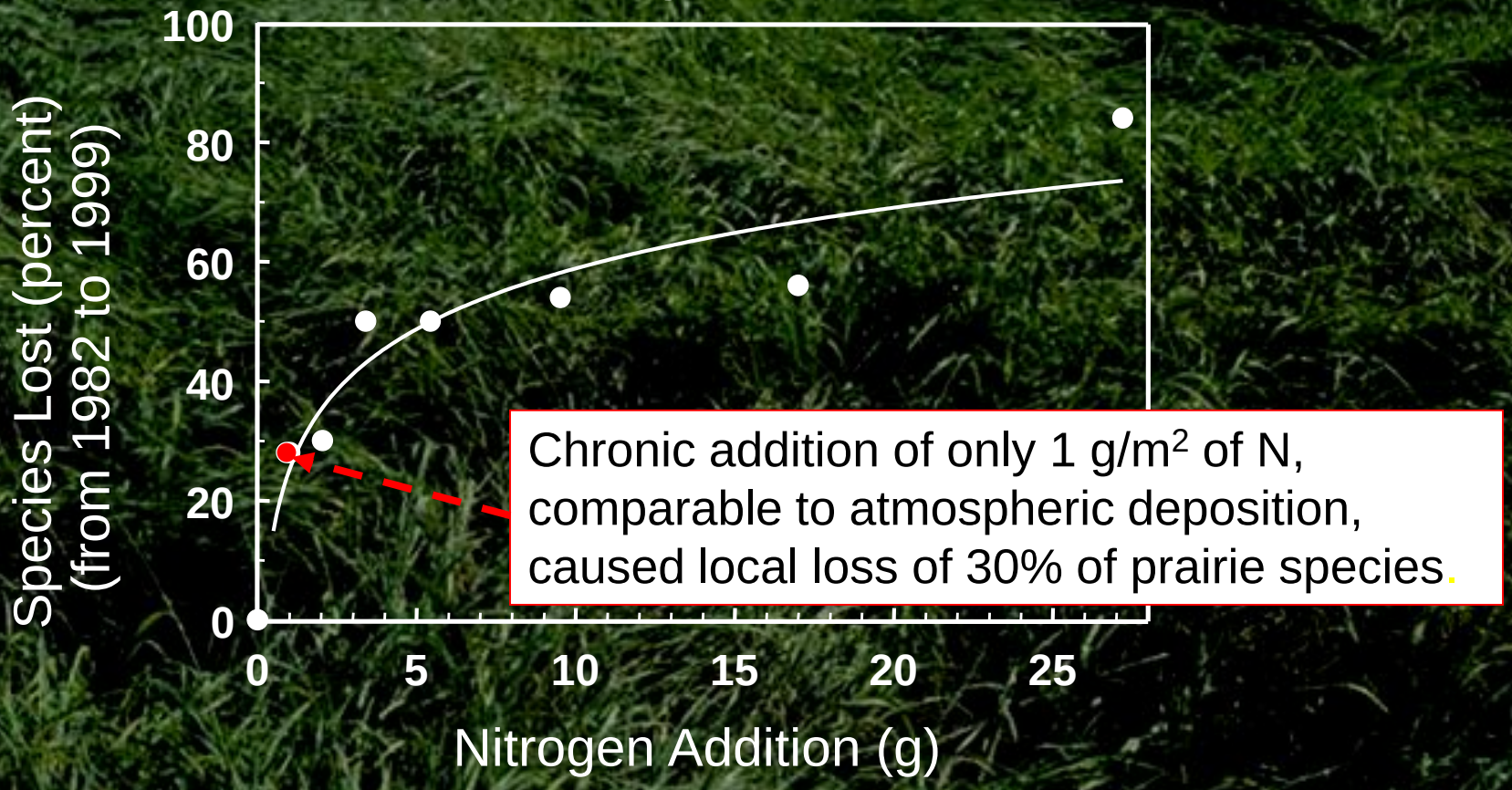
Conversion to agriculture decreases ecosystem diversity, decreases ecosystem services, and increases extinctions.

photo credit: USDA Forest Service

Native Prairie Receiving No Added Nitrogen

A Control Plot in a 207-Plot Nitrogen Addition Experiment

Increased Nitrogen Causes Loss of Biodiversity



High Nitrogen Addition: Dominated by a European Weed, Quack Grass

What Determines the Flow of Ecosystem Services?

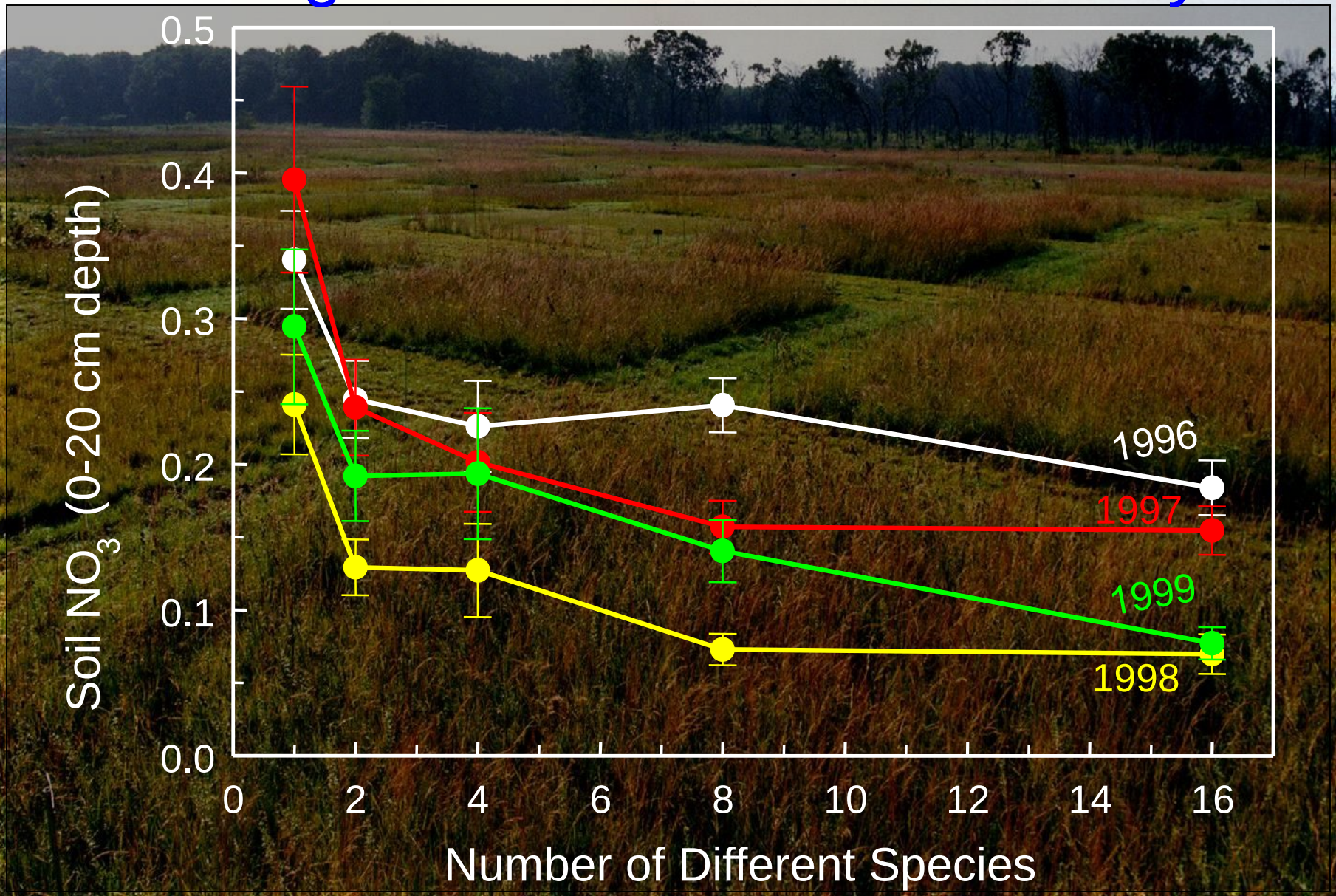
Does Biodiversity Matter?

- Does biodiversity influence ecosystem stability, productivity, nutrient dynamics, disease dynamics, or susceptibility to invasion by exotic species?

- Could the loss of biodiversity impact the supply of ecosystem services of value to society?

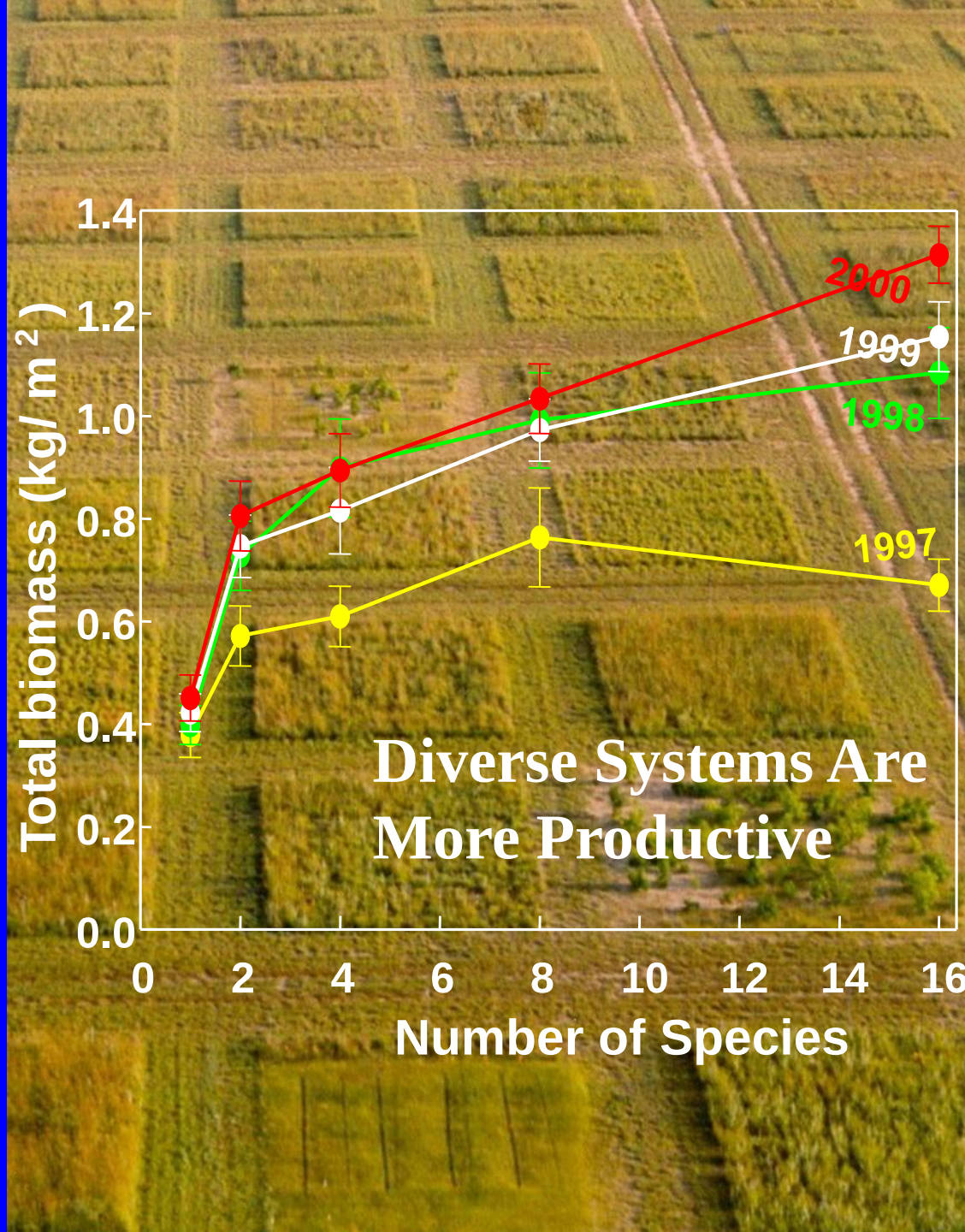
The Cedar Creek Biodiversity Experiments

Diverse Systems Use Limiting Resources More Efficiently



Our Research Shows:

- Ecosystem biodiversity enhances productivity, nutrient use efficiency
- Greater diversity leads to greater ecosystem stability and predictability
- Greater diversity leads to less disease
- The quality and quantity of ecosystem services depends on the diversity and composition of managed and natural ecosystems



How Can We Optimize Ecosystem Services on a Human-Dominated Earth?

By using – not fighting – ecological processes and principles

With cradle-to-grave analysis of the full costs and benefits of all agricultural, forestry, and manufactured products and processes

By basing policy, ethics and actions on processes and products that maximize the long-term net return to all of society

Forests, Farms and Ecosystem Services

- Farmers and foresters are the major land managers of the earth
- Current incentives are to produce crops at lowest price, ignoring costs to ecosystem services

We could maximize total return to society by paying land managers for the value of both the goods and ecosystem services they provide.

USDA-ARS

New York City and Catskill Water Production

New York City invested $2 billion to preserve the watersheds of the Catskills and their ecosystem services.

This is saving $1 Billion per year.

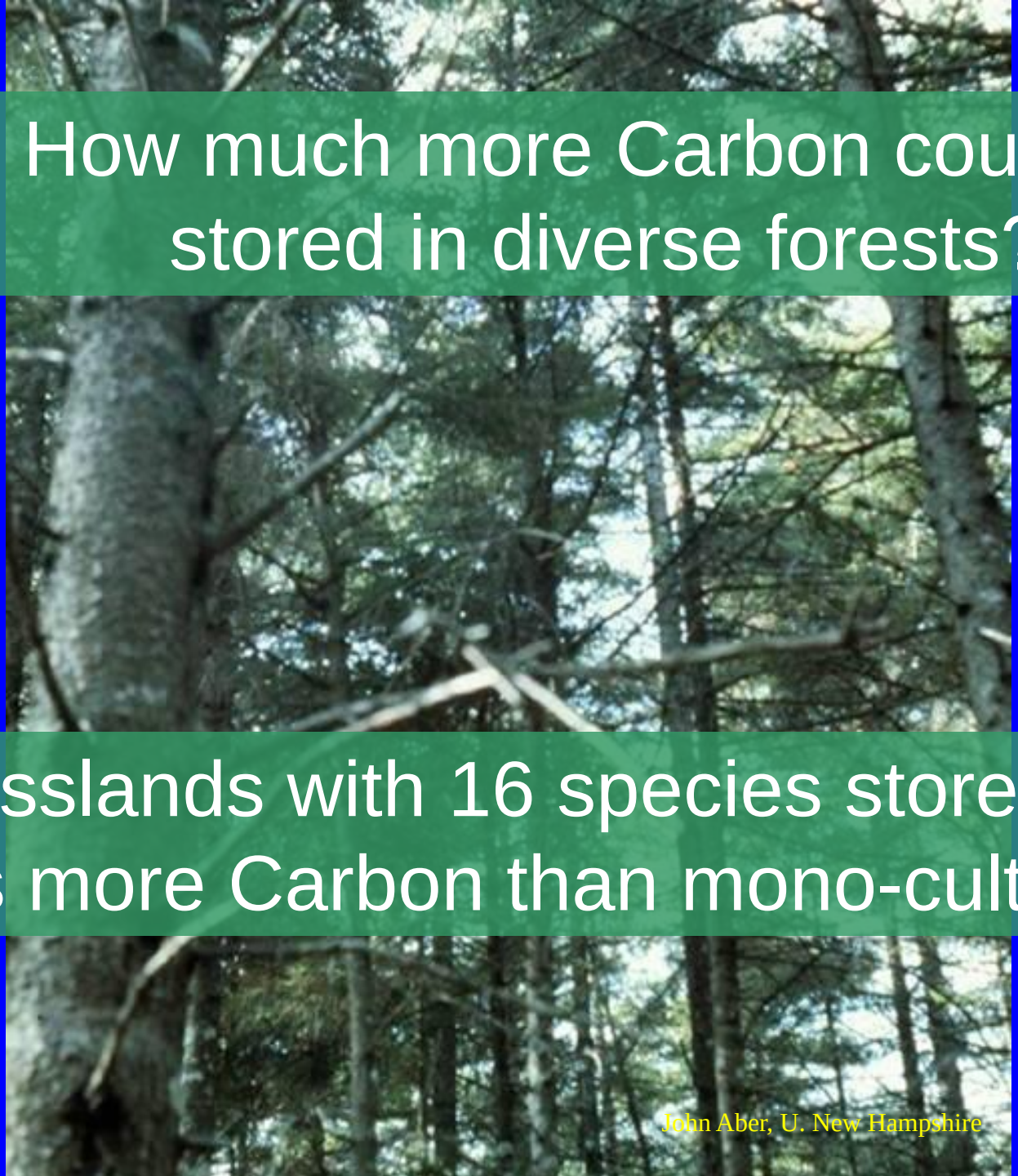
Steve Carpenter, U Wisconsin

Optimizing Ecosystem Services

Forested ecosystems remove and store some of the carbon dioxide released by fossil fuel use

Colors depict sources of CO_2 emissions:
white, light of cities;
red, forest & agricultural fires;
yellow, gas flares.

Source: Gene Feldman, NASA; W.T. Sullivan, III, University of Washington; Defense Meteorological Satellite Program of USAF



How much more Carbon could be stored in diverse forests?

Grasslands with 16 species store 2.7 times more Carbon than mono-cultures.

John Aber, U. New Hampshire

Three grasses – Corn, Wheat and Rice – provide 60% of human caloric needs.

photo credit: USDA-ARS

Irish Potato Famine

SEARCHING FOR POTATOES IN A STUBBLE FIELD.

Illustrated London News

Low Crop Diversity:

Ireland Depended On One Strain of One Crop

Genetic Diversity in Seed Banks and Nature is Used to Fight New Diseases

North Central Regional Plant Introduction Station
Ames, Iowa

Northern Corn Blight

Gary Munkvold, Iowa State U.

The Three Most Abundant Plants On Earth – Corn, Wheat, Rice –

Hosts for New Pathogens?

photo credits: USDA-ARS

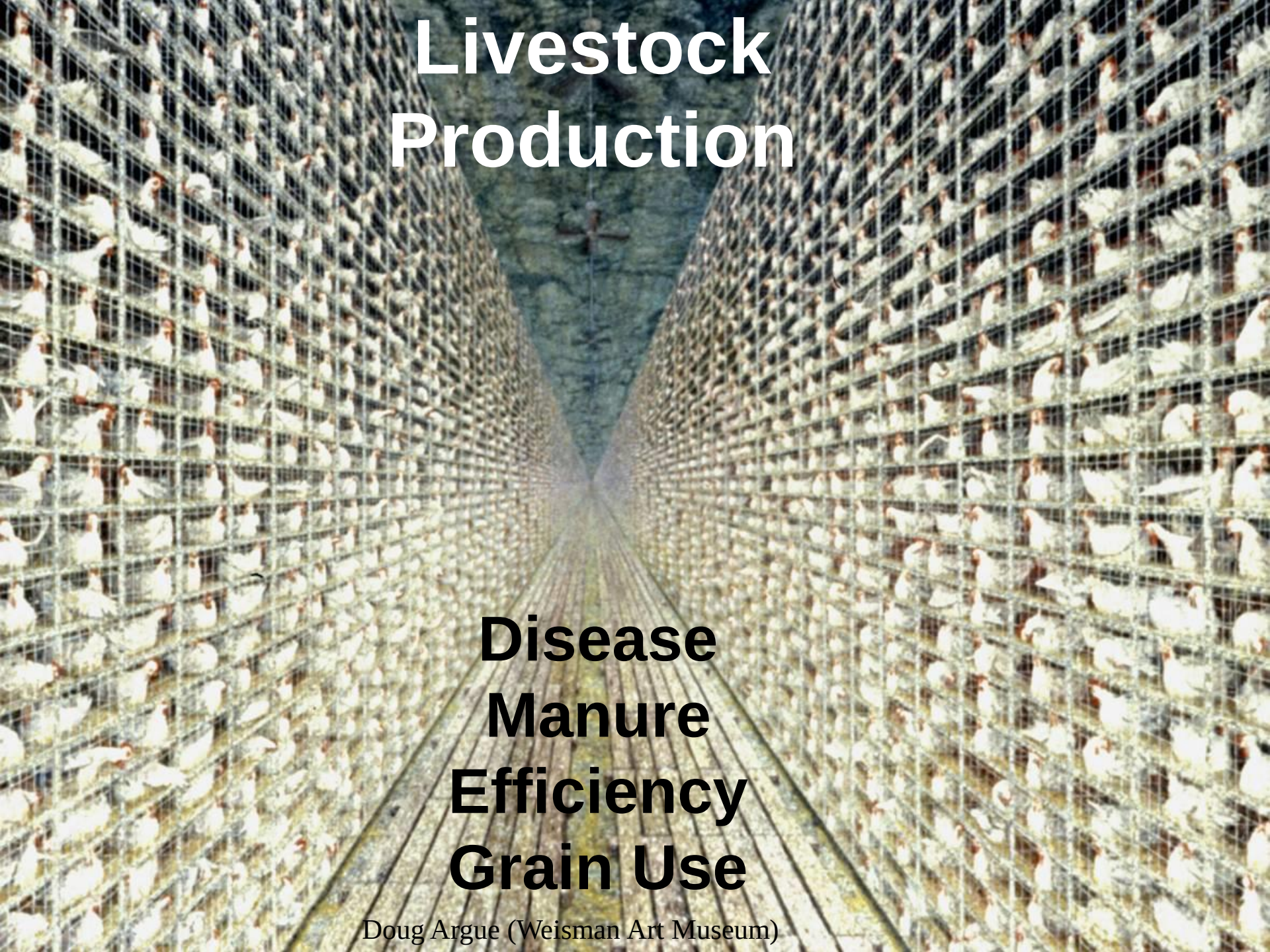
Crop Strength Through Diversity

Rice Diversity Fights Disease and Eliminates Fungicide

photo credits: NASA

Livestock Production

Disease
Manure
Efficiency
Grain Use



Meat Production Methods

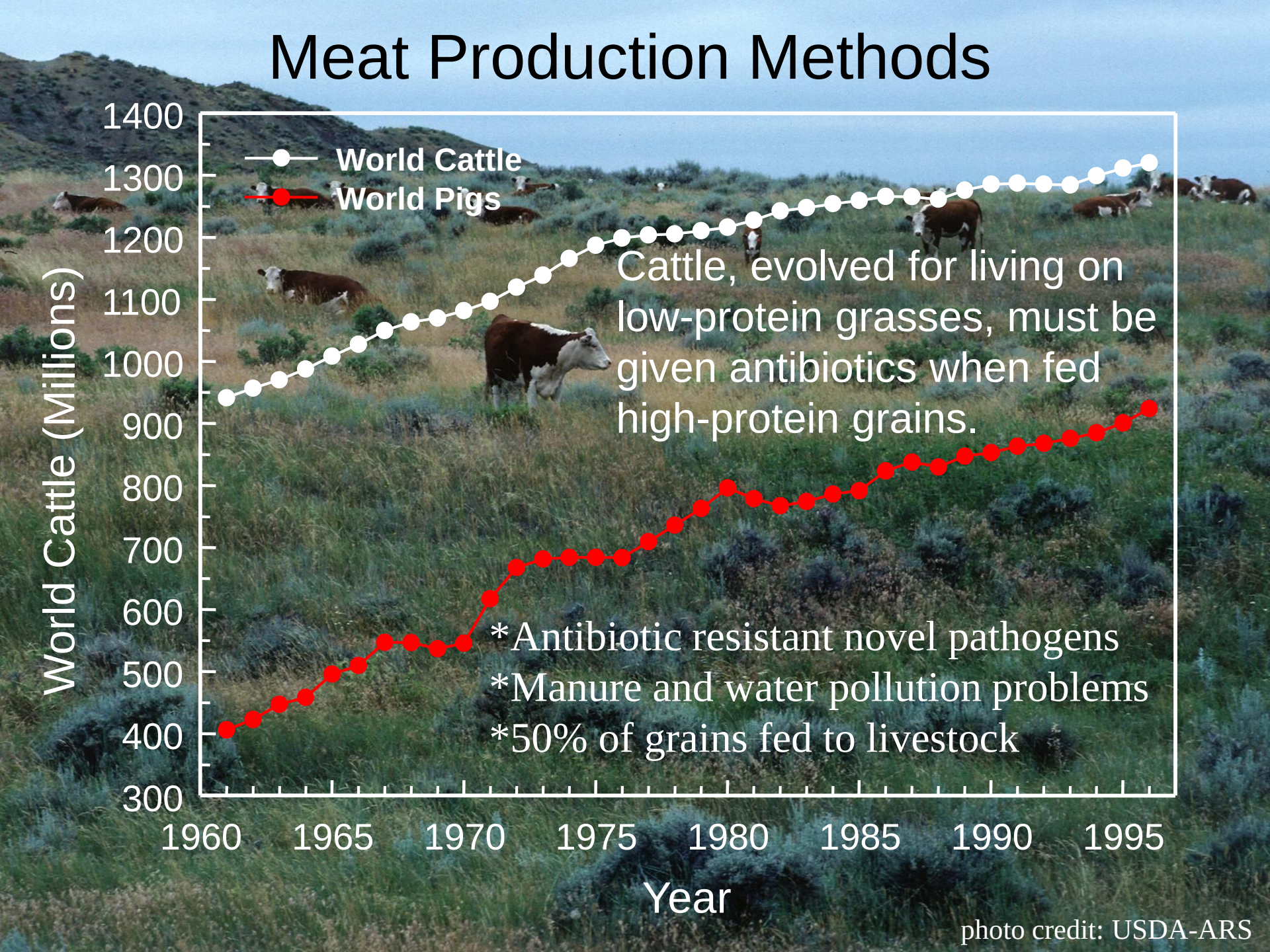
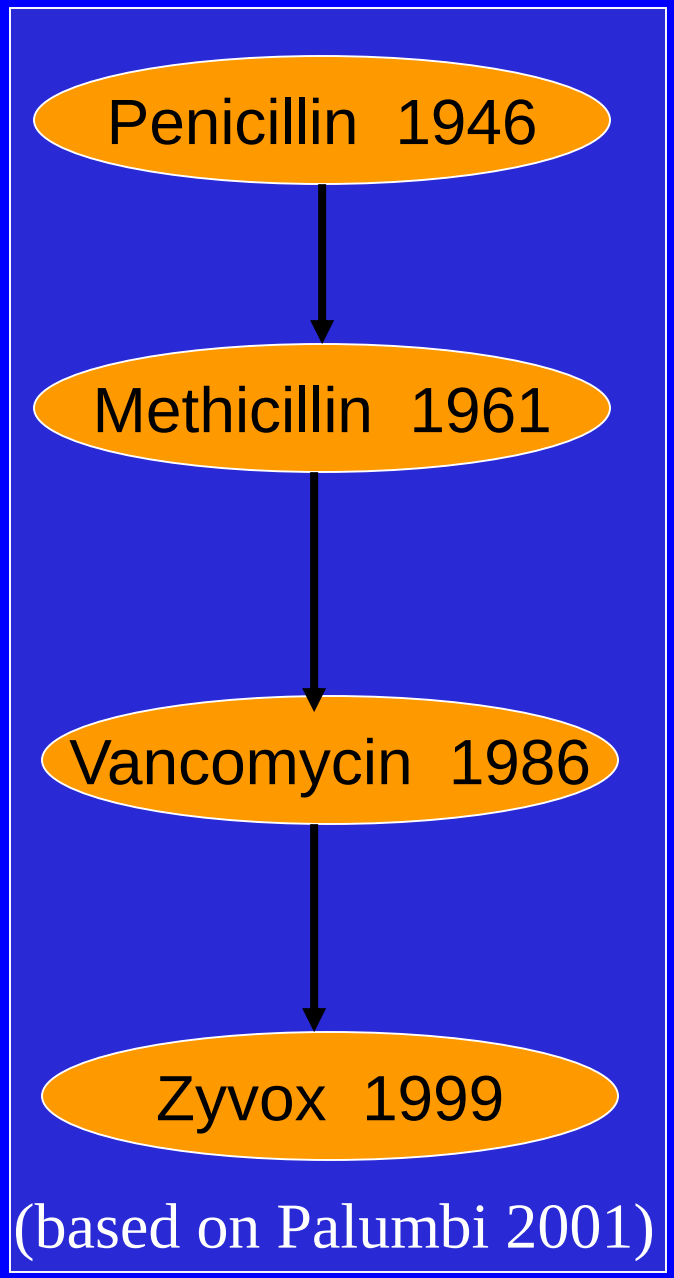


photo credit: USDA-ARS

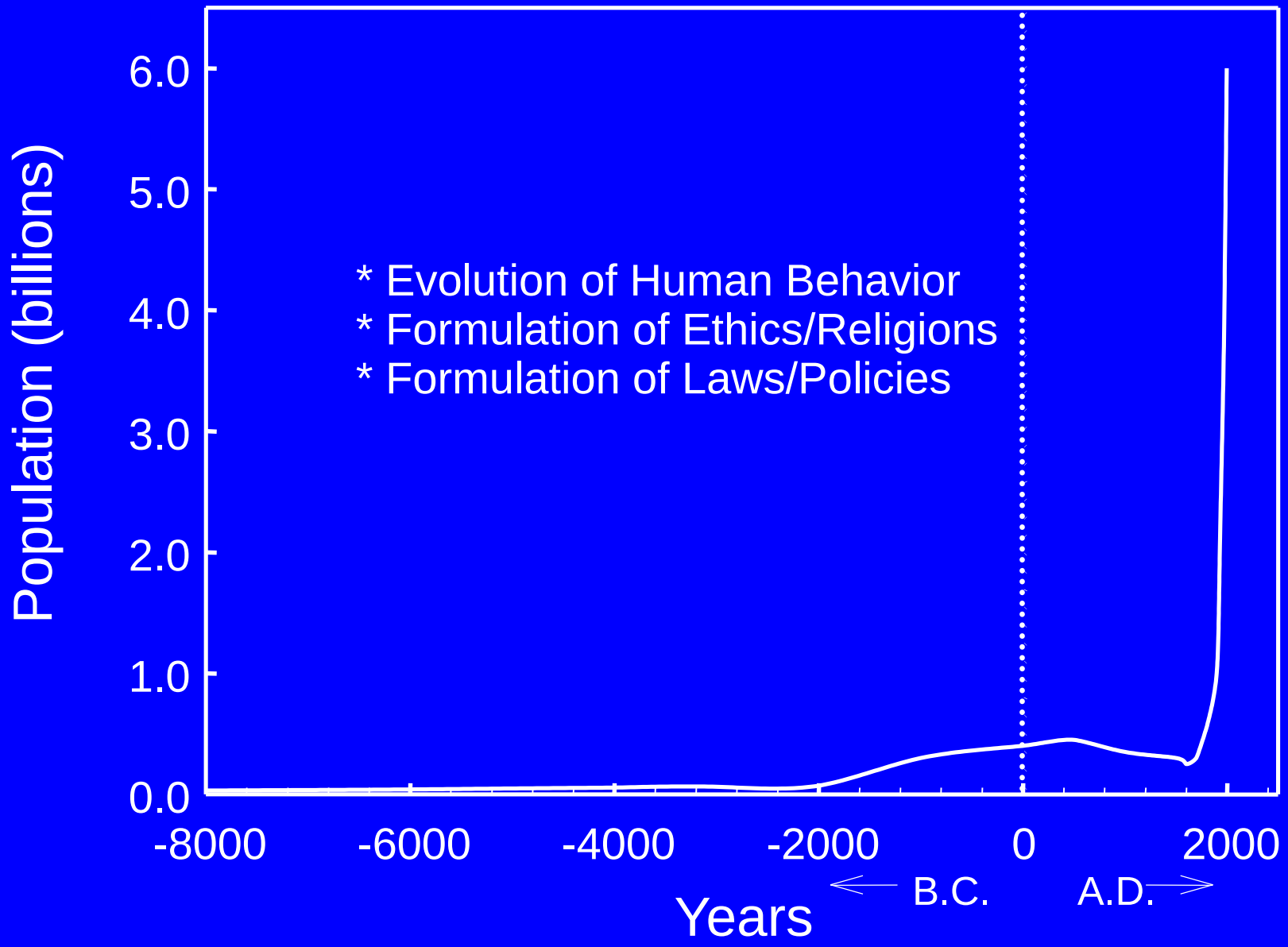
Overuse and Rapid Evolution of Resistance:



Antibiotic Resistance & Pesticide Resistance:
Loss of valuable medicines and agri-chemicals

It is time to incorporate the insights of ecology and evolution into medicine, agriculture, forestry and environmental management.

Ethics and Policies for A Human-Dominated World



Global Ecosystem Domination: Challenges and Solutions

Challenge

To improve the long-term welfare of all of society by assuring a sustainable and equitable flow of vital goods and ecosystem services for current and future generations.

Solutions

- Measure the full costs and benefits of alternative practices;
- Determine which practices maximize the net benefits to society;
- Incorporate this knowledge – and the search for ever better practices – into policy and ethics.

There are solutions, and we will find better and

Once moving in the right direction

even the giant ground sloth could have moved fast enough to solve these problems.

better solutions, once we focus on the problems

Dr. G. David Tilman

Dr. Tilman is the Distinguished McKnight University Professor in the Department of Ecology, Evolution, and Behavior, at the University of Minnesota, and the director of the Cedar Creek Natural History Area. His research interests include the ecological effects of human domination of the earth, population ecology and theory of community dynamics and biodiversity, the role of resource competition, biodiversity and ecosystem functioning, and the effects of habitat destruction.

Dr. Tilman is intrigued by the causes of broad, general patterns in ecological systems, especially patterns in the biological diversity, structure and dynamics of plant (and sometimes insect) communities. He also focuses on a related issue - the effects of biodiversity on the stability and functioning of ecosystems, which is scientifically intriguing and of great importance to society. Finally, he is interested in the impacts of human domination of global ecosystems, especially in the impacts of nitrogen deposition, habitat destruction/fragmentation, and invasive exotic species. He studies mechanisms of resource competition among terrestrial plants, especially in the grasslands of Minnesota's Cedar Creek Natural History Area. These collaborative projects take place at Cedar Creek and are supported by the NSF Long-Term Ecological Research Program or The Andrew Mellon Foundation.