The Marcellus Shale Play

Impacts to stream ecosystems and potential regulation of intensity of mining
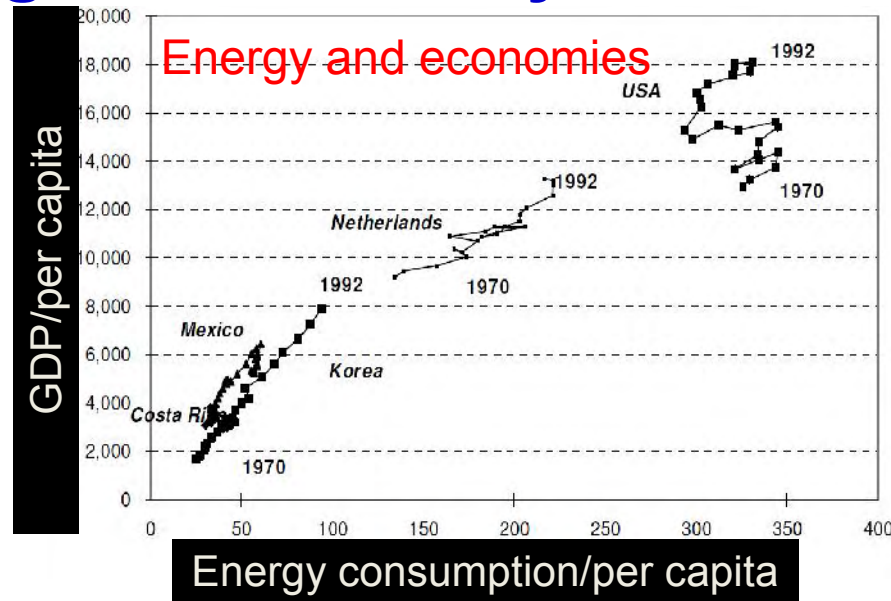
Jerry V. Mead, Frank Anderson, David Velinsky, and Richard Horwitz

Patrick Center for Environmental Research
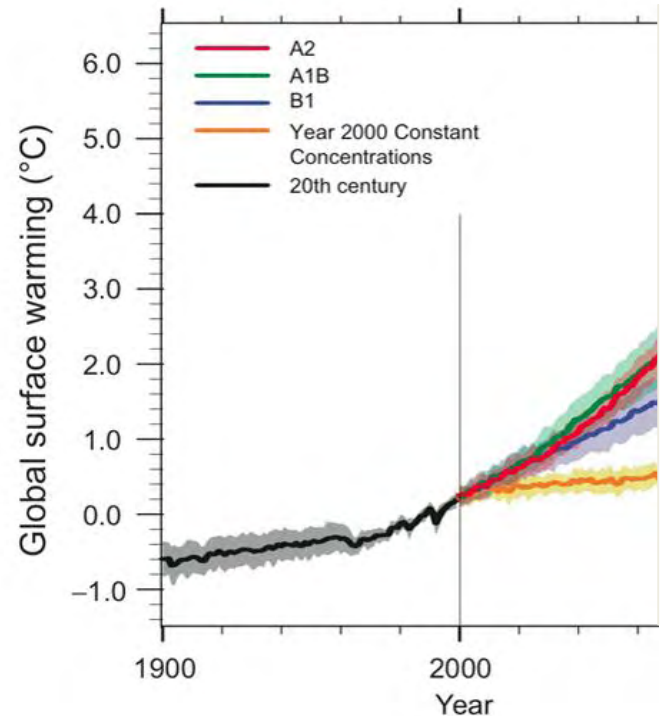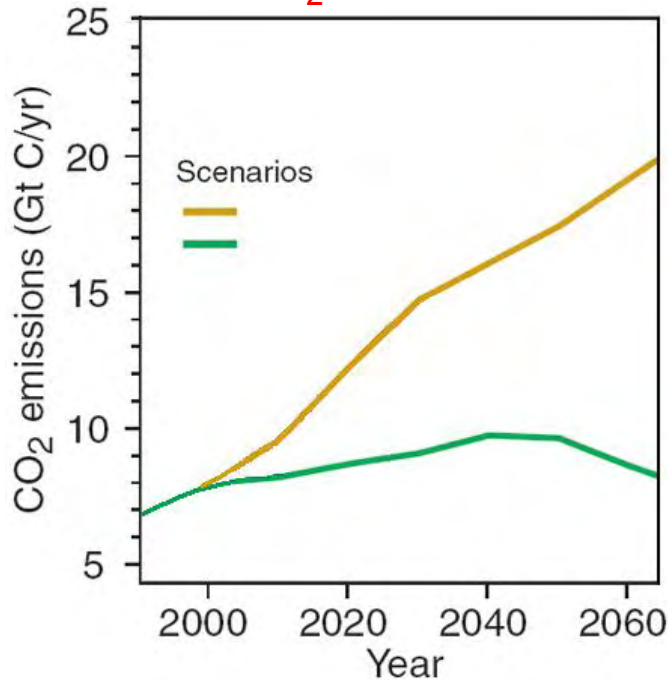
The Academy of Natural Sciences

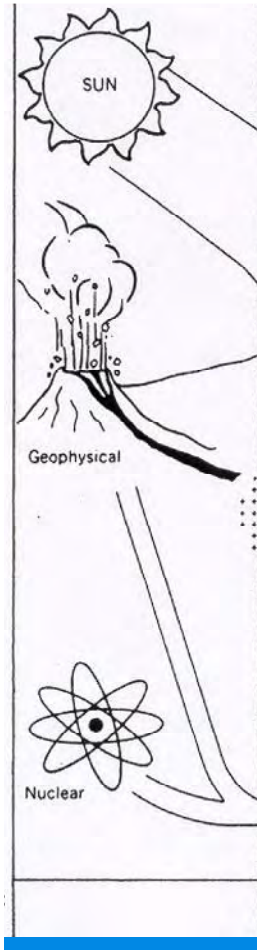# Energy use, global economy, and climate change

Energy and economies

GDP/per capita vs Energy consumption/per capita

CO₂ emissions

Climate change

This is how real economies work

Energy Sources

SUN

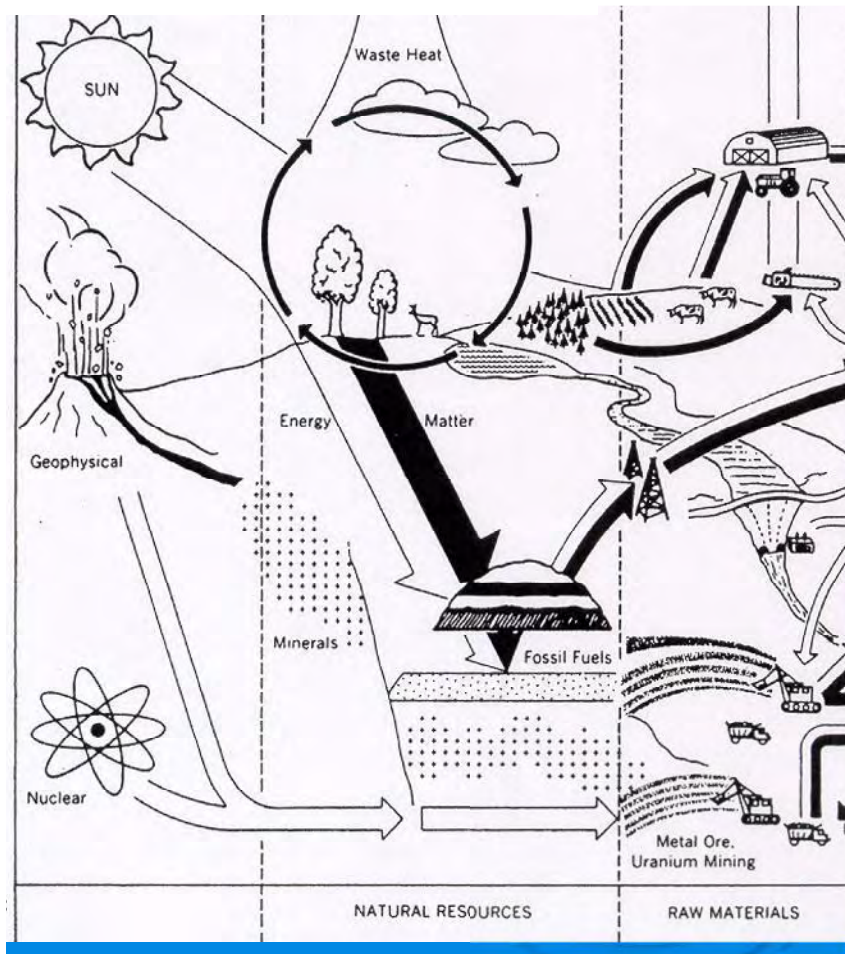Geophysical

Nuclear

This is how real economies work
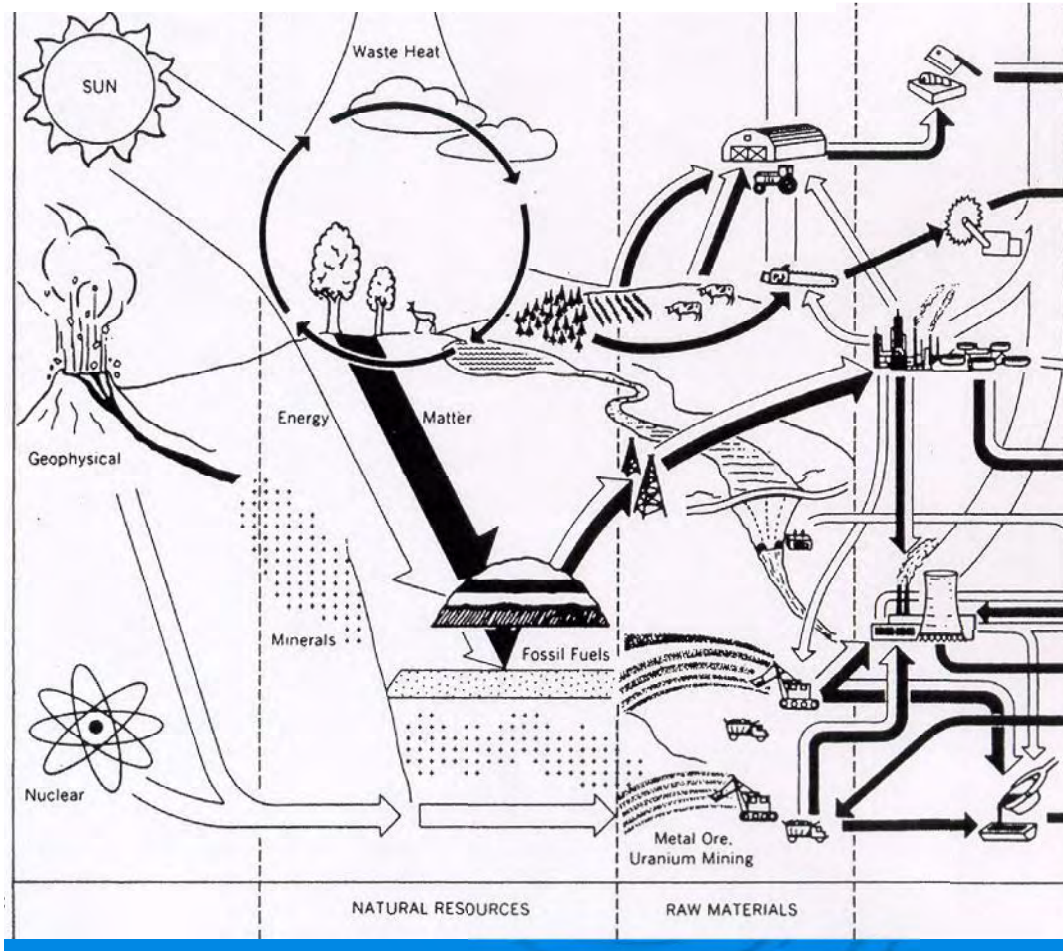
Raw Materials
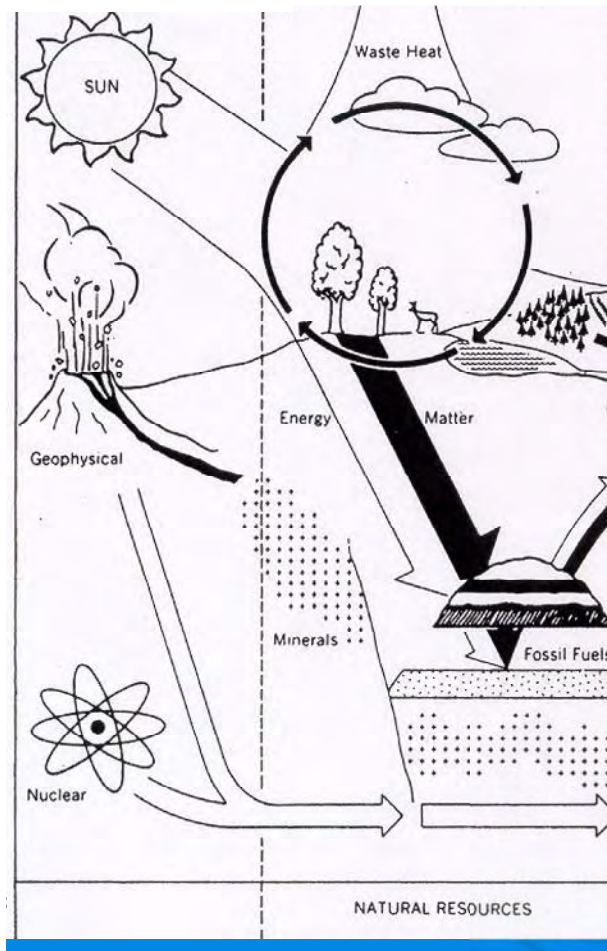
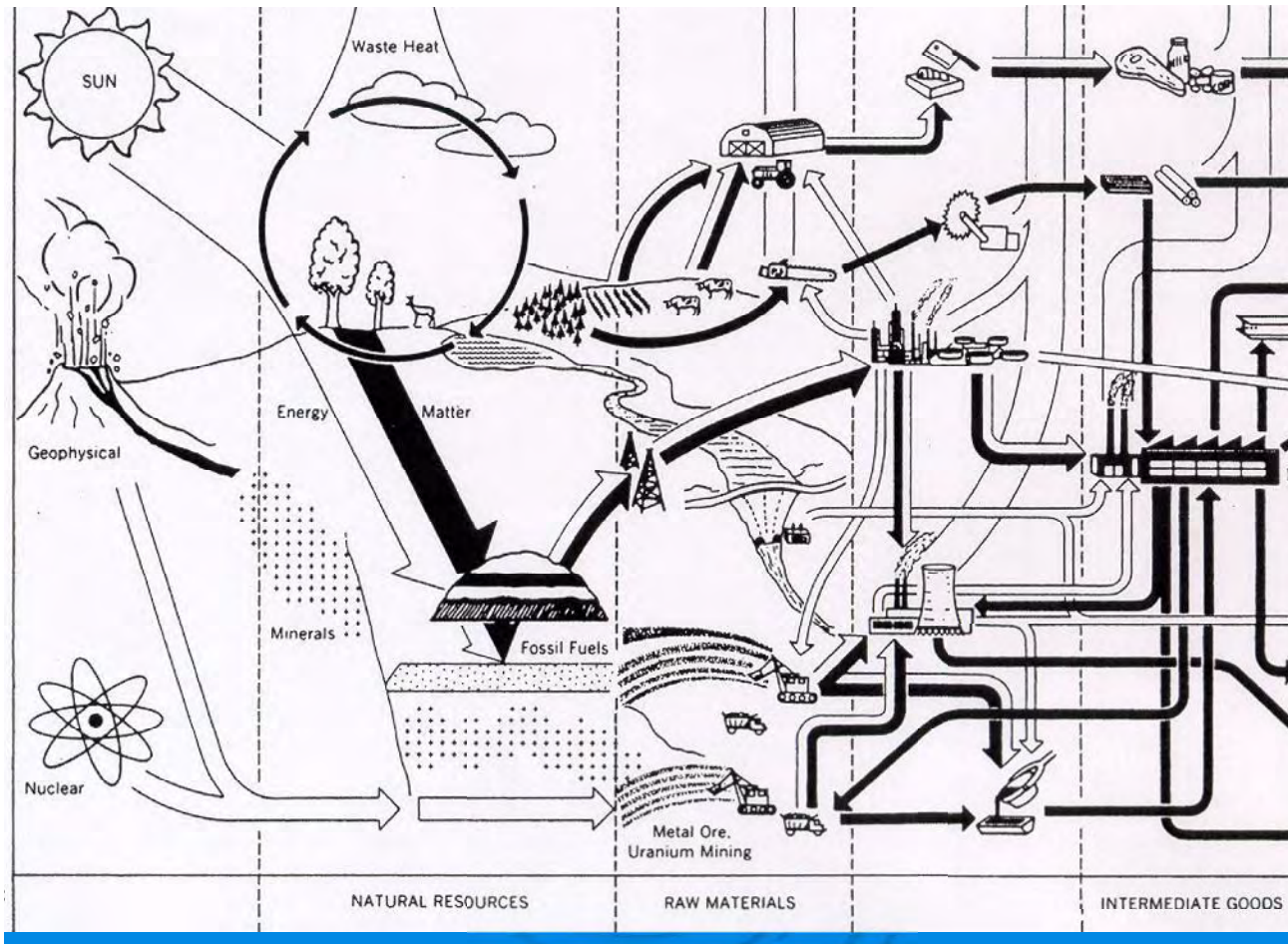# This is how real economies work

Exploitation

This is how real economies work

Processing

This is how real economies work

Manufacture

This is how real economies work

Consumption

This is how real economies work

MAINTENANCE OF ENVIRONMENTAL PREREQUISITES AND AMENITIES | CULTURAL TRANSFORMATIONS

Energy Sources | Raw Materials | Exploitation | Processing | Manufacturing | Consumption

SUN

Waste Heat

Geophysical

Energy   Matter

Minerals

Fossil Fuels

Nuclear

Metal Ore, Uranium Mining

NATURAL RESOURCES | RAW MATERIALS | INTERMEDIATE GOODS | FINAL DEMAND
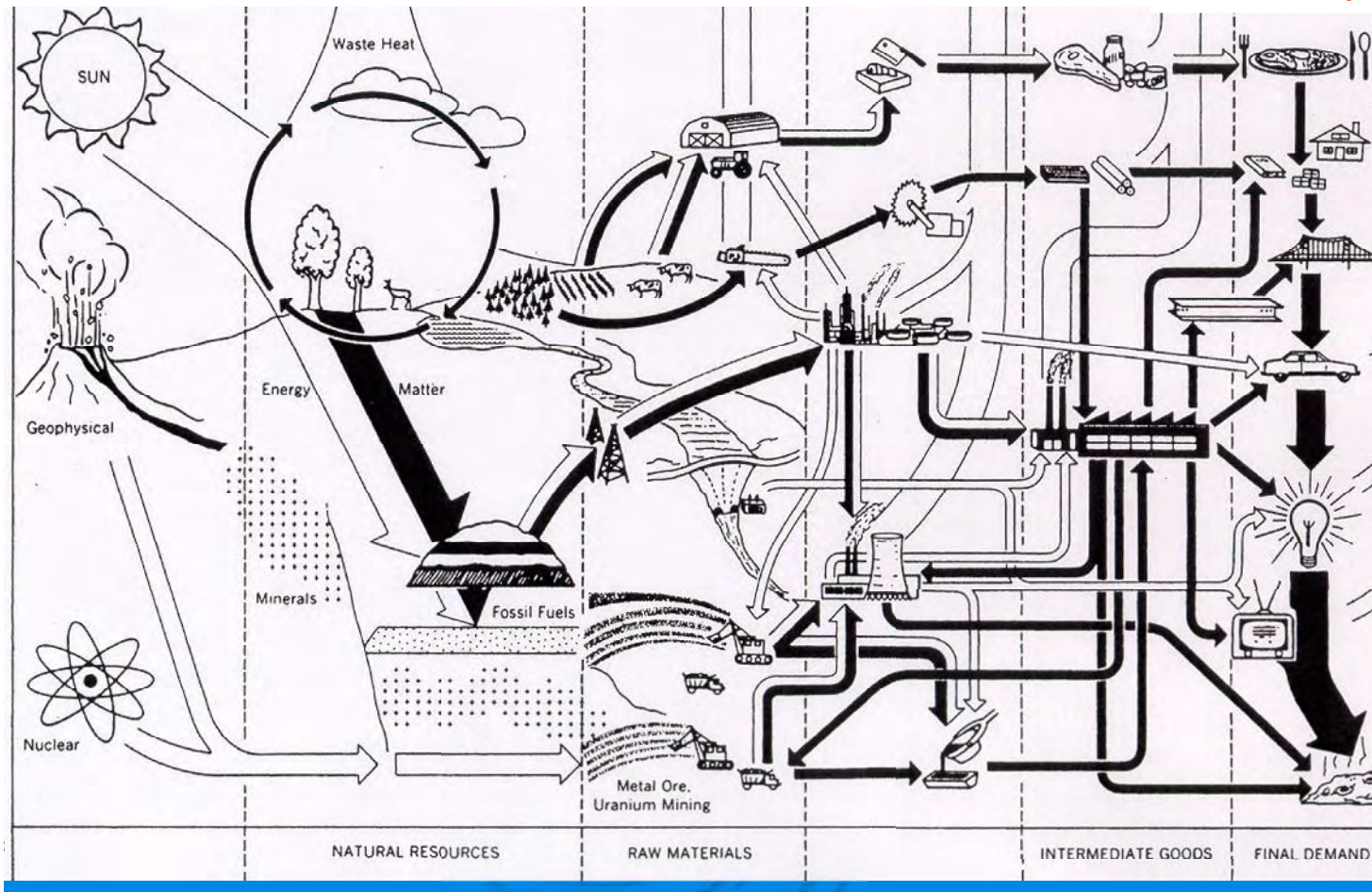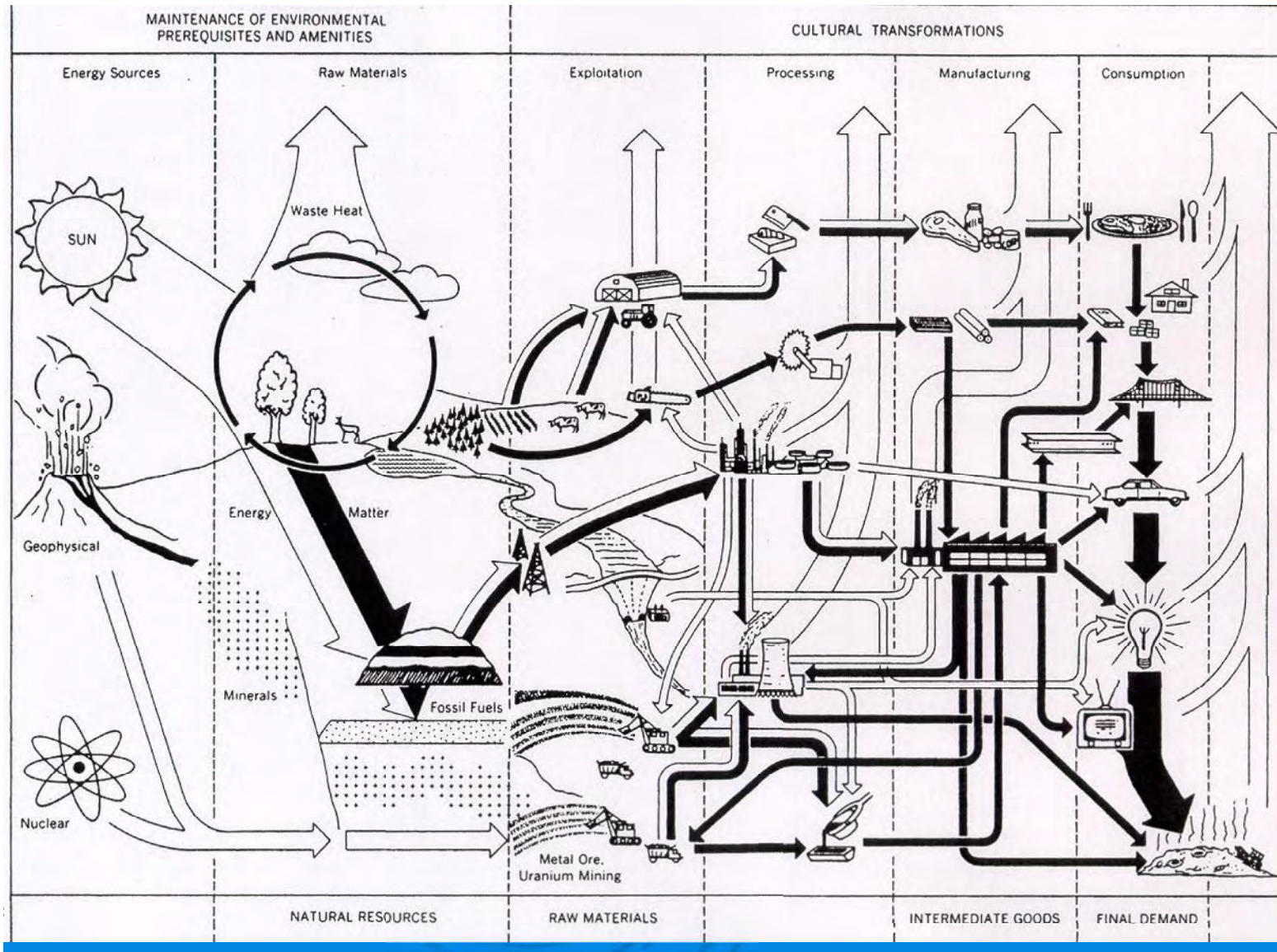
Global energy mix
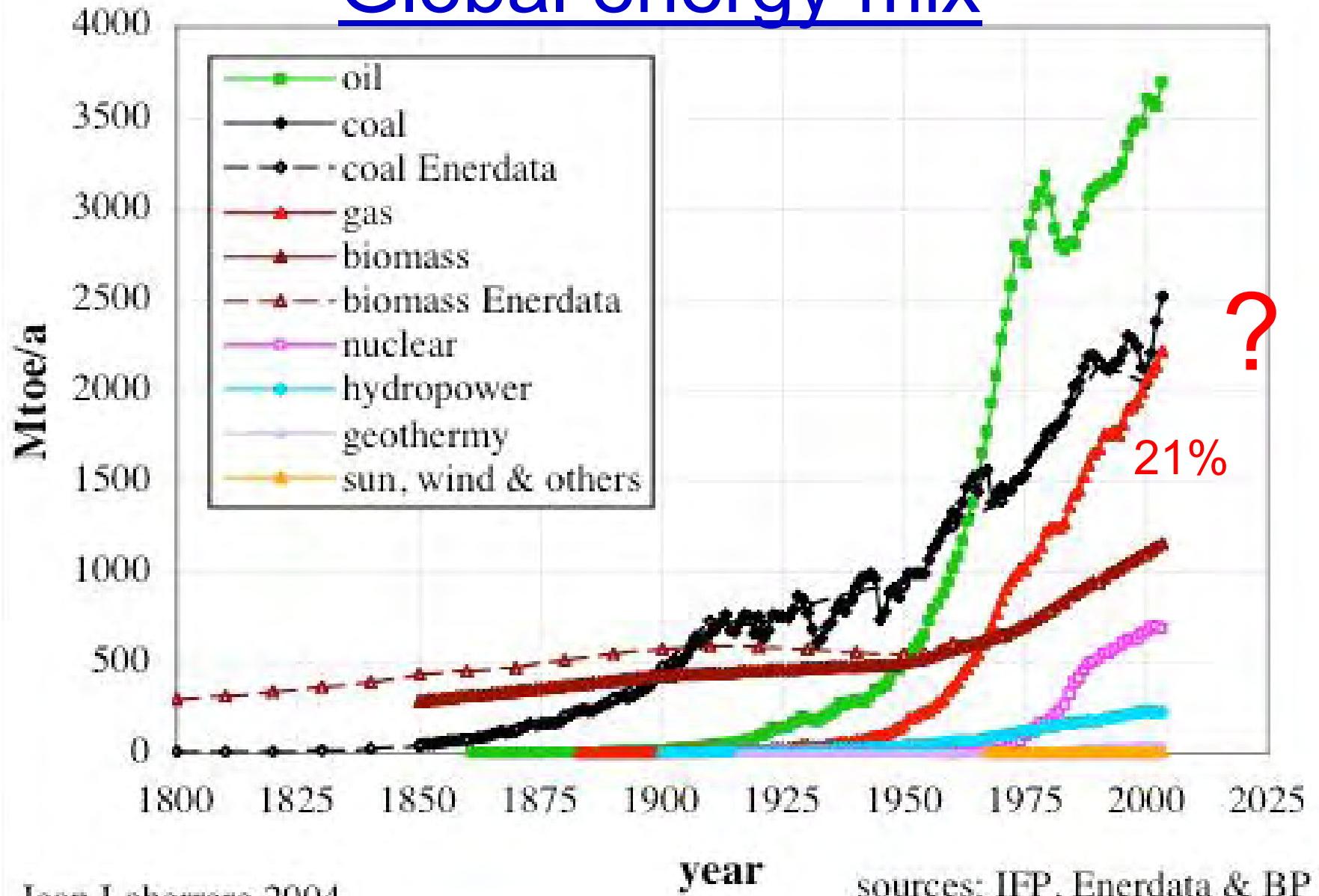
Jean Laherrere 2004

sources: IFP, Enerdata & BP

The Epoch of Fossil Fuel Exploitation

(after Hubbert, 1969)

"Hubbert's pimple"

Is peak oil real?

"Our ignorance is not so vast as our failure to use what we know"

Trillion kwh per year — 300, 200, 100

-5, -4, -3, -2, -1, 0, +1, 2, +3, +4, +5

Stonehenge Built

Iron in Middle East

Parthenon completed

Pyramids constructed

Mayan culture

Inquisition

Black Death

Magellan's Circumnavigation

Steam Engine
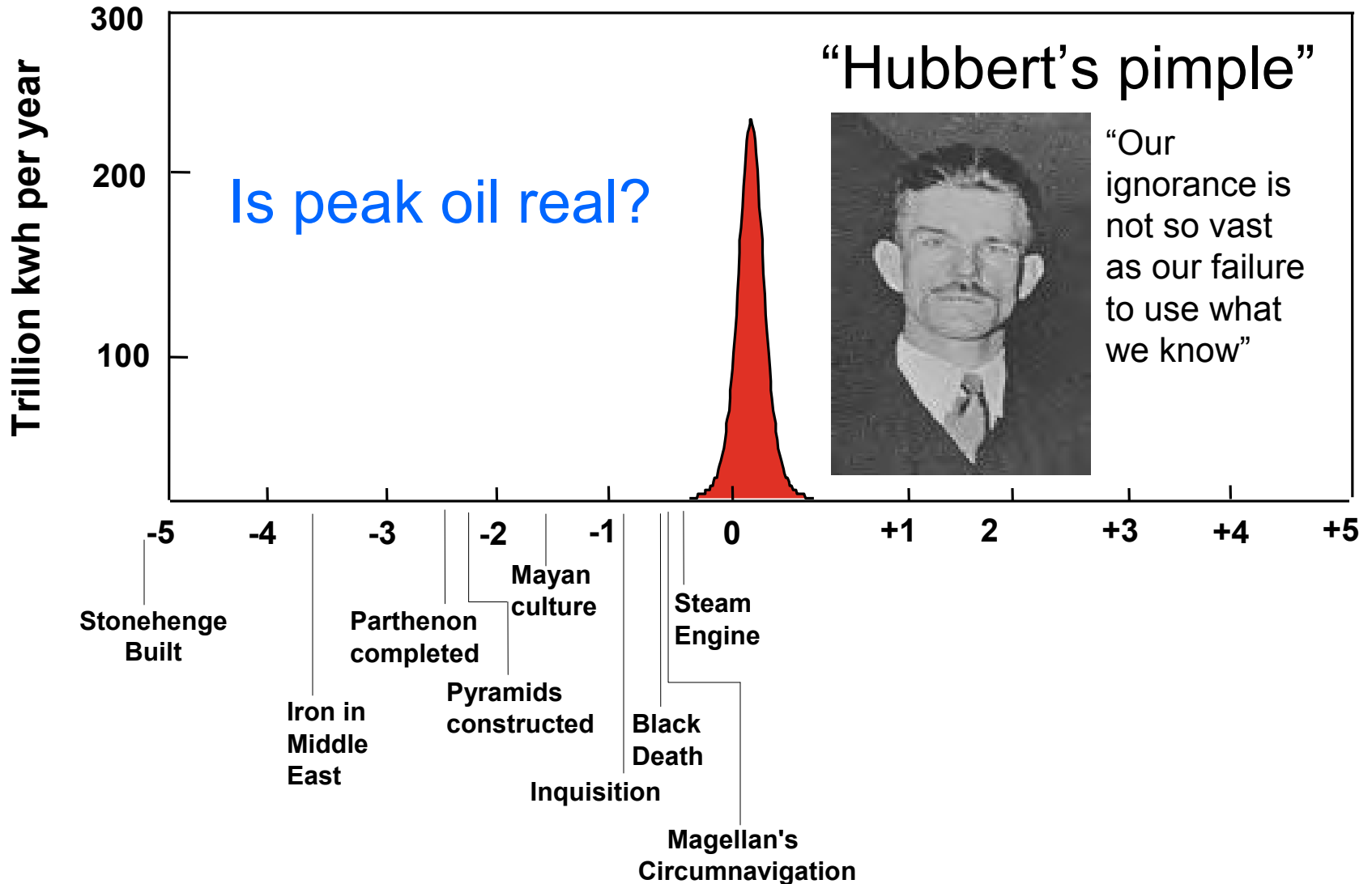
US Lower 48 annual production & discovery shifted by 32 years

Discoveries →

Legend:
- disc smooth 5yr & shift 32 yr
- prod. O Gb

Y-axis: production & discovery Gb/a
X-axis: year
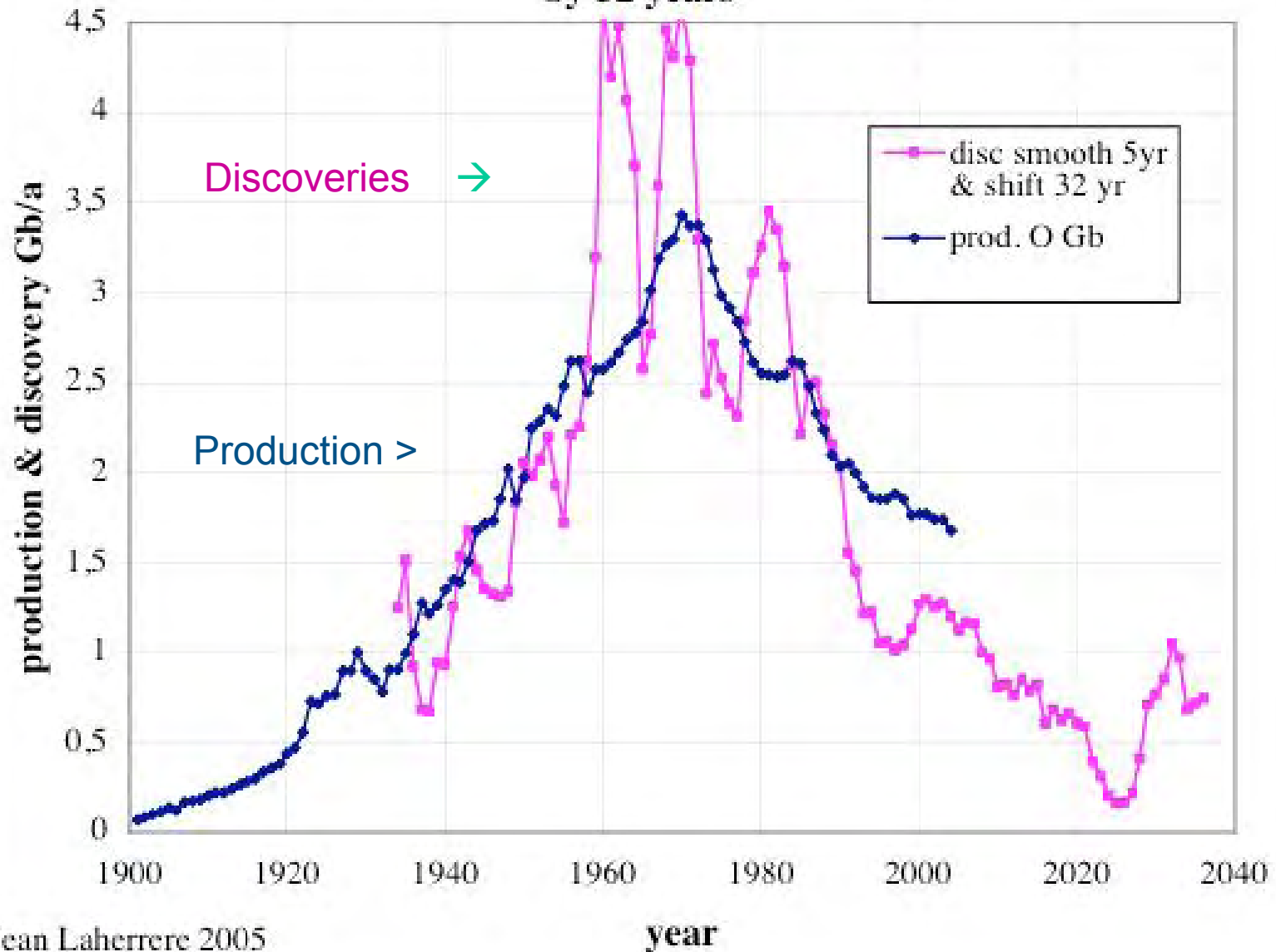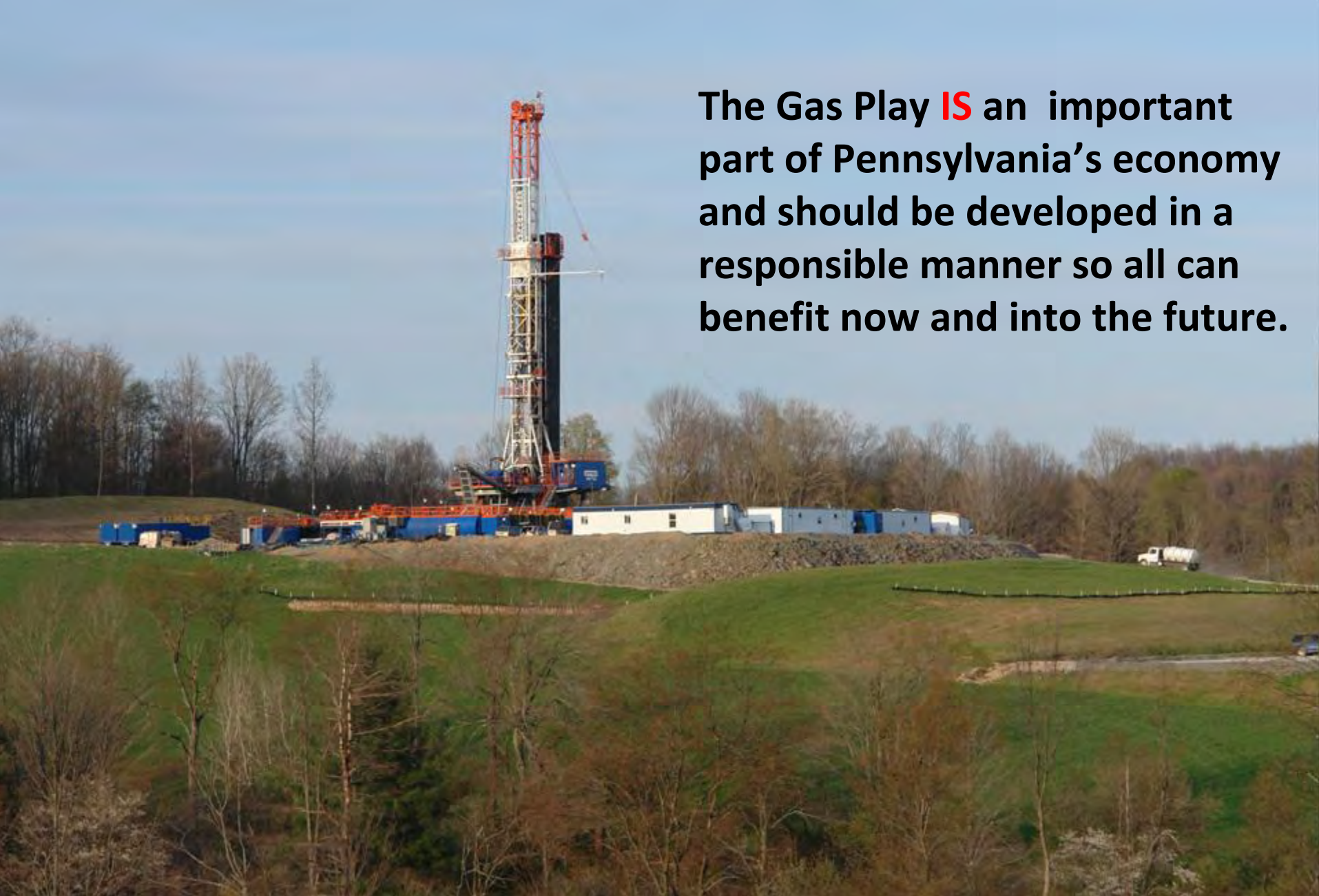
Jean Laherrere 2005

Fossil fuels are a sweet deal!

C.A.S Hall 2006
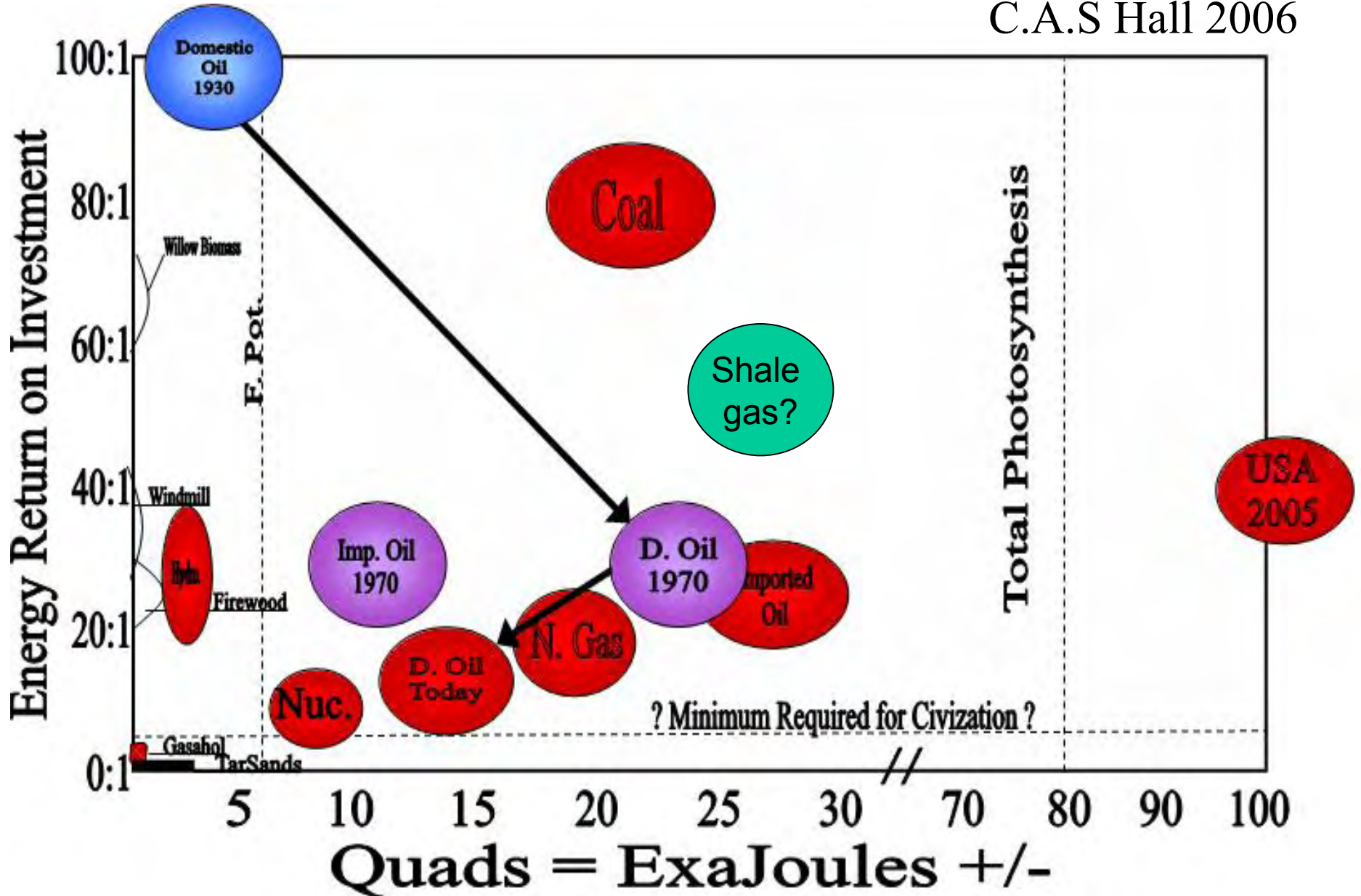
Patrick Center for Environmental Research   The Academy of Natural Sciences

The Gas Play **IS** an important part of Pennsylvania's economy and should be developed in a responsible manner so all can benefit now and into the future.

Endangerment Causes

Urbanization	247
Agriculture	205
Water diversions (e.g., reservoirs)	160
Recreation, tourism development	148
Pollution	143
Domestic livestock, ranching	136

Czech et al. 2000. *Bioscience* 50(7):593-601.

Causes (cont.)

Mineral, gas, oil extraction	134
Non-native species	115
Harvest	101
Modified fire regimes	83
Road construction/maintenance	83
Industrial development	81

Czech et al. 2000. *Bioscience* 50(7):593-601.

Patrick Center for Environmental Research   The Academy of Natural Sciences
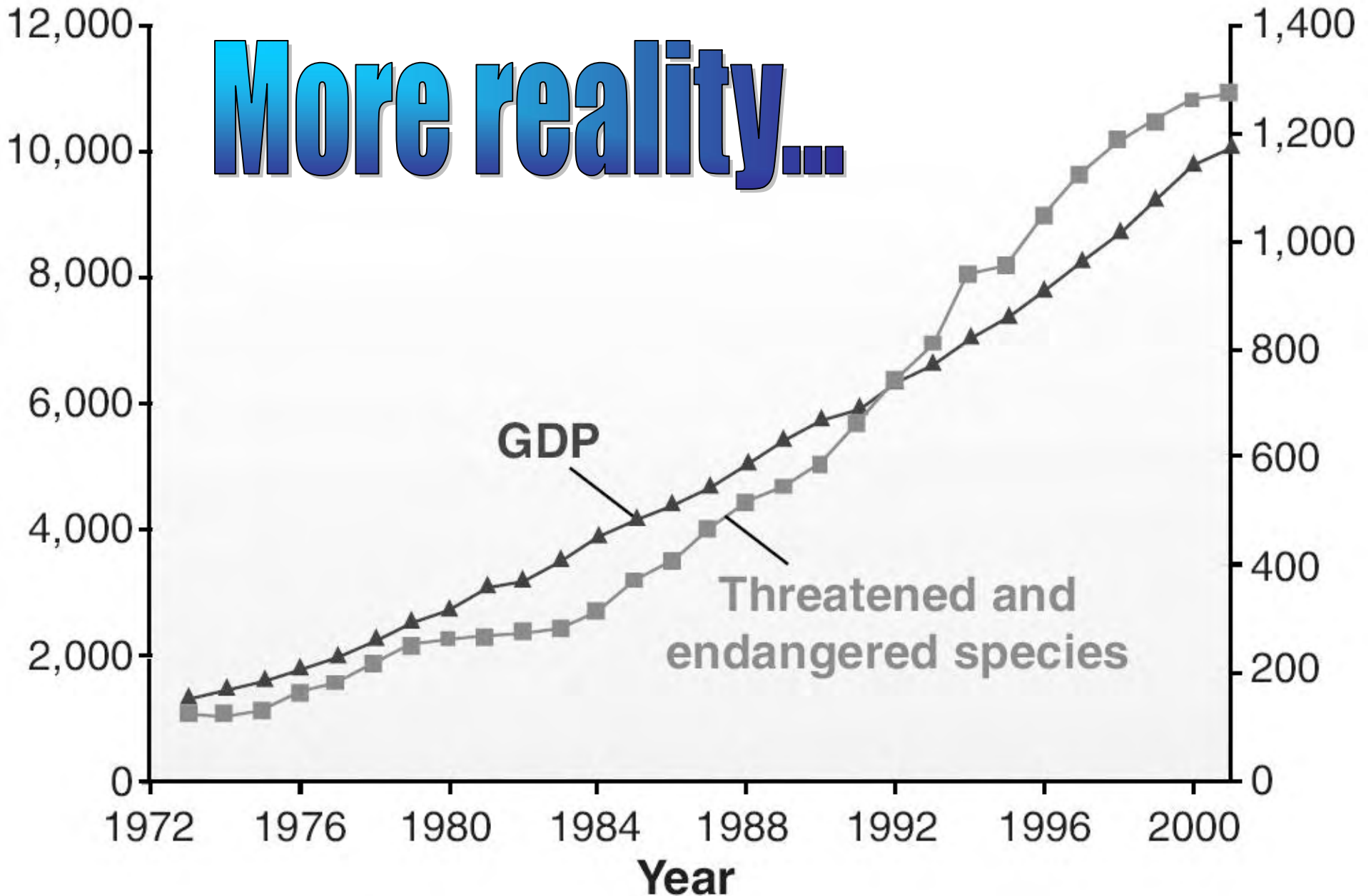
Potential issues with shale mining

Short Term (construction)
- Water withdrawals
- Flowback disposal
- Light and noise
- Drilling ponds – wildlife
- Air quality
- Seismic activity

Long Term (occupancy)
- Pad on landscape
- GW contamination
- Habitat fragmentation
- Solids disposal on site
- Invasive species
- Edge effects; succession

Why is it important to monitor these activities?

• Both loss of forest area and chemical impacts can reduce _Ecosystem Services_ of upper Delaware Watershed stream network by:

       - reducing nutrient removal,

       - impacting recreational fisheries,

       - reducing water quality, and

       - decreasing recreational use.

>> Very little information is available related to land use changes and the biological impacts of increases in total dissolved solids in smaller streams and watersheds due to drilling activities therefore a study that investigates the **Cumulative Impacts to Aquatic Resources** needs to be undertaken.

What are some of the potential impacts?
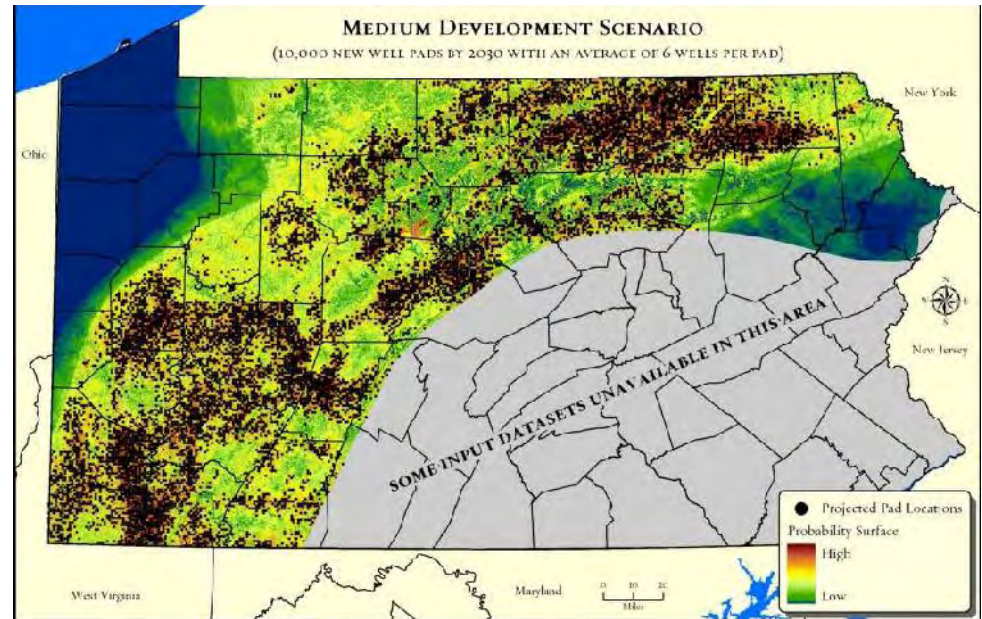

www.state.nj.us/drbc/
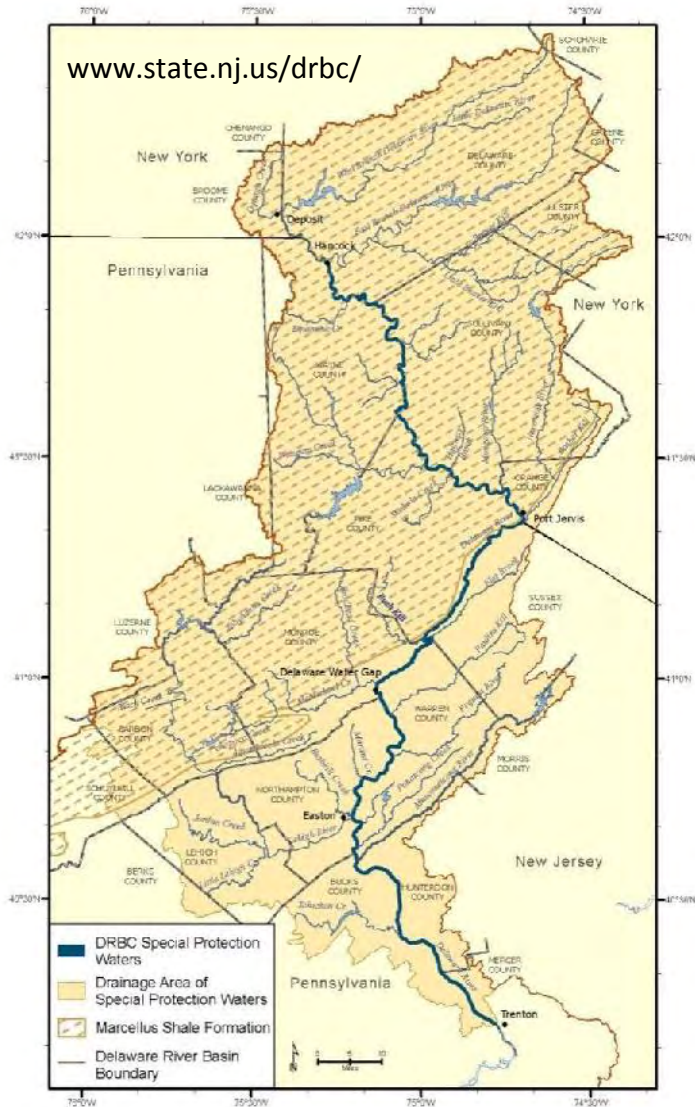
- *Decreased Water Quantity:* Water withdrawals from small streams, rivers and groundwater

- *Decreased Water Quality* (surface and groundwater): High concentrations of dissolved solids (and radioactive material) can impact ground and surface waters and decrease biological diversity and function

- *Land-Habitat Fragmentation:* Reduction of forest and open space, loss of connectivity among habitats

Academy's pilot study - sampling and methods
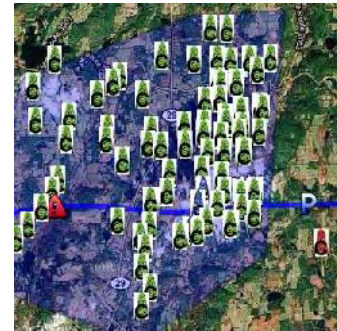
(Anderson et al., In review)

- ~9 sites (3 HD, 3 LD and 3 references)

- *Chemical Indicators*
  - Conductivity
  - pH
  - Dissolved Oxygen
  - Turbidity

- *Biological Indicators*
  - macro-invertebrates (to family)
  - algal community
  - aquatic amphibian communities

- *Watershed Indicators*
  - land cover
  - watershed area
  - riparian cover
  - stream substrate
  - stream width, water velocity

MEDIUM DEVELOPMENT SCENARIO
(10,000 NEW WELL PADS BY 2030 WITH AN AVERAGE OF 6 WELLS PER PAD)

SOME INPUT DATASETS UNAVAILABLE IN THIS AREA

Projected Pad Locations
Probability Surface
High
Low

http://pa.audubon.org/PDFs/energy_analysis%20report.pdf

Study Area

High Density

Low Density

Along with reference locations
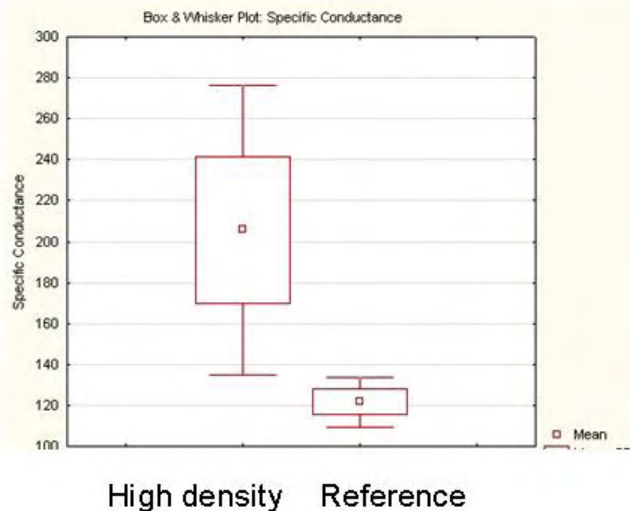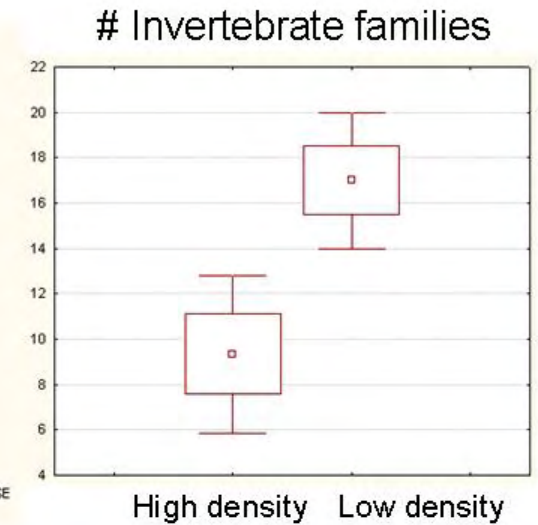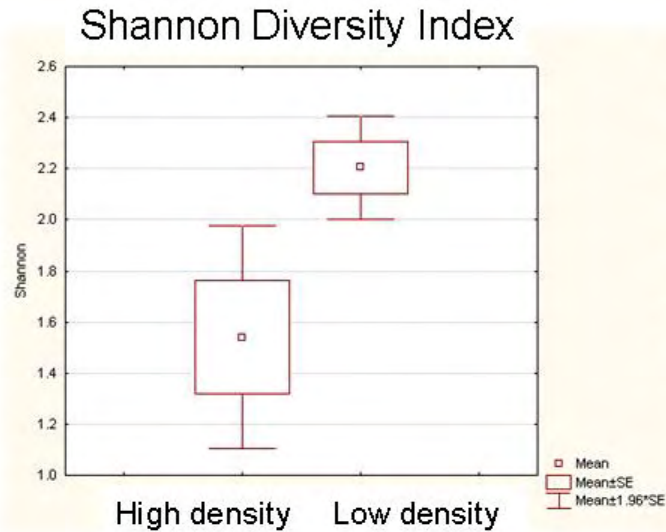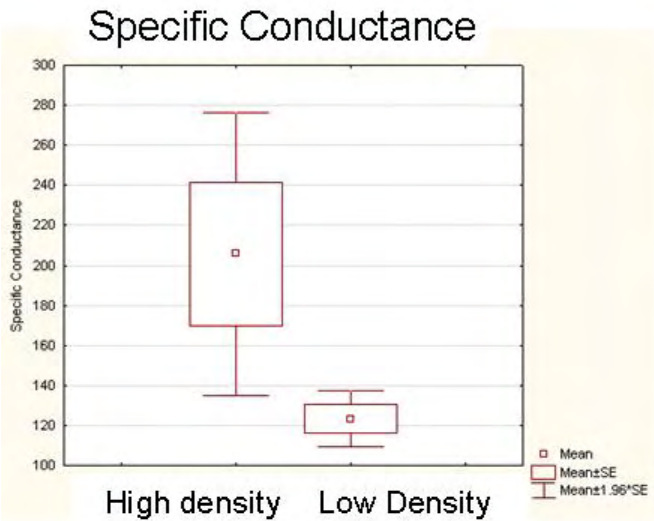
All test sites and all but 1 reference site were located in Southwestern Susquehanna County Pennsylvania, within or nearby the townships of Dimock and Springville.
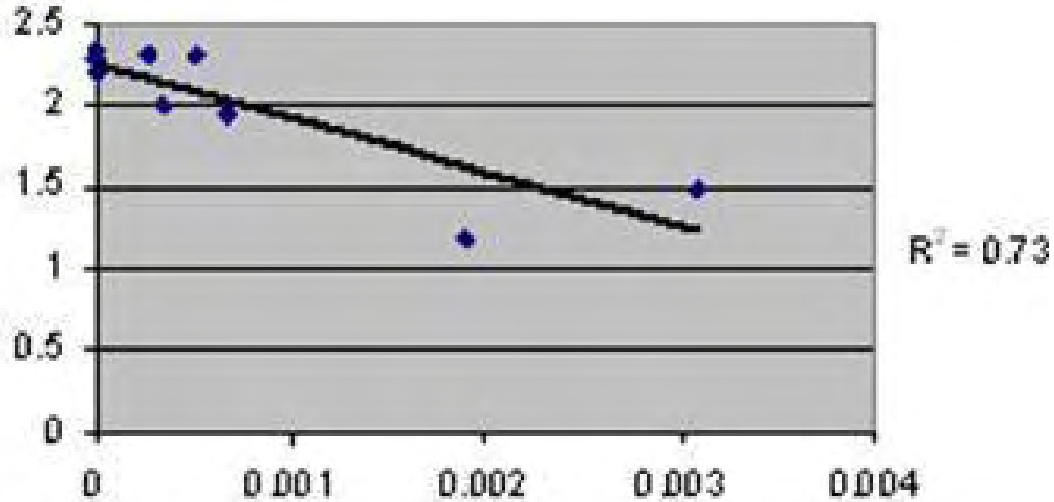
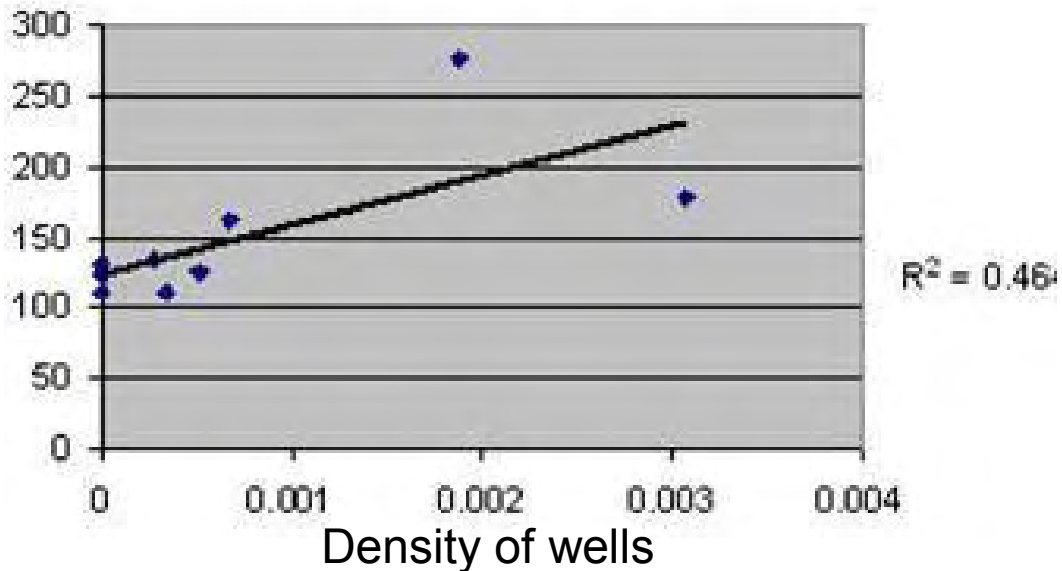# Well density and stream health
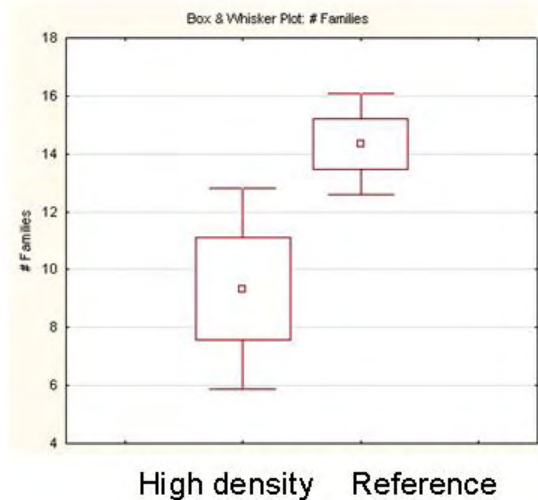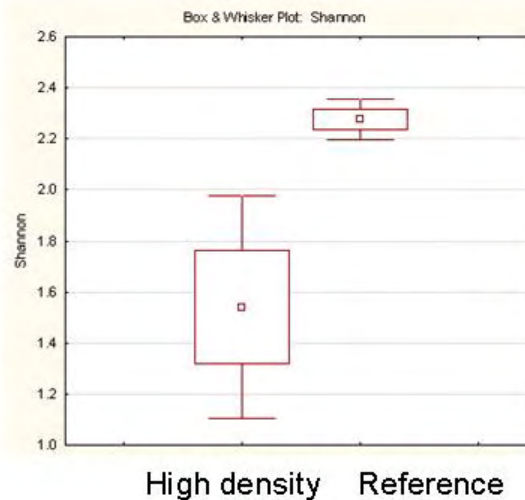
(Anderson et al., In review)

Well density and stream ecosystem

Shannon Index vs Well Denisty

$R^2 = 0.73$

Specific Conductance vs Well Density

$R^2 = 0.46$

Density of wells

What to do next?

Cumulative Impact Statement

Developing guidelines and tools for managers to minimize the impacts of Marcellus shale gas mining on stream ecosystems and land use

More sites and indicators to increase statistical power of decision making process
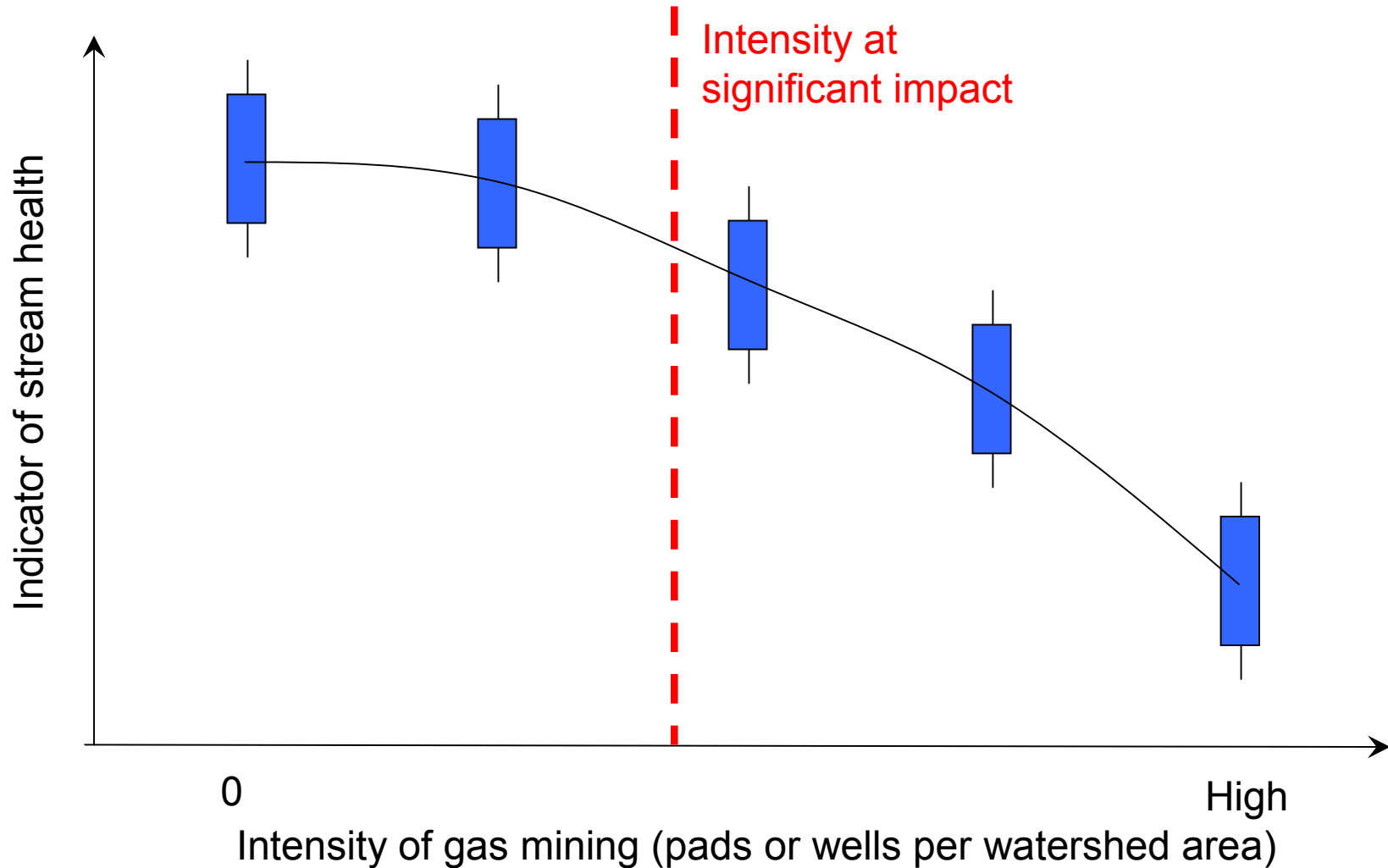
Goals of Study

- To determine if the density of wells in a watershed influences stream ecosystem health and water quality;

- To determine the relationships among well density, stream ecosystem health, and water quality .

Proposed study design

- Whole basin assessment of stream reaches (120 meter long reach);

- Evaluate watershed conditions of reaches with wells in their watershed;

- Study 36 stream reaches with a gradient of well density, but little variation in watershed conditions;

- Relate well density to indices of stream community health.

Main project target

Thank you!