Earth's Climate: Past, Present and Future
OLLI Central Spring 2016:
week 7 (May 11th) & week 8
Paul Belanger
Solutions – part A
The Ultimate Primary Focus: Energy and Sequestration of CO2

1. Economics
   - of doing nothing (solely adapting) vs. the economics of mitigation
   - Actuality: it WILL be a combination
2. Capitalism, GDP/growth based economics vs. "Herman Daly" economics (no-growth/steady-state)
3. Solutions? Paradigm shift? From we can't/too expensive to WE CAN
4. There is promise, but at what cost? (One might be surprised).
   - Energy
   - Mitigation – Agricultural revolution/biofuels: Biochar for Carbon Dioxide Removal (CDR)

The economics/the solutions? continued

5. Geoengineering:
   - Solar Radiation Management (SRM) and
   - Carbon Dioxide Removal (CDR)
6. Biochar vs. BECCS solutions SEE MY BIOCHAR LINK IN OTHER PAGES: http://denverclimatestudygroup.com/?page_id=28
7. Efficiency – the single quickest way to reduce:
   - What NREL is doing: Efficiency, Solar, wind, other
8. Other strategies:
   - CCL – carbon fee/dividend
   - Cap and trade?
9. Gloom and Doom? NO! IT'S A CHALLENGE, and humanity has always been challenged and we are an adaptable species that has met the challenge over and over again!

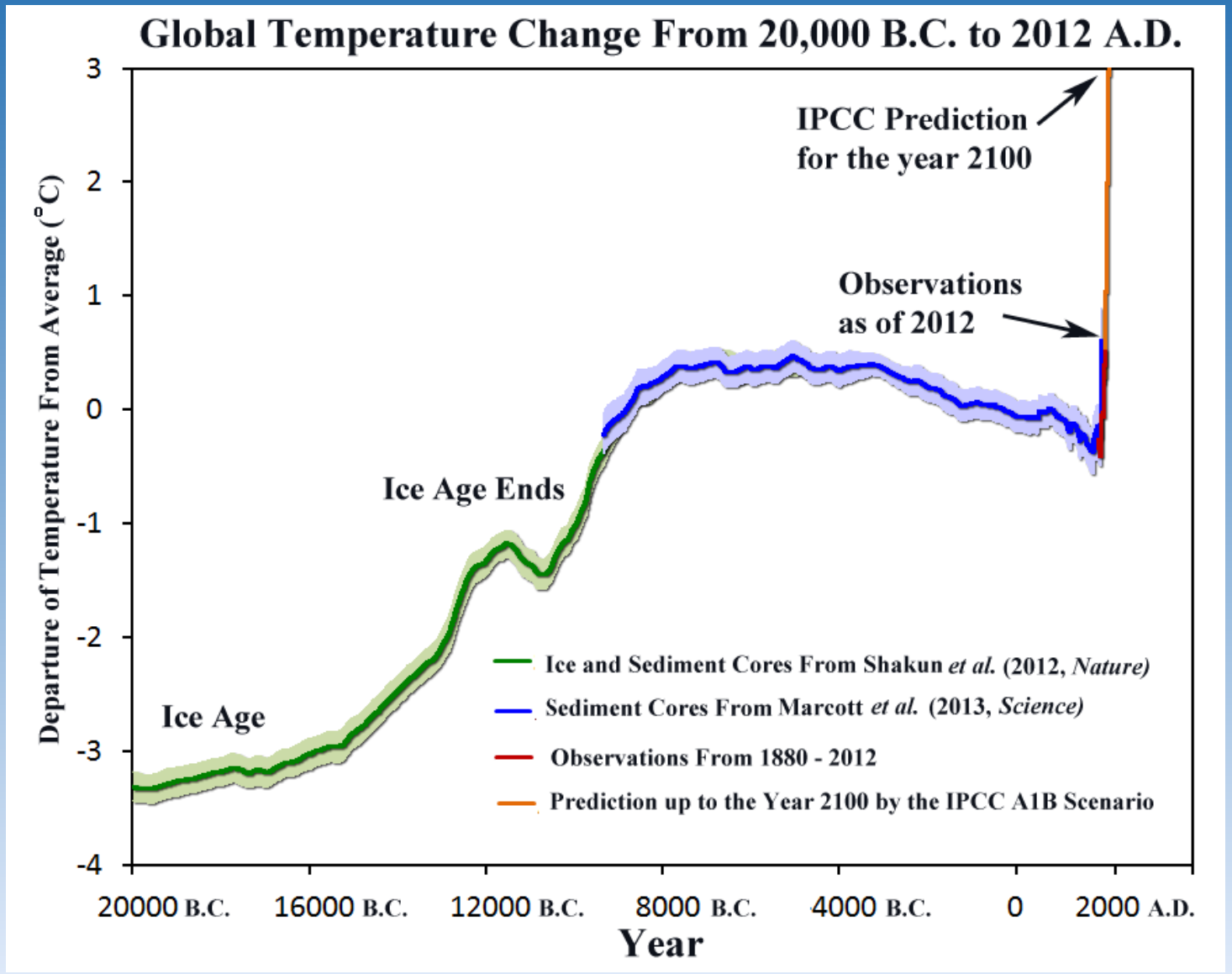
FIRST

- Web site:
  - Week 6 – the Anthropocene
  - Week 7 (and 8)
- A reading: Richard Alley's a Terrible shower – transitions are not without difficulty – but also with opportunity
- http://denverclimatestudygroup.com/wp-content/uploads/2015/10/A-terrible-shower.pdf

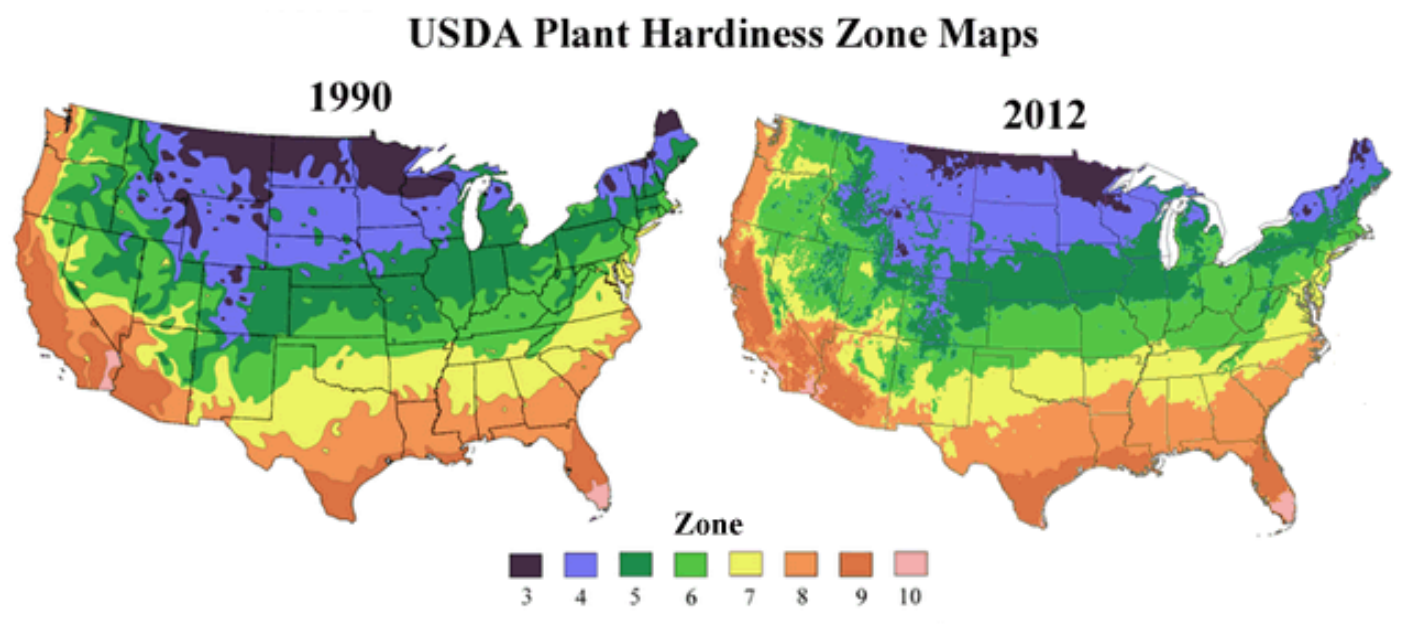
SECOND

- WHY I hope you are convinced
  - climate change is happening at an unprecedented rate
  - There are unknown implications of ocean acidification at these rates of change
  - There are economic repercussions
    - due to sea level rise
    - increased incidents of severe weather
    - Agricultural
    - Etc.

And to review the data


Global Temperature Change From 20,000 B.C. to 2012 A.D.
Departure of Temperature From Average (°C)
3
2
1
0
-1
-2
-3
-4
IPCC Prediction
for the year 2100
Observations
as of 2012
Ice Age Ends
Ice Age
Ice and Sediment Cores From Shakun et al. (2012, Nature)
Sediment Cores From Marcott et al. (2013, Science)
Observations From 1880 - 2012
Prediction up to the Year 2100 by the IPCC A1B Scenario
20000 B.C.
16000 B.C.
12000 B.C.
8000 B.C.
4000 B.C.
0
2000 A.D.
Year

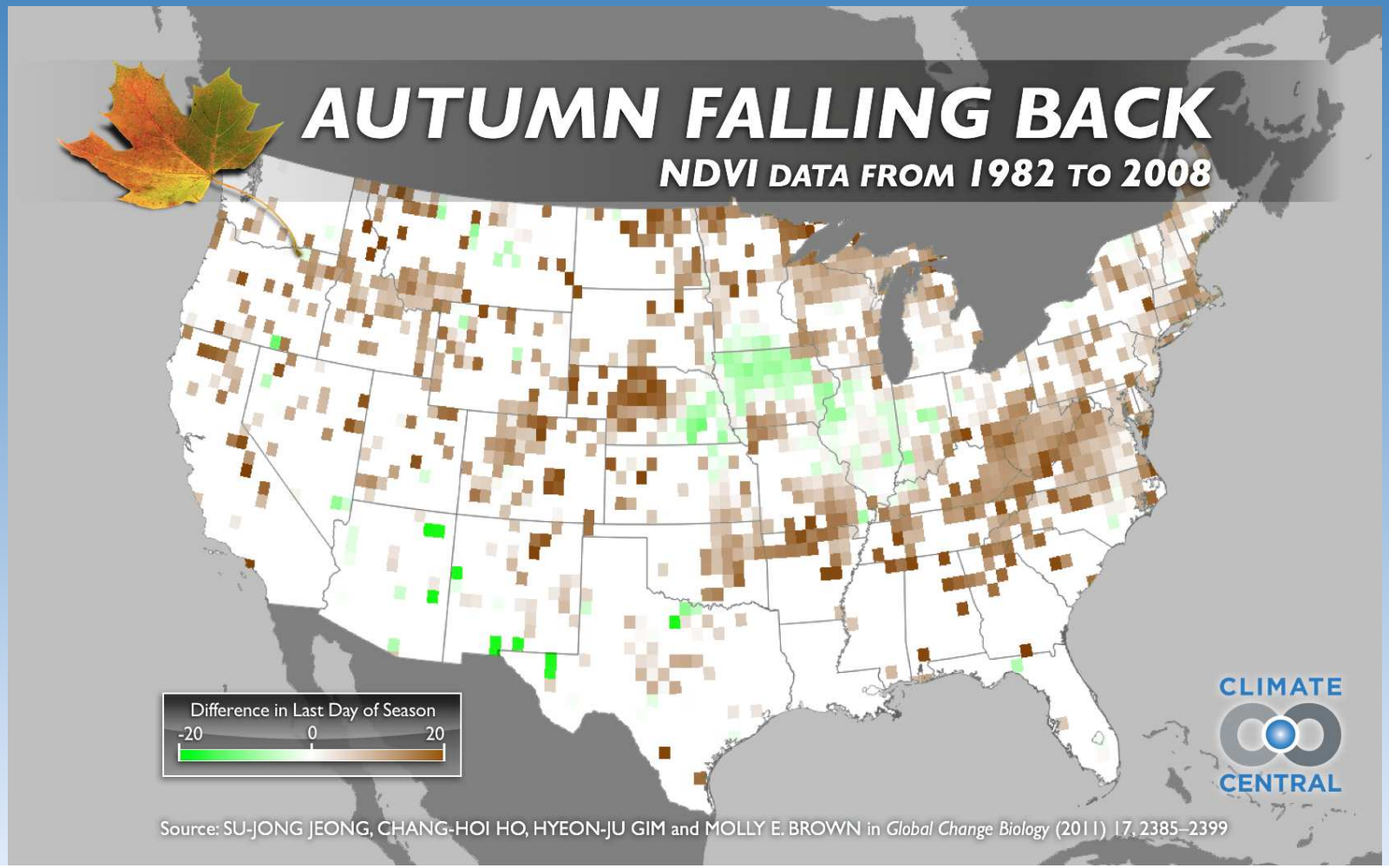
Plants and Animals are Responding to a Warming Climate

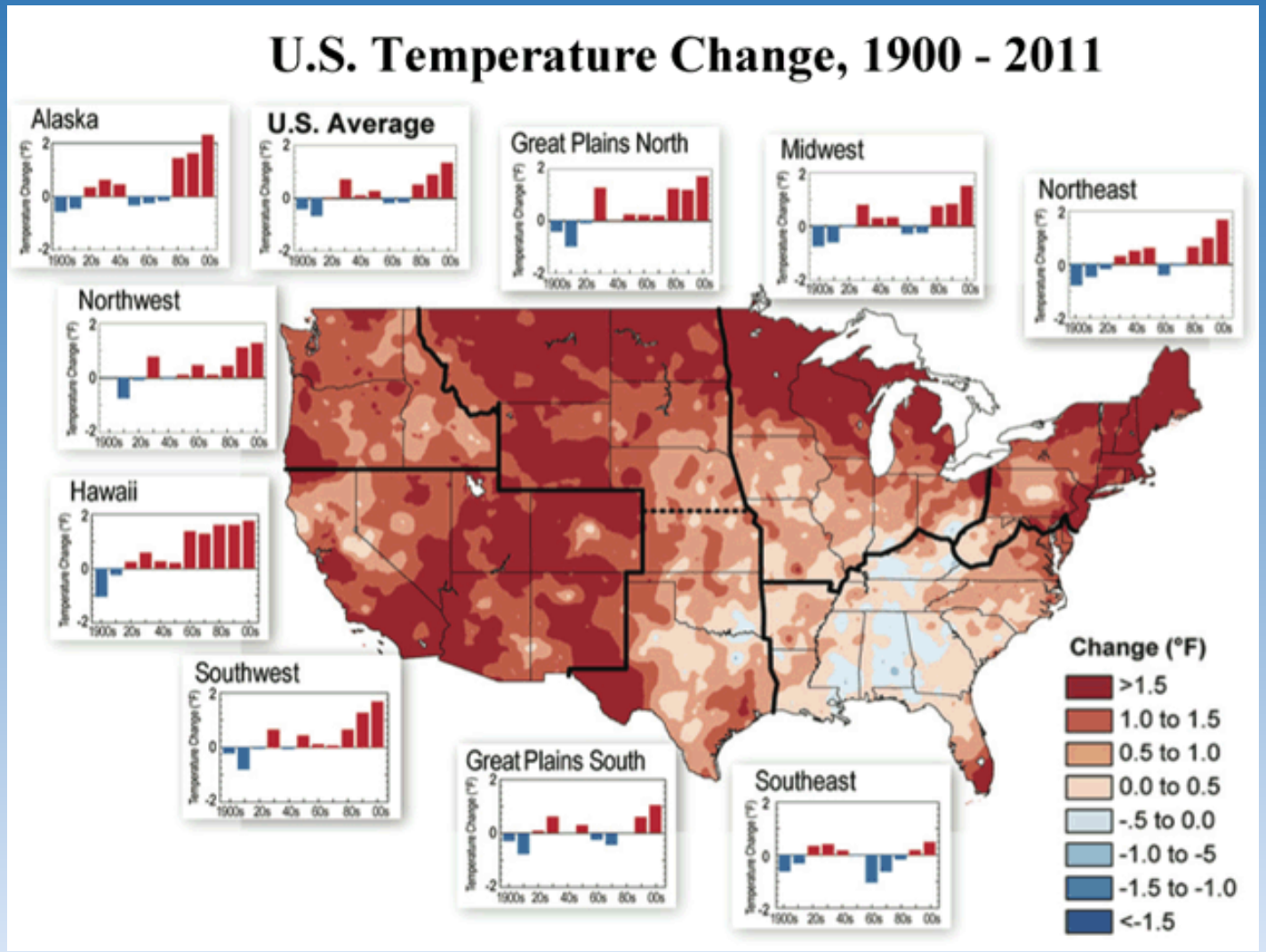


Spring is springing forward: Spring events, like bird and butterfly migrations, flower blooming times, and frog mating, have been advancing by about three days per decade over the past 30 years.

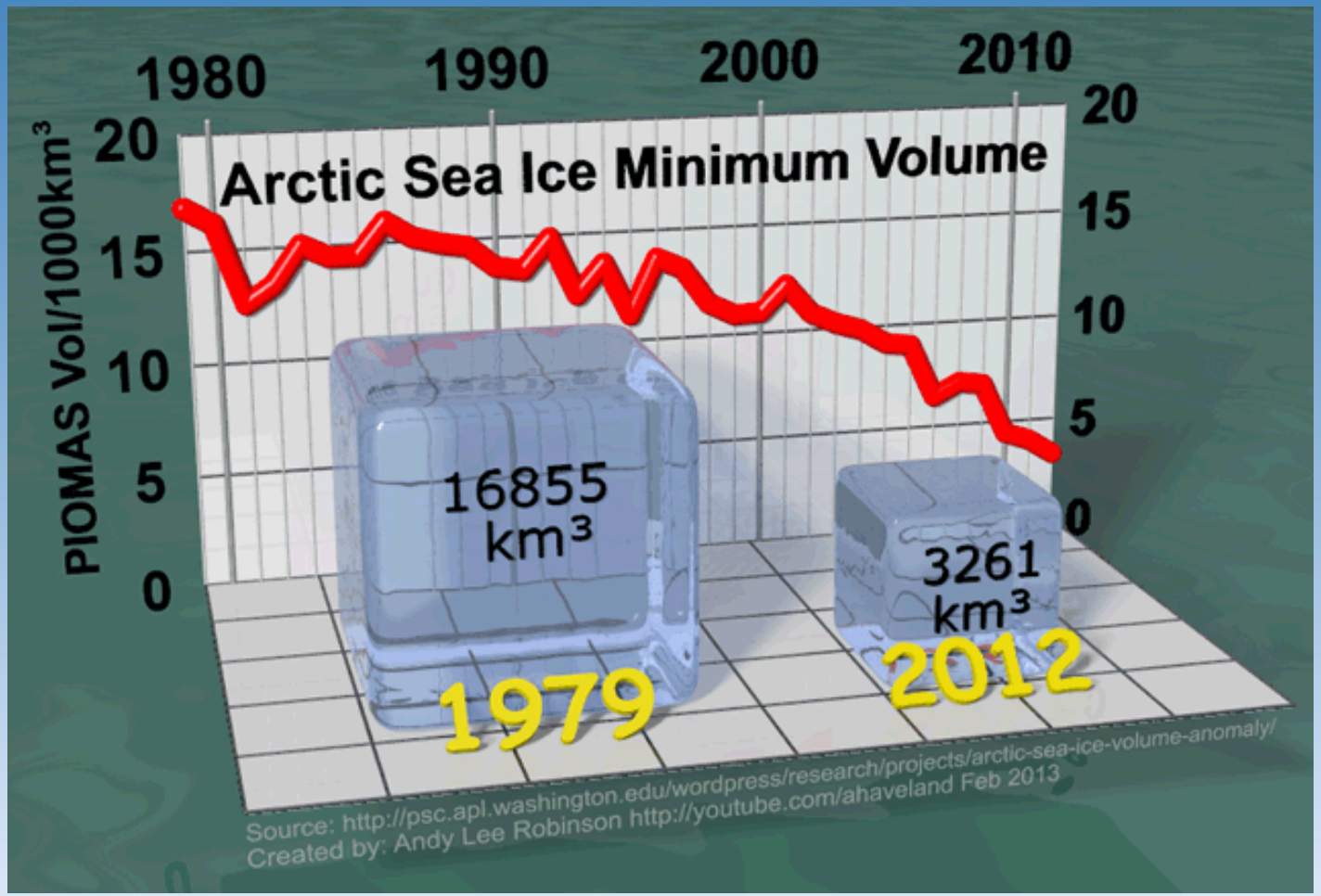
Source: Jeong et al., 2011, "Phenology shifts at start vs. end of growing season in temperate vegetation over the Northern Hemisphere for the period 1982–2008"

Fall is falling back: From 2000 - 2008, the end of the growing season was delayed by 2.3 days. In the U.S., fall now occurs ten days later than it did 30 years ago.



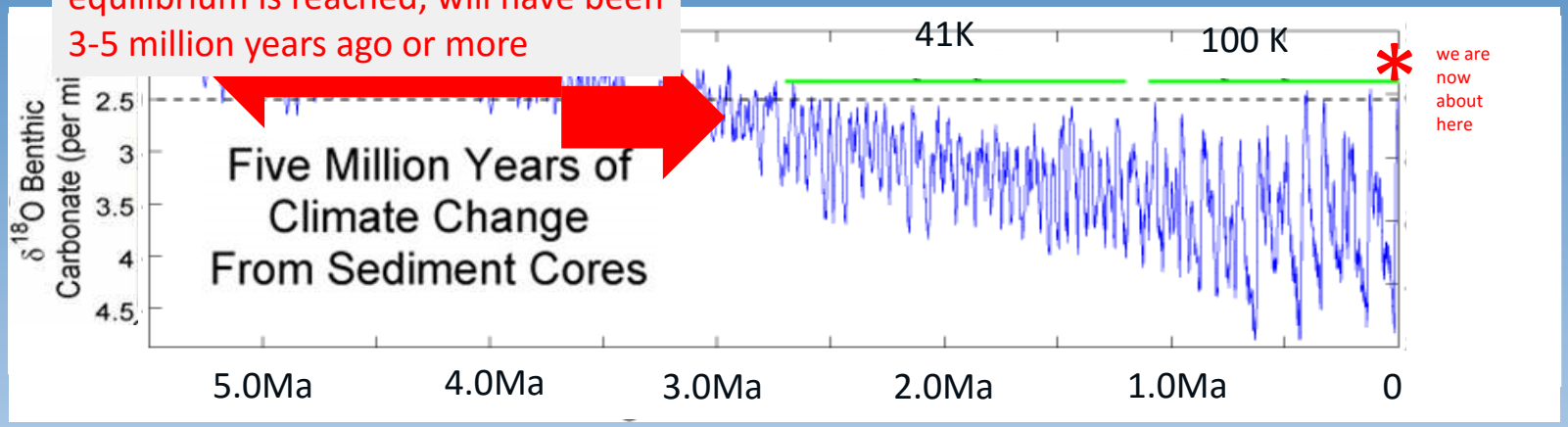

U.S. Temperature Change, 1900 - 2011
Alaska
U.S. Average
Great Plains North
Midwest
Northeast
Northwest
Hawaii
Southwest
Great Plains South
Southeast
Change (°F)
>1.5
1.0 to 1.5
0.5 to 1.0
0.0 to 0.5
-.5 to 0.0
-1.0 to -5
-1.5 to -1.0
<-1.5

Arctic Sea Ice Volume has Shrunk by 5x; Extent by 2x



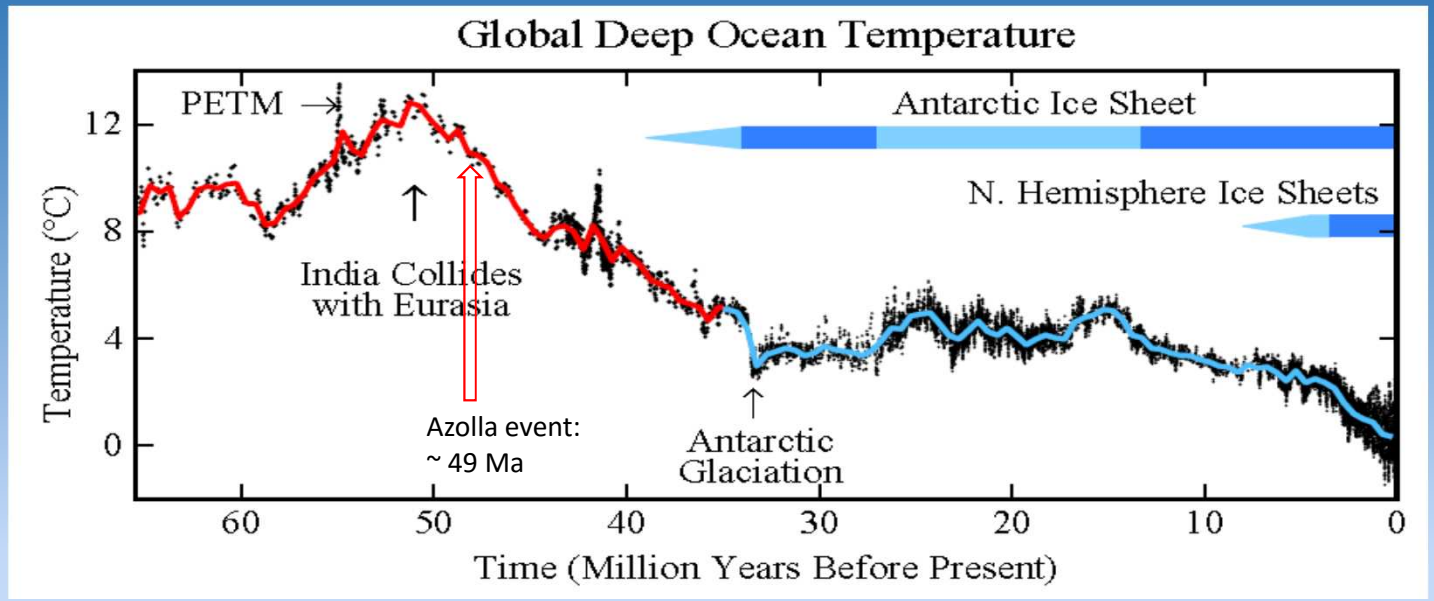
Climate Changes from Ocean Sediment Cores, since 5 Ma. Milankovitch Cycles

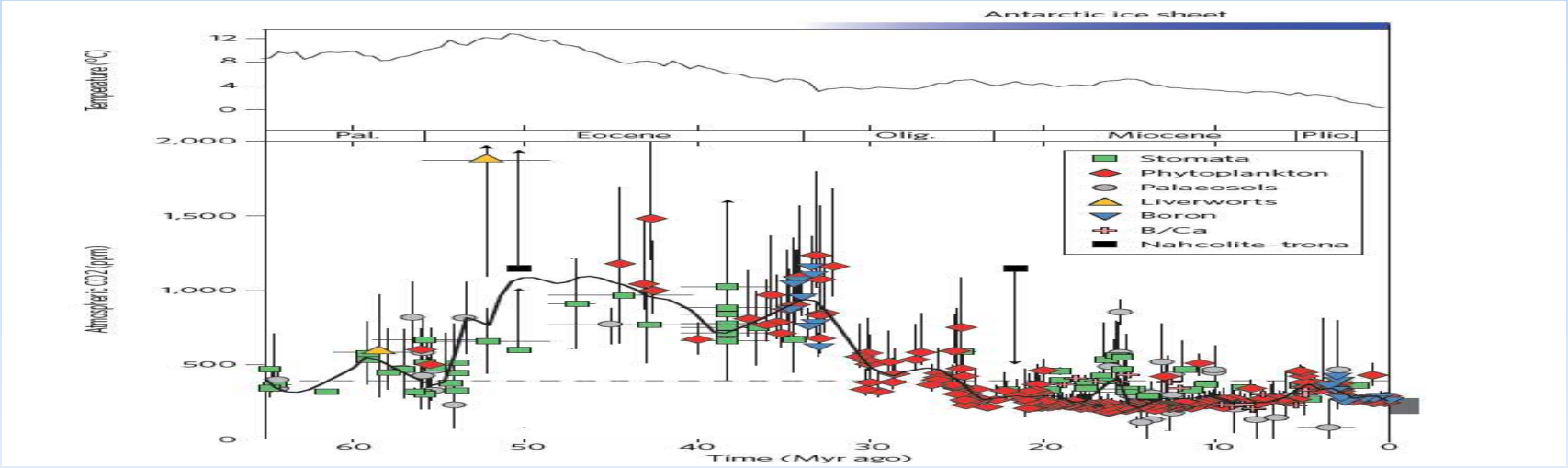
the last time inferred temperatures will have been this high – once equilibrium is reached, will have been 3-5 million years ago or more



When CO_2 levels get below ~400-600 ppm Orbital parameters become more important than CO_2

DATA


Global Deep Ocean Temperature
PETM
India Collides with Eurasia
Azolla event: ~ 49 Ma
Antarctic Glaciation
Antarctic Ice Sheet
N. Hemisphere Ice Sheets
Temperature (°C)
Time (Million Years Before Present)


Antarctic ice sheet
Temperature (°C)
Pal.
Eocene
Olig.
Miocene
Plio
Stomata
Phytoplankton
Palaeosols
Liverworts
Boron
B/Ca
Nahcolite–trona
Time (Myr ago)

http://media.hhmi.org/hl/12Lect4.html

Earth's Climate: Past, Present and Future

Solutions – part A

1. Economics
   - of doing nothing (solely adapting) vs. the economics of mitigation
   - Actuality: it WILL be a combination
2. Capitalism, GDP/growth based economics vs. "Herman Daly" economics (no-growth/steady-state)
3. Solutions? Paradigm shift? From we can't/too expensive to WE CAN
4. There is promise, but at what cost? (One might be surprised).
   - Energy
   - Mitigation – Agricultural revolution/biofuels: Biochar for Carbon Dioxide Removal (CDR)

Economics

- See week 7 links, EEE links and AR5-WG2:
  - **Economic related reports:**
  - 2015 The Social Cost of Carbon study summary
  - 2007.03.18 Discount Rate and Climate Change DLC
  - **Stern Report**: sternreview_report_complete
  - Nordhaus briefly describes the "free rider" problem and his proffered solution as a lead-in to his recent review of the book, *Climate Shock*. Here's the link to the NY Review of Books website: http://www.nybooks.com/articles/archives/2015/jun/04/new-solution-climate-club/
  - In a different format, Nordhaus produced a 30-slide PowerPoint version for his Presidential address to the AEA last January. Available at http://carbon-price.com/wp-content/uploads/2015-01-04-Nordhaus-ClimateClubAEA-v2-slides.pdf
  - 2015-01-04-Nordhaus-ClimateClubAEA-v2-slides
  - **MIT**: GOOGLE LIST OF LINKS: https://scholar.google.com/scholar?q=mit+report+on+climate+change+economics&hl=en&as_sdt=0&as_vis=1&oi=scholart&sa=X&ved=0CBsQgQMwAGoVChMIkMfkl8i9yAIVSuJjCh1x7wKk
  - **IPCC AR5 WG2**: http://www.ipcc.ch/report/ar5/wg2/#.UuAsbxDn9hE

Notes

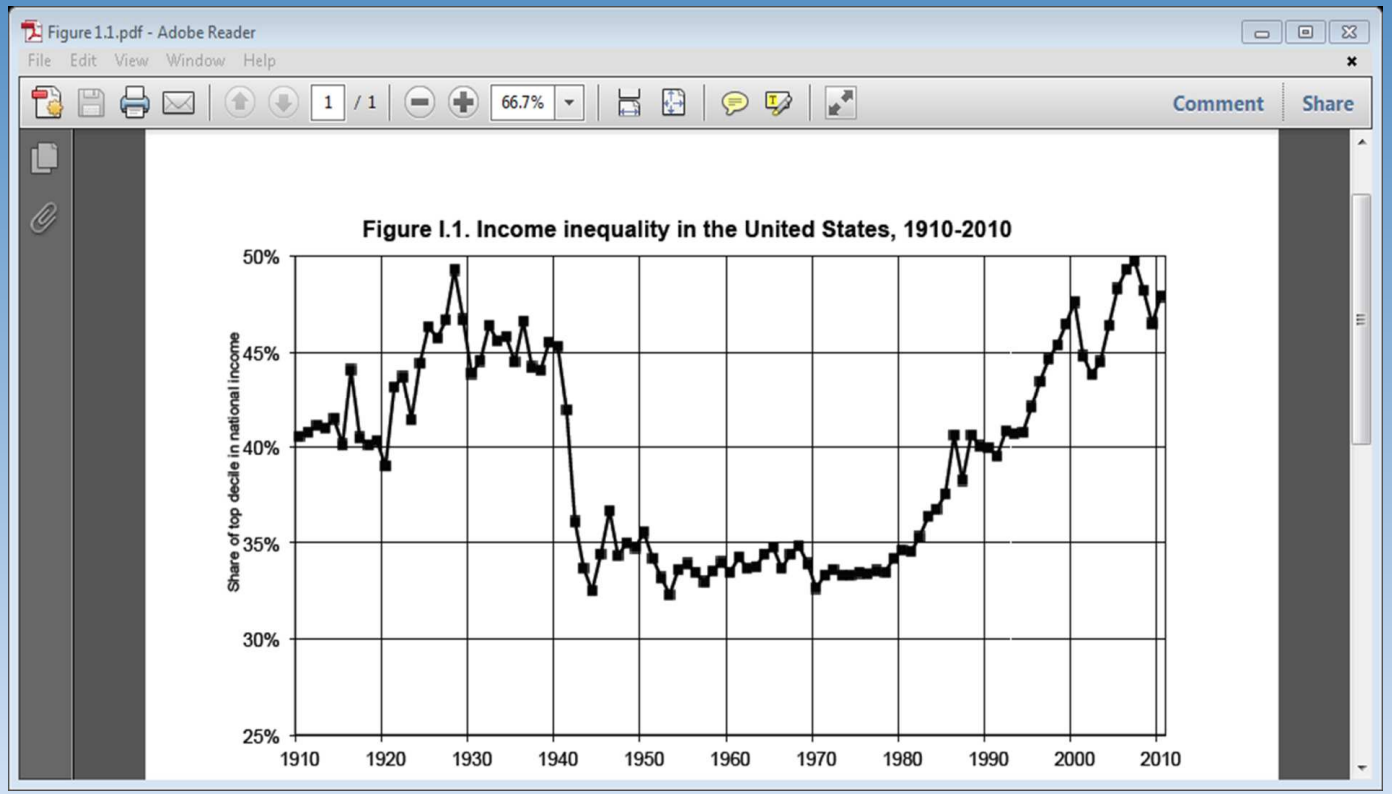
- Stern/Nordhaus – promote support a high discount rate – doing something NOW
- IPCC acknowledges adaptation will be a must (the change is in the bank and accumulating interest)
- Bjorn Lomborg – Danish economist (not a denier) argues for spending later – i.e. no discount rate
  - https://en.wikipedia.org/wiki/Bj%C3%B8rn_Lomborg
  - http://www.desmogblog.com/bjorn-lomborg

- Which leads to whether or not we need a paradigm shift (#3)

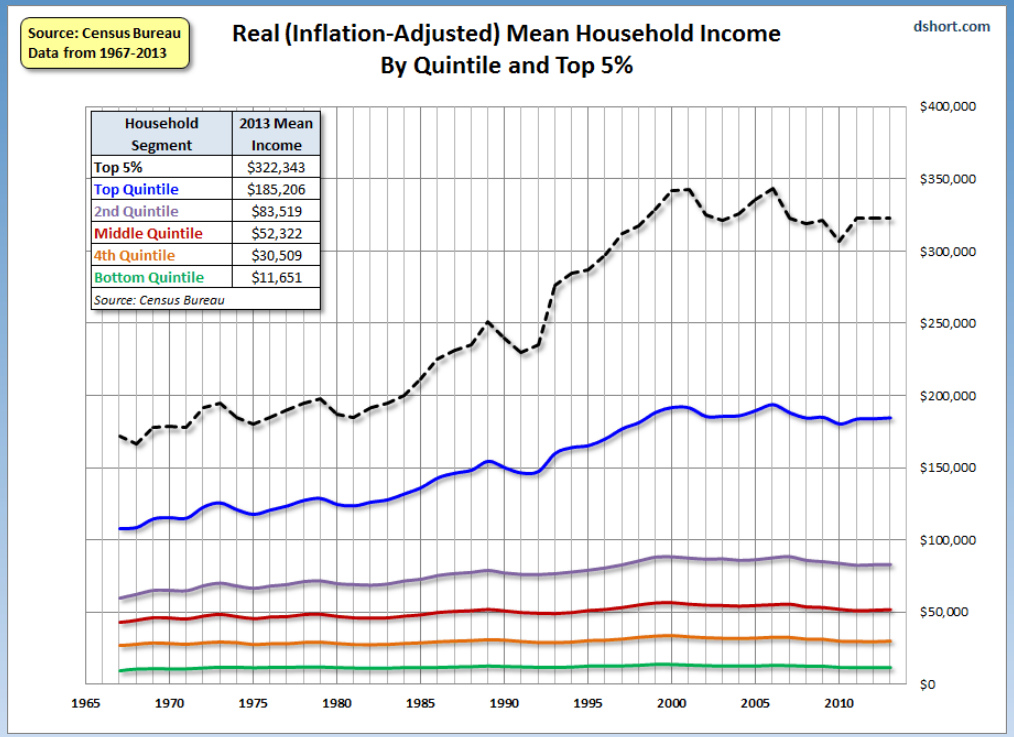
Earth's Climate: Past, Present and Future

Solutions – part A

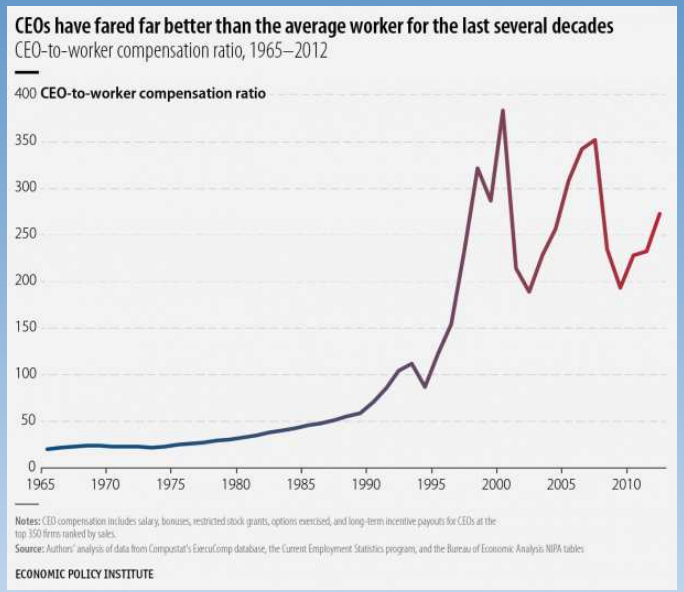
1. Economics
   - of doing nothing (solely adapting) vs. the economics of mitigation
   - Actuality: it WILL be a combination
2. Capitalism, GDP/growth based economics vs. "Herman Daly" economics (no-growth/steady-state)
3. Solutions? Paradigm shift? From we can't/too expensive to WE CAN
4. There is promise, but at what cost? (One might be surprised).
   - Energy
   - Mitigation – Agricultural revolution/biofuels: Biochar for Carbon Dioxide Removal (CDR)



Courtesy of Gary Wyngarden: Capitalism vs. the Planet



Courtesy of Gary Wyngarden: Capitalism vs. the Planet



Courtesy of Gary Wyngarden: Capitalism vs. the Planet

Global Footprint

see http://www.footprintnetwork.org/en/index.php/GFN/page/glossary

- Human activities consume resources and produce waste
- Ecological Footprint Accounting addresses whether the planet is large enough to keep up with the demands of humanity.
- Biocapacity represents the planet's biologically productive land areas including our forests, pastures, cropland and fisheries
- Biocapacity can then be compared with humanity's *demand* on nature: our **Ecological Footprint.** The Ecological Footprint represents the productive area required to provide the renewable resources humanity is using and to absorb its waste.

- Our current global situation: *Since the 1970s, humanity has been in ecological overshoot with annual demand on resources exceeding what Earth can regenerate each year*.
- It now takes the Earth one year and six months to regenerate what we use in a year.
- We maintain this overshoot by liquidating the Earth's resources. Overshoot is a vastly underestimated threat to human well-being and the health of the planet, and one that is not adequately addressed.

- For 9 billion people (midrange projection for 2050) to live at North American/Western European standards will require 5 planets.

Drawbacks of Capitalism

- Wealth and Income Distribution
- Largely ignoring the ecological impacts and biocapacity of the planet

Growth Dilemma

- Growth is unsustainable in its current form
- De-growth is unstable

Obama quoted in episode of Years of Living Dangerously (paraphrased): “It’s difficult in a Democracy to do something/pass something where the pay-back is 10 or more years out”

http://media.hhmi.org/hl/12Lect4.html

The solution: steady state economics?

- Herman Daly's steady state economics see:
  - https://en.wikipedia.org/wiki/Herman_Daly
  - http://steadystate.org/herman-daly/
  - http://steadystate.org/category/herman-daly/

The problem: how to effect that change

Earth's Climate: Past, Present and Future

Solutions – part A

1. Economics
   - of doing nothing (solely adapting) vs. the economics of mitigation
   - Actual will likely be a combination
2. Capitalism, GDP/growth based economics vs. "Herman Daly" economics (no-growth/steady-state)
3. Solutions? Paradigm shift? From we can't/too expensive to WE CAN
4. There is promise, but at what cost? (One might be surprised).
   - Energy
   - Mitigation – Agricultural revolution/biofuels: Biochar for Carbon Dioxide Removal (CDR)

Need for a paradigm shift

- **Kerry Emanuel quote on p. 76:** "…costs may be high and those paying them are not likely to be serious beneficiaries of their own actions**. Indeed, there are few, if any, historical examples of civilizations consciously making sacrifices on behalf of descendents (sic) two or more generations removed**."
- That's what the discount rate is about. **In that regard we need a social paradigm shift**
  - If we are so concerned about leaving a national debt to our children and grandchildren, shouldn't we put the costs of climate change as part of that equation?
  - For those that don't accept climate change maybe it would be a good thing to limit CO2 into the atmosphere anyway, especially at the rates we are putting it into the atmosphere – BECAUSE OF OCEAN ACIDIFICATION issues and the law of unintended consequences!

Earth's Climate: Past, Present and Future

Solutions – part A

1. Economics
   - of doing nothing (solely adapting) vs. the economics of mitigation
   - Actuality: it WILL be a combination
2. Capitalism, GDP/growth based economics vs. "Herman Daly" economics (no-growth/steady-state)
3. Solutions? Paradigm shift? From we can't/too expensive to WE CAN
4. There is promise, but at what cost? (One might be surprised).
   - Energy
   - Mitigation – Agricultural revolution/biofuels: Biochar for Carbon Dioxide Removal (CDR)

Renewables:

- Photovoltaics (PV)
- Concentrated solar power (CSP)
- Wind
- Geothermal
  - Ground source
  - Deep thermal

Hawaii becomes First State to Mandate 100% Renewable Energy.

See NREL slides for more details: http://denverclimatestudygroup.com/wp-content/uploads/2015/04/OSHER-10.14.15.pdf

Renewables:

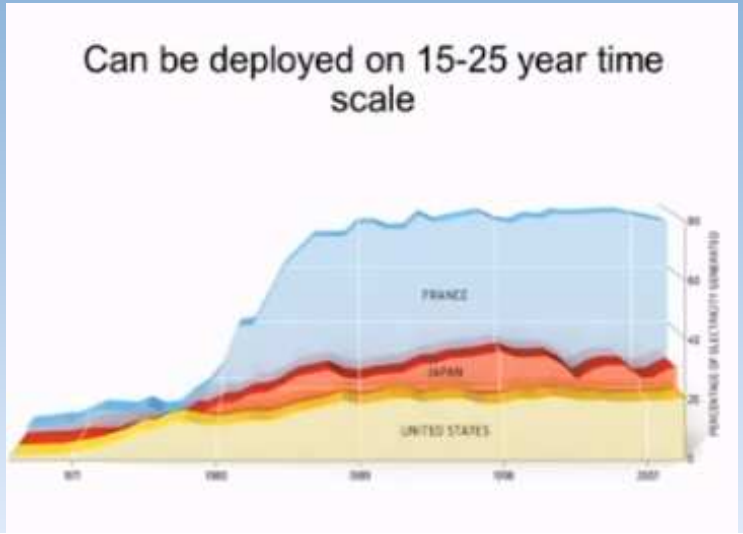
- The myth of Baseload https://www.youtube.com/watch?v=deWtgpheDJM&feature=youtu.be ; see other related videos at http://energyshouldbe.org/
- Wind power:
  7/7/2015 — A: Colorado Matters: Could Conservative Denver Billionaire (Phil Anschutz) Become West's Climate Hero?

  It's an argument of engaging energy companies vs. "dissing" them for renewables. See more at: http://www.cpr.org/news/story/could-conservative-denver-billionaire-become-wests-climate-hero#.dpuf
  - **excerpt**: "This will generate four times the amount of power that comes out of Hoover Dam. It would supply every household in Los Angeles and San Francisco combined with green power."

Colorado changes in renewable energy

Other non-carbon sourced energy to consider?

- Non Carbon based: Nuclear (fission and fusion)
  - Fission: Very Controversial
  - Fusion: clean / difficult to achieve
  - Need national policy change on reprocessing
  - See Kerry video at 56 minutes for discussion and conclusions thereafter: https://www.youtube.com/watch?v=7so8GRCWA1k



However – POTENTIAL big game changers in Energy and Carbon Dioxide Removal

1. Energy – from fusion
2. Mitigation in the form of carbon dioxide removal (CDR), agricultural changes and biofuels

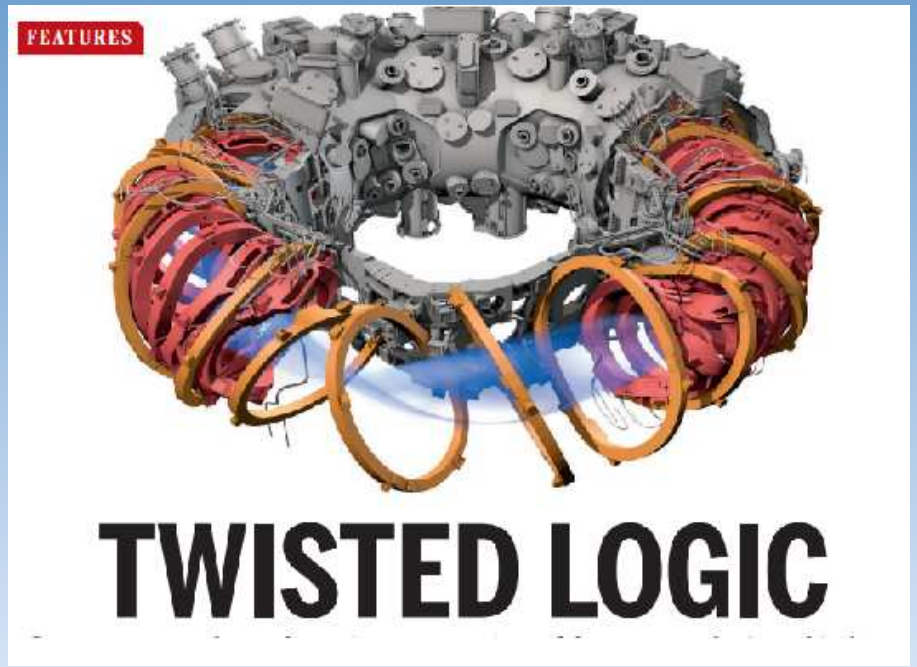
1. Energy – from fusion

Lockheed Martin Compact Fusion breakthrough?

- http://www.lockheedmartin.com/us/products/compact-fusion.html
- http://aviationweek.com/blog/high-hopes-can-compact-fusion-unlock-new-power-space-and-air-transport
- http://aviationweek.com/fusion-podcast

1. More on Fusion:

Fusion article in Science: Twisted Logic Science-2015-Clery-369-7



2. Carbon Dioxide Removal (CDR)

Biochar

- See week 7, 2014 http://denverclimatestudygroup.com/?page_id=776
- And biochar tab: http://denverclimatestudygroup.com/?page_id=28

2. Carbon Dioxide Removal (CDR)

- https://en.wikipedia.org/wiki/Biochar:

"**Biochar** is charcoal used as a soil amendment. Like most charcoal, biochar is made from biomass via pyrolysis. Biochar is under investigation as an approach to carbon sequestration to produce negative carbon dioxide emissions.[1] Biochar thus has the potential to help mitigate climate change via carbon sequestration.[2][3] Independently, biochar can increase soil fertility ofacidic soils (low pH soils), increase agricultural productivity, and provide protection against some foliar and soil-borne diseases.[4] Furthermore, biochar reduces pressure on forests.[5] Biochar is a stable solid, rich in carbon, and can endure in soil for thousands of years.[1]"

The rest – next week, week 8