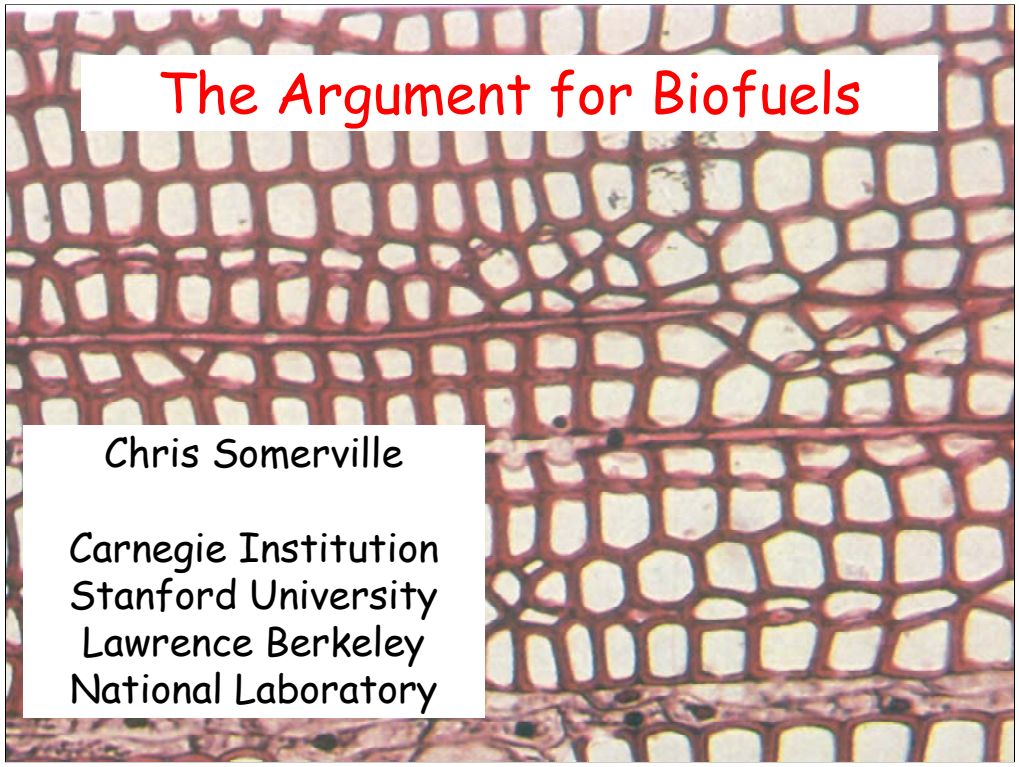
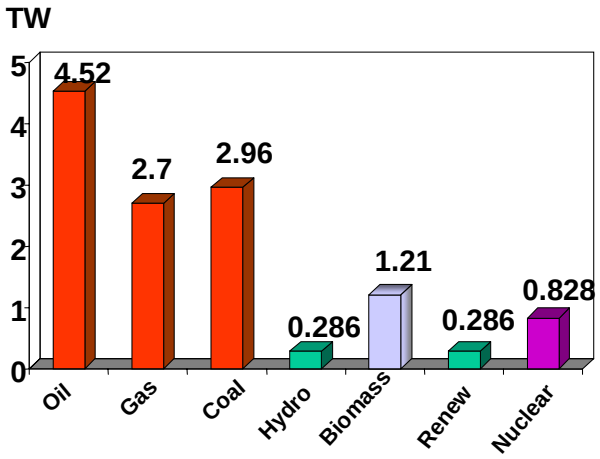
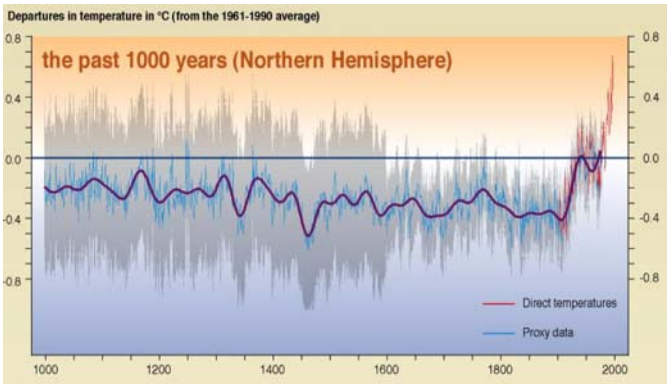

The Argument for Biofuels
Chris Somerville
Carnegie Institution
Stanford University
Lawrence Berkeley
National Laboratory

Mean Global Energy Consumption, 1998
(Total 12.8 TW)



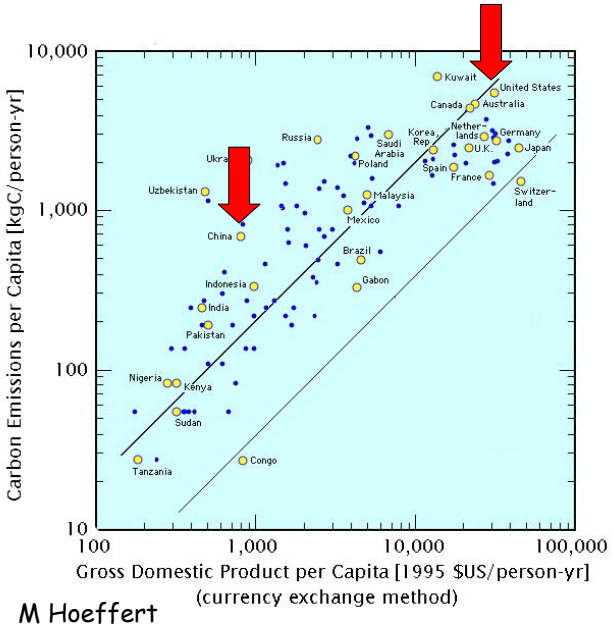
Nate Lewis, Caltech

The world is warming



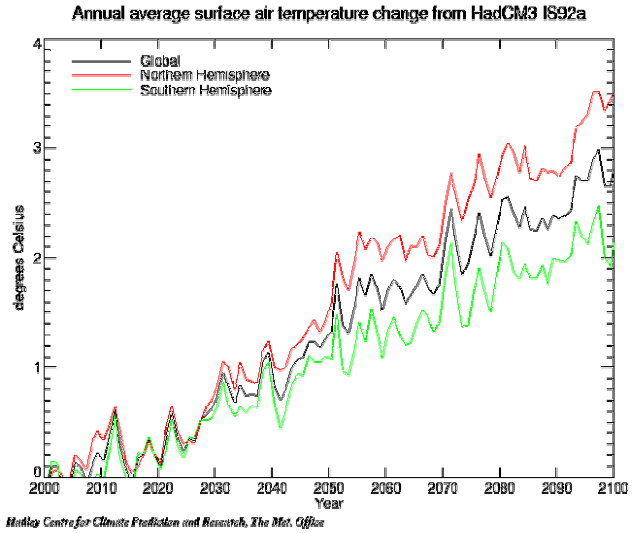
From: Anders Röj (Volvo Inc.) Agenda 2020 Technology Summit (2004)

CO_2 release rises with per capita GDP

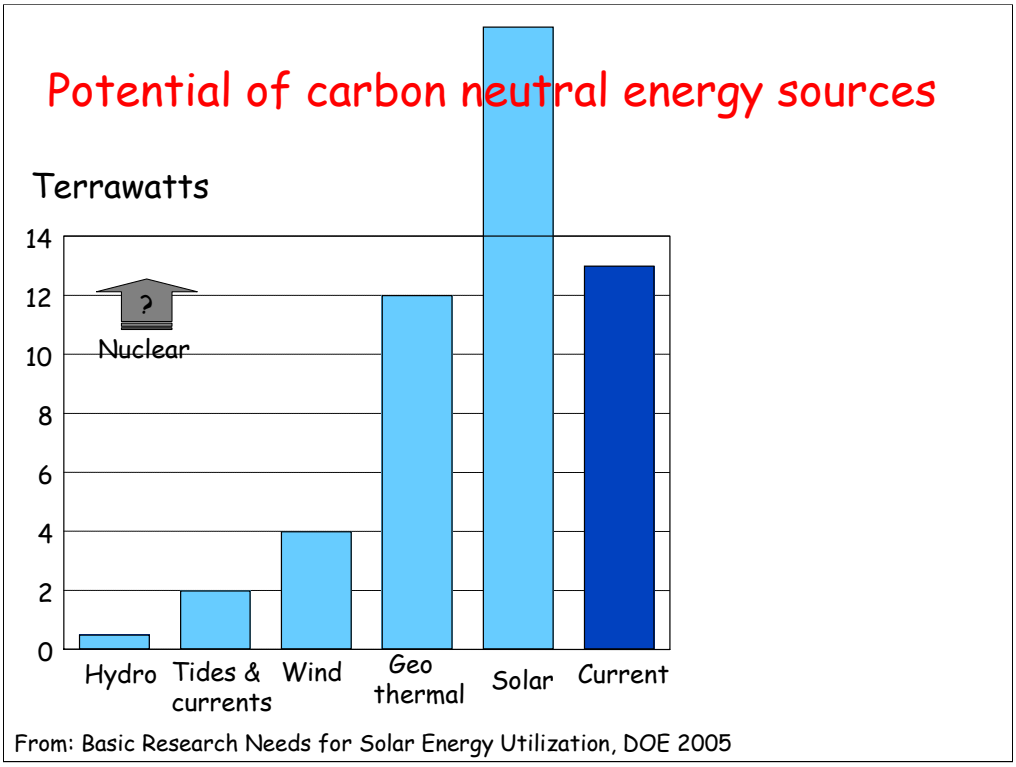


M Hoeffert

Predicted increase in global mean temperature due to CO_2 accumulation

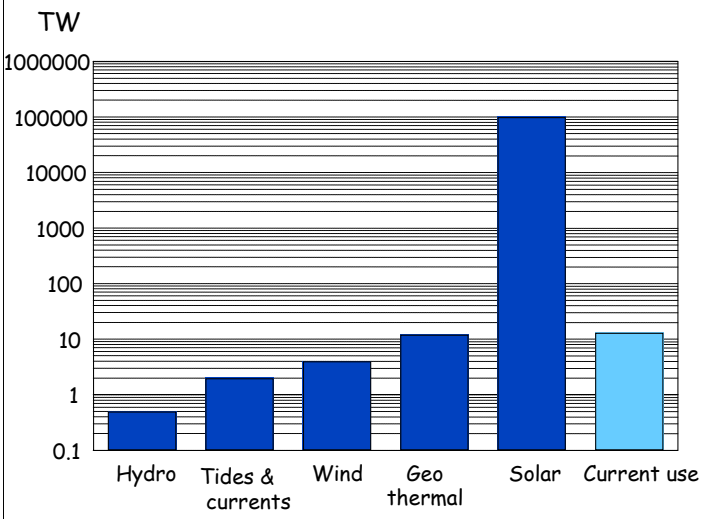


www.metoffice.com/research/hadleycenter



From: Basic Research Needs for Solar Energy Utilization, DOE 2005

Potential of underused renewable energy sources



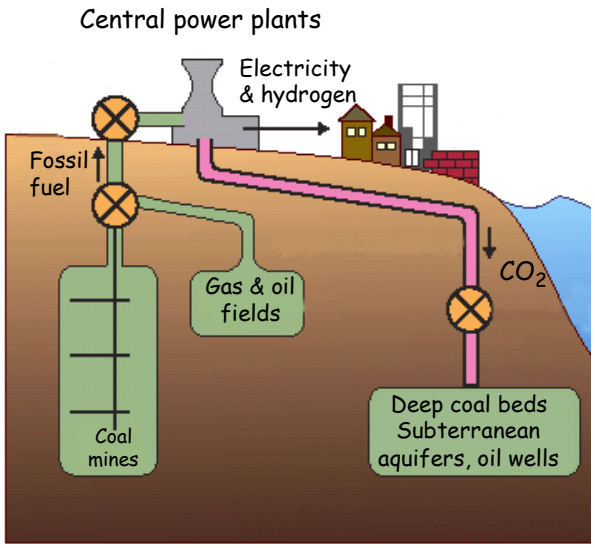
From: Basic Research Needs for Solar Energy Utilization, DOE 2005

~26,000 km^2 of photovoltaic devices would meet US energy needs

Total shipped 1982-98 = 3 km^2

Turner, Science 285,687

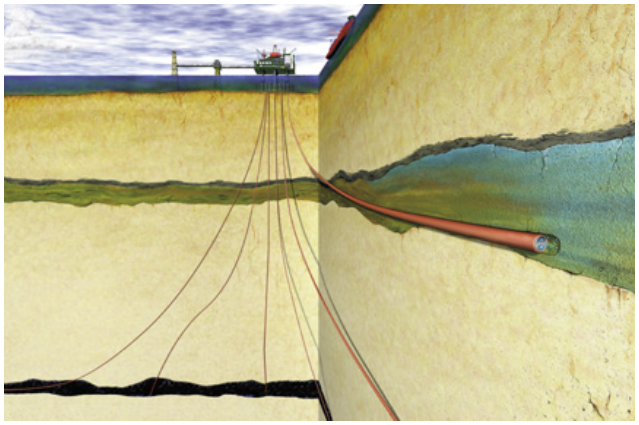
Sequestration vision



Modified from Hoffert et al. Science 298,981

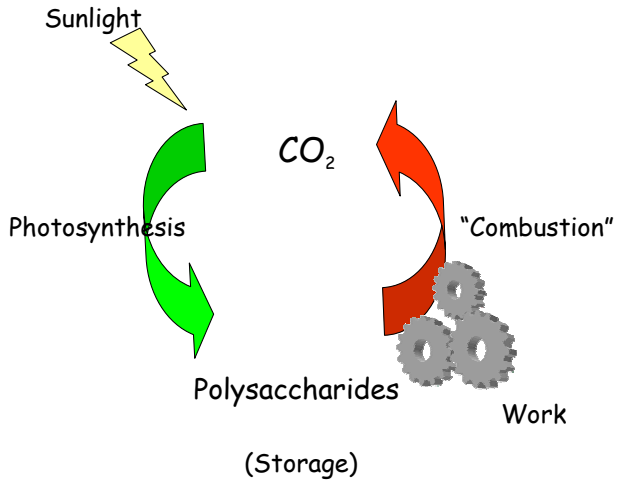
The Sleipner Experiment

1 million tons/y; capacity 600 B tons
7000 such sites needed



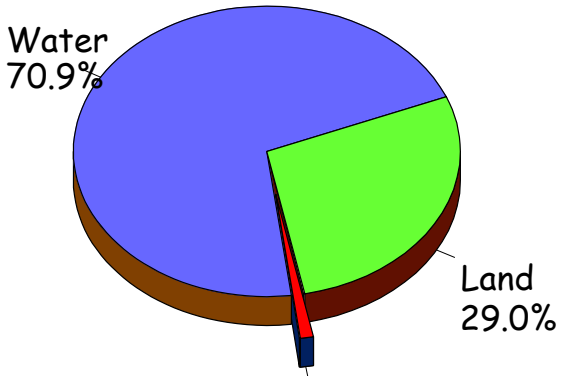
www.agiweb.org/geotimes

Combustion of biomass provides carbon neutral energy



Is there enough land to produce a significant amount of biofuels?

90,000 TW of energy arrives on the earths surface from the sun



Amount of land needed for 13 TW at 1% efficiency

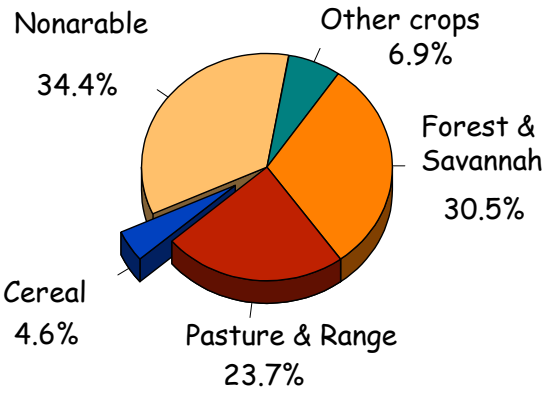
5% of land
650 MHa

>1% yield is feasible

Yield of 26.5 tons/acre observed by Young & colleagues in Illinois without irrigation

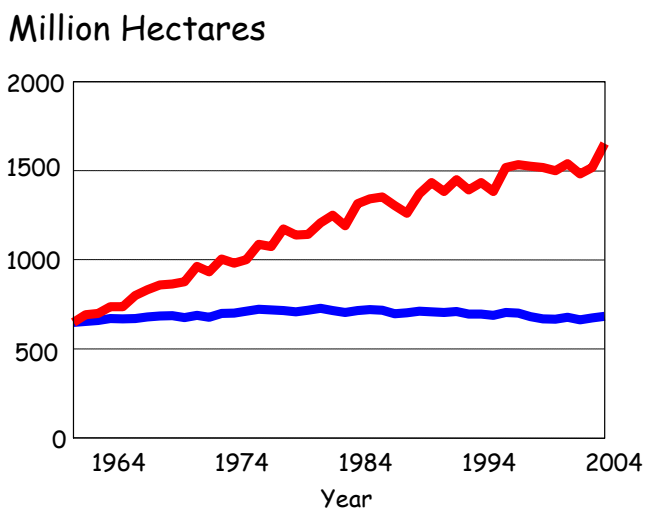
Courtesy of Steve Long and Emily Heaton

Land Usage



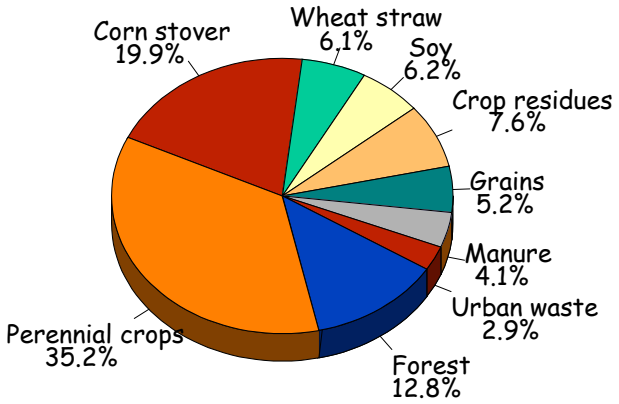
AMBIO 23,198 (Total Land surface 13,000 M Ha)

Global grain production with and without yield enhancements



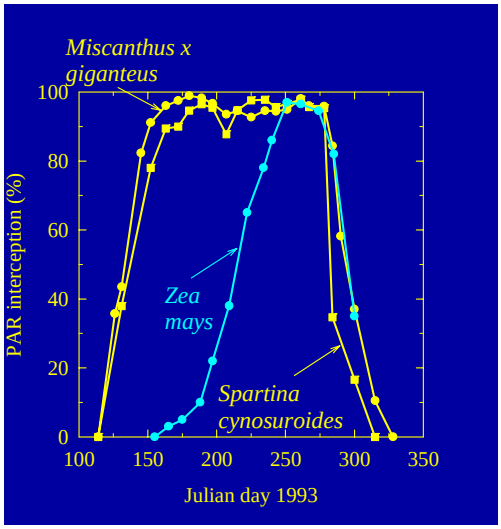
Data from worldwatch

US Biomass inventory = 1.3 billion tons



From: Billion ton Vision, DOE & USDA 2005

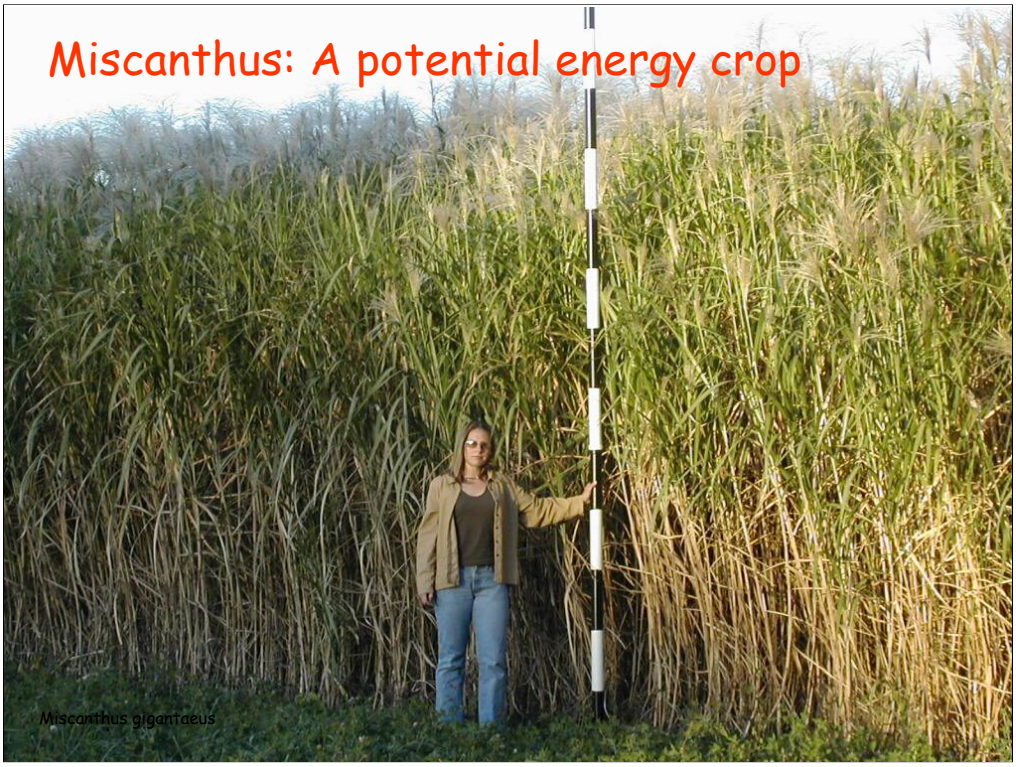
Perennials have more photosynthesis than annuals



Courtesy of Steve Long, University of Illinois

Note. Annualized net photosynthesis is proportional to the area under the curve. Thus, it can be seen that the perennial crops have much higher Annualized net photosynthesis than the annual crop (Zea mays)

Note from steve Long "You are very welcome to make use of the mineral recycling diagram and also the Miscanthus images. We do also have images of Miscanthus and switchgrass growing side-by-side, if that is of help - let me know. There was no attachment, but we do have actual data of radiation interception by Miscanthus and by corn crops on the South Farms that demonstrate your point on radiation use (our Miscanthus typically forms a closed canopy a month or two ahead of corn and remains green and photosynthetically active until the first heavy frost - usually early November; our corn usually looses photosynthetic activity and its chlorophyll in the last week of August). I am not sure that I can obtain the data though before Tuesday, but if you need it sooner let me know; I will be in the office tomorrow. In the meantime, I have attached a figure for corn and Miscanthus radiation interception from my earlier work in the UK; corn there is very late, grown for silage and usually green until the first frost."


Miscanthus: A potential energy crop
Miscanthus giganteus

Switchgrass: A potential energy crop

Switchgrass (Panicum virgatum)

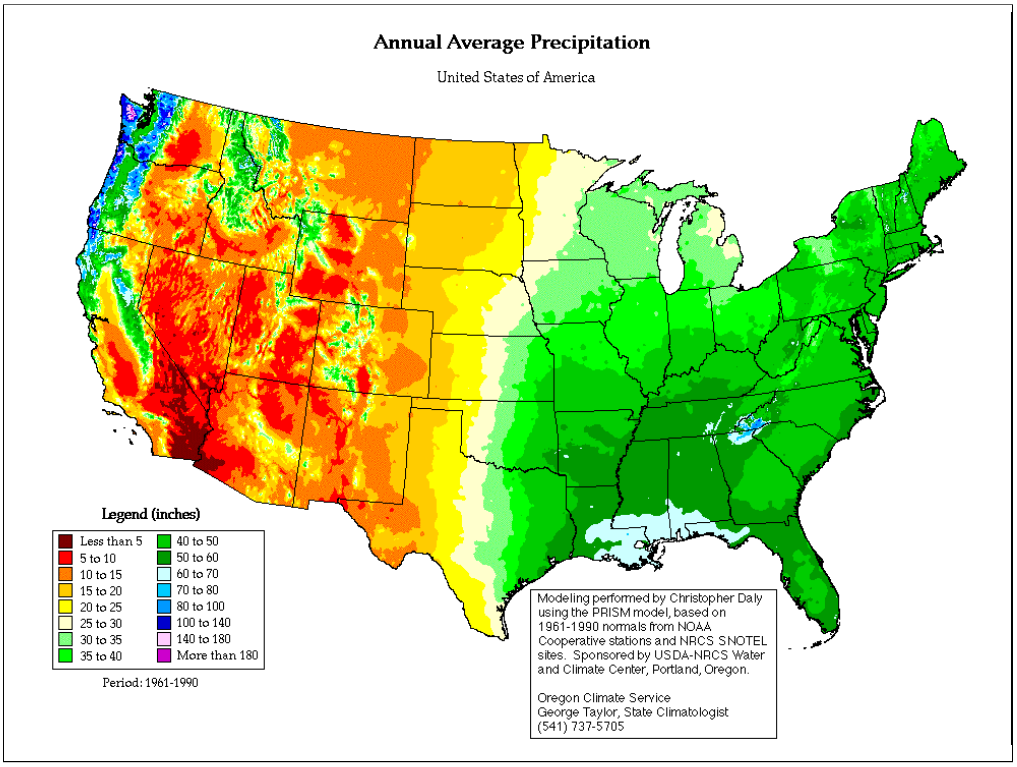
USDA-NRCS PLANTS Database / Hitchcock, A.S. (rev. A. Chase). 1950. *Manual of the grasses of the United States*. USDA Misc. Publ. No. 200. Washington, DC.

Harvesting Miscanthus

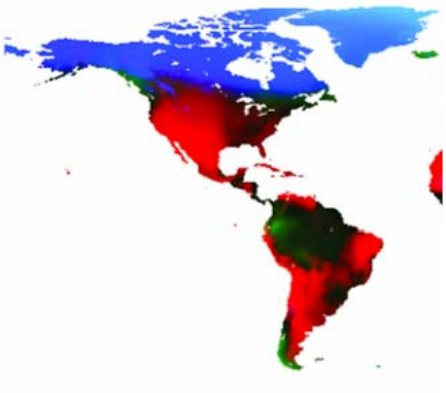
http://bioenergy.ornl.gov/gallery/index.html

Geographic distribution of energy crops

Wright et al DOE-ORNL-EERE

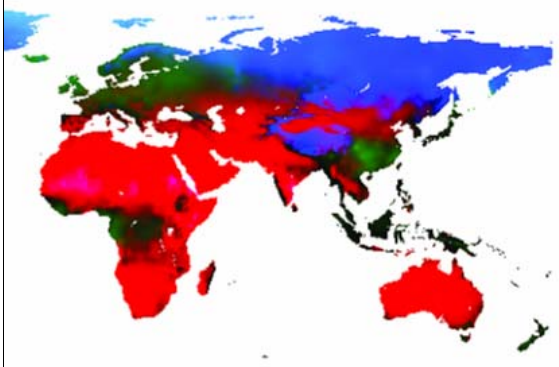

Annual Average Precipitation
United States of America
Legend (inches)
Less than 5
5 to 10
10 to 15
15 to 20
20 to 25
25 to 30
30 to 35
35 to 40
40 to 50
50 to 60
60 to 70
70 to 80
80 to 100
100 to 140
140 to 180
More than 180
Period: 1961-1990
Modeling performed by Christopher Daly using the PRISM model, based on 1961-1990 normals from NOAA Cooperative stations and NRCS SNOTEL sites. Sponsored by USDA-NRCS Water and Climate Center, Portland, Oregon.
Oregon Climate Service
George Taylor, State Climatologist
(541) 737-5705

Water and temperature limit growth



Baldocchi et al. 2004
SCOPE 62

Water and temperature limit growth



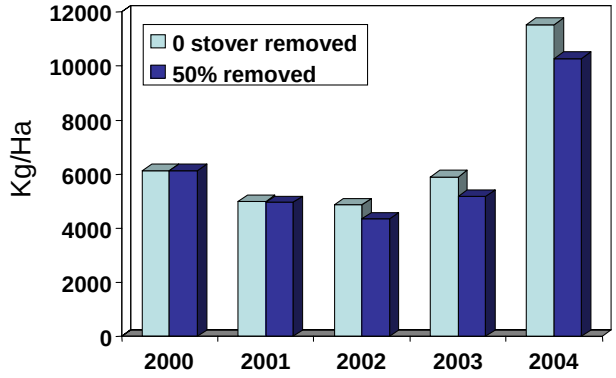
Baldocchi et al. 2004 SCOPE 62

Comments

- Perennial energy crops are expected to be more environmentally benign than production agriculture
  - Low fertilizer and chemical inputs
  - Late-harvest supports biodiversity
  - Mixed cultures possible
  - Many species can be used

Effect of 50% stover removal on corn grain yields in eastern NE.

(120kg N/ha)



K. Vogel et al., unpublished

Pests and pathogens may prevent large-scale cultivation of perennials

Asian soy rust

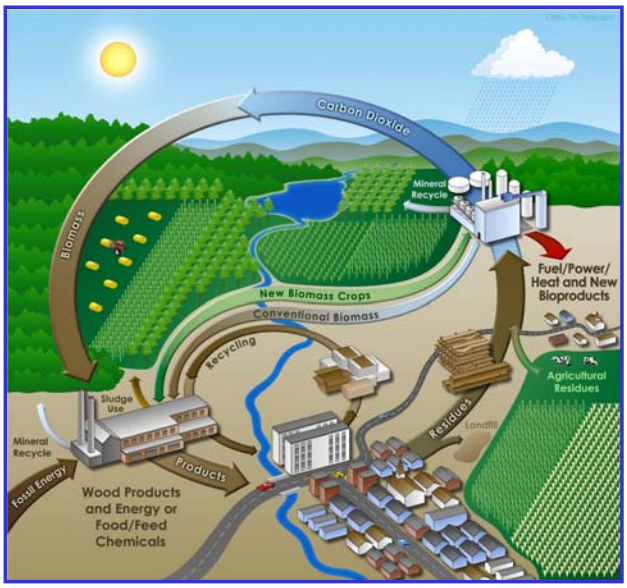
Many questions need answers

- What are the probable effects on food security?
- What are the tradeoffs in environmental effects?

Many questions need answers

- What are the probable social effects in various regions of the world?
- What trade policies and regulations may be useful?

A Vision of the Future



http://genomicsgtl.energy.gov/biofuels/index.shtml