Potential Biomass
No Land Use Change

DOE –" Billion Ton Supply" (in millions)

Forest product residues	145
Logging residues	64
Urban wood residues	47
Agricultural residues	428
Process residues/manure	106
	790

IEA – 2008

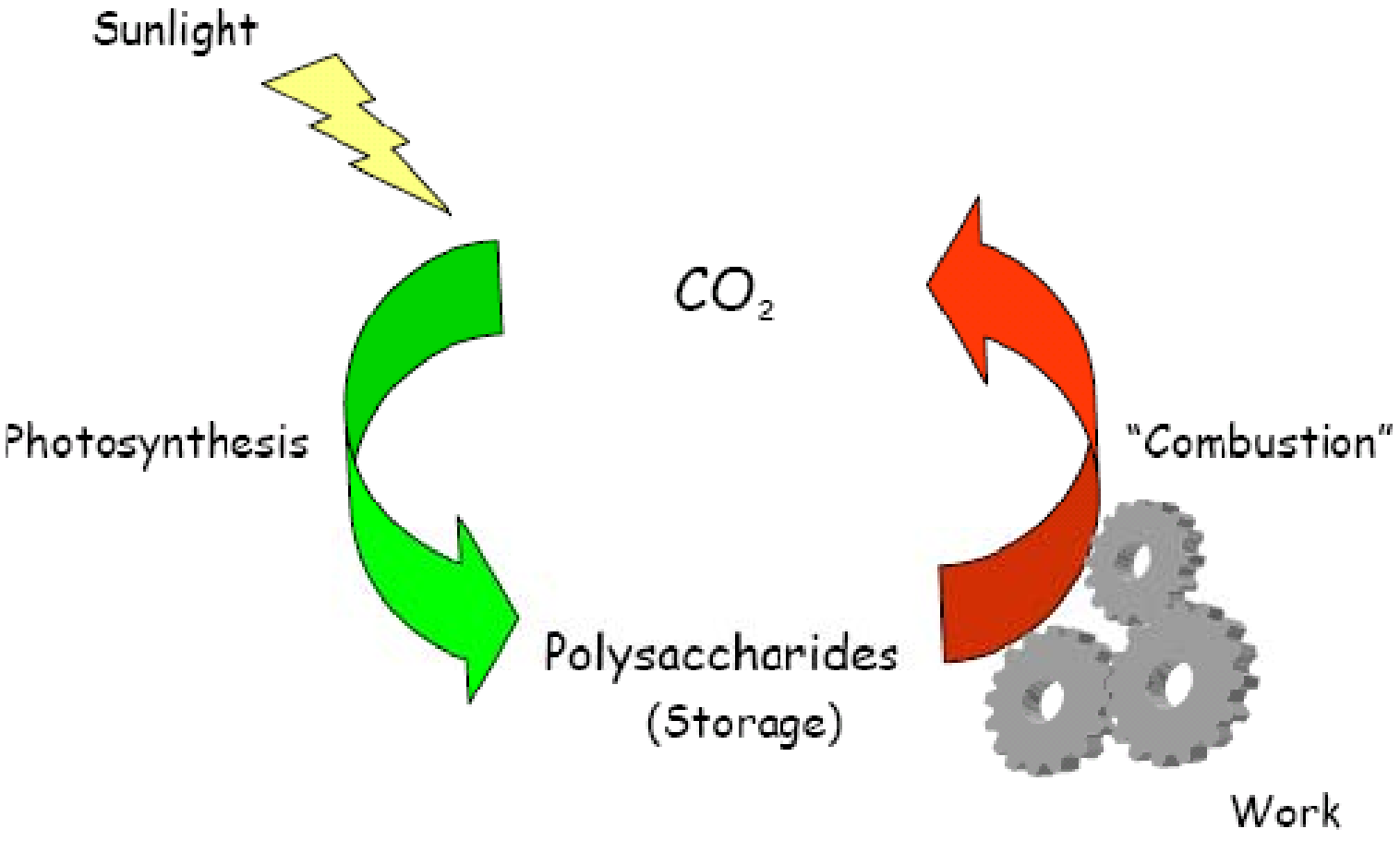
100 EJ from crop and forest residues worldwide

Other Sources

Municipal solid waste	50?
Cover crops (summer/winter)	200?
	250

- Algae
- Flue gases
- Fall harvests from CRP

Combustion of biomass provides carbon neutral energy



Feedstock Credit is Critical to Findings of Greenhouse Gas Benefits

Source of Fuel*	Making Feed-stock	Refining Fuel	Vehicle Operation (Burning Fuel)	Net Land Use Effects		Total GHGs	% Change in Net GHGs vs. Gasoline
				Feedstock Uptake from Atmosphere (GREET)	Land Use Change		
Gasoline	**+4**	**+15**	**+72**	**0**	–	**+92**	–
Corn Ethanol (GREET)	**+24**	**+40**	**+71**	**-62**	–	**+74** **(+135** without feedstock credit)	**-20%** **(+47%** without feedstock credit)
Cellulosic Ethanol (GREET)	**+10**	**+9**	**+71**	**-62**		**+27** (+**90** w/o feedstock credit	**-70%** (-2% w/o feedstock credit

Greenhouse gasses (CO_2) per mega joule of fuel

Why a land feedstock credit?

- Land already exists
- Forests and Grassland conversion
- Cropland produces carbon benefit in form of protein, carbohydrates, fats.

Opportunity Cost

Carbon Benefit of Using Land for Biofuel

- 3 t/ha/yr – corn ethanol – GREET
- 8.6 t/ha/yr – cellulosic ethanol – GREET (swtichgrass at 18 t/ha/yr, 359 l/t)

Carbon Cost of Using Land for Biofuel

- Fallow land - forest regeneration, temperate forest 7.5 - 12 t/ha/yr
- Existing forest (lose 600-1000 tons) = 15-35 t/ha/yr (over 30 years) plus lost forest growth
- Existing grassland/savannah (lose 75-300 tons), 2.5-10 t/ha/yr (over 30 years) plus lost forage

When you divert cropland to biofuels

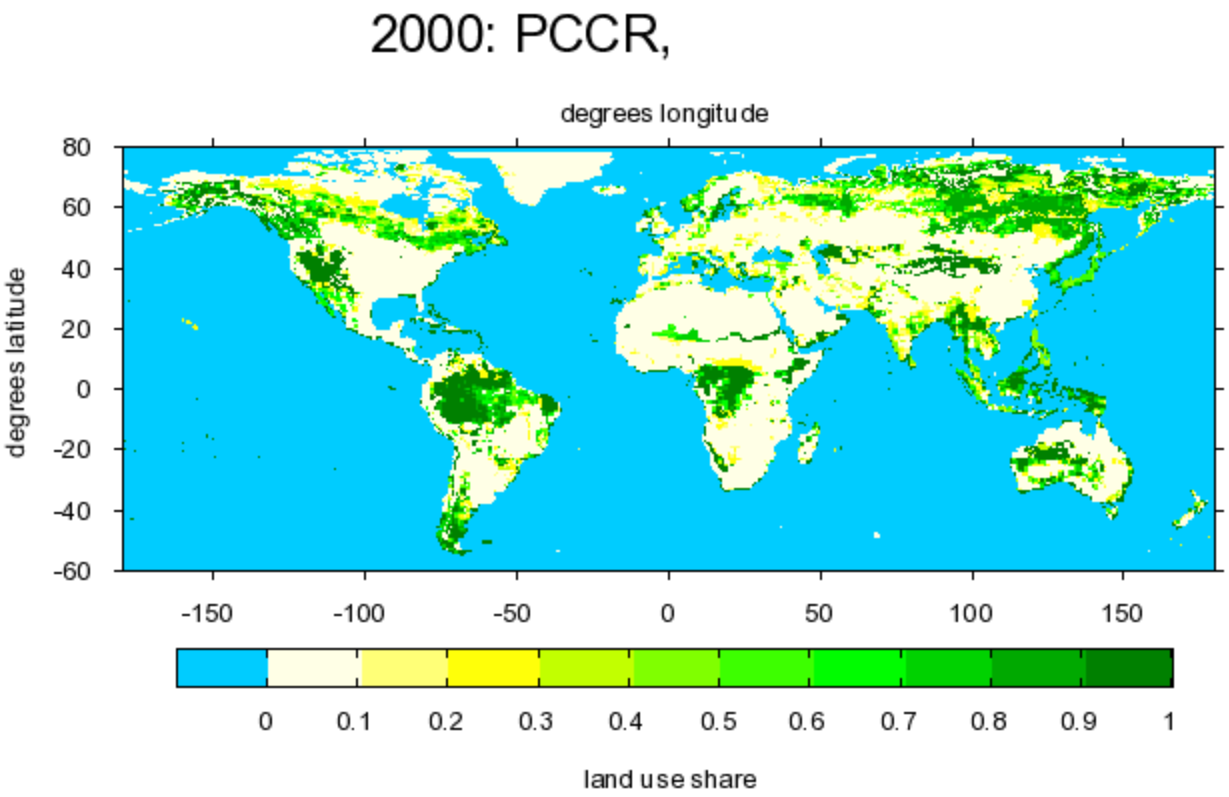
1. People consume less food

2. Farmers plow up more land

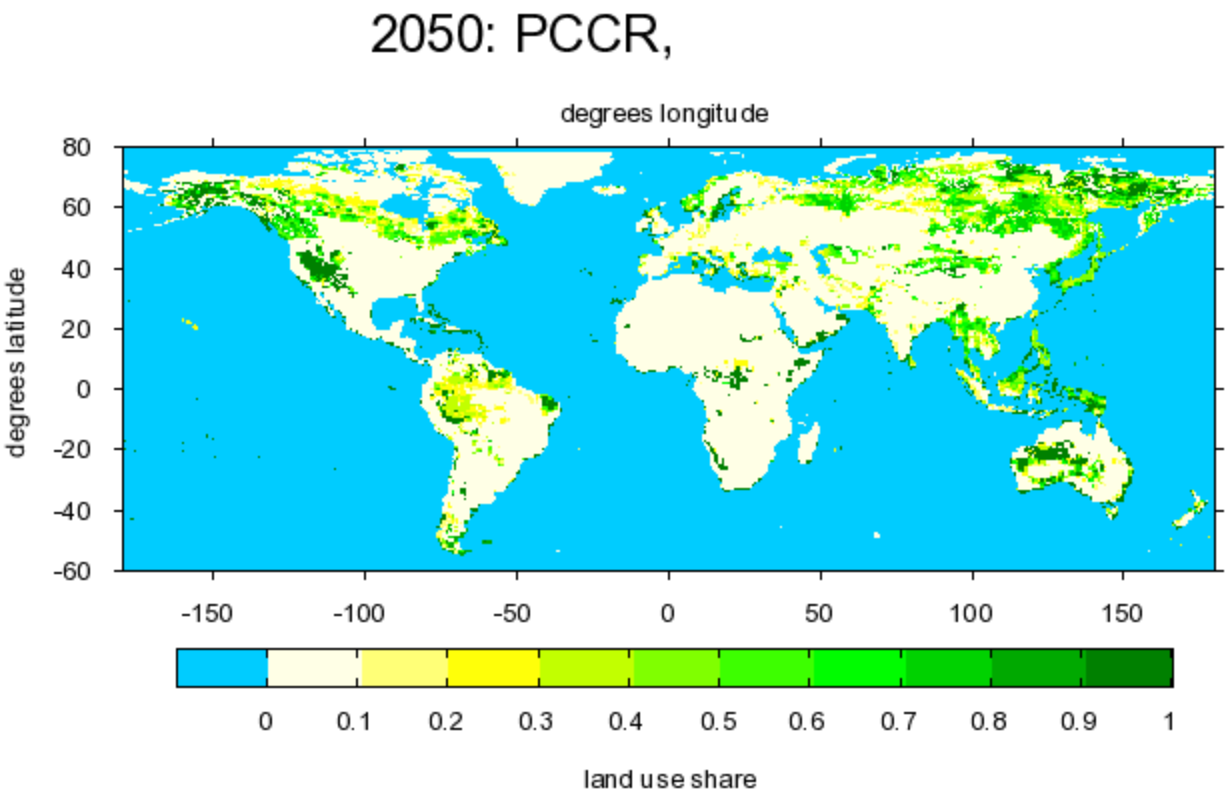
3. Farmers additionally boost yields


The new situation: Surge in prices
New trend?
Corn
Wheat
Rice
Oil (right scale)
US$/ton
US$/barrel
800
600
400
200
0
100
75
50
25
0
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Source: Data from FAO 2008 and IMF 2008.

Natural Forest
(Melillo, Gurgel, et al. 2008)



Natural Forest ("Deforestation" Scenario)



GHGs from Nitrous Oxide For Yield Gains

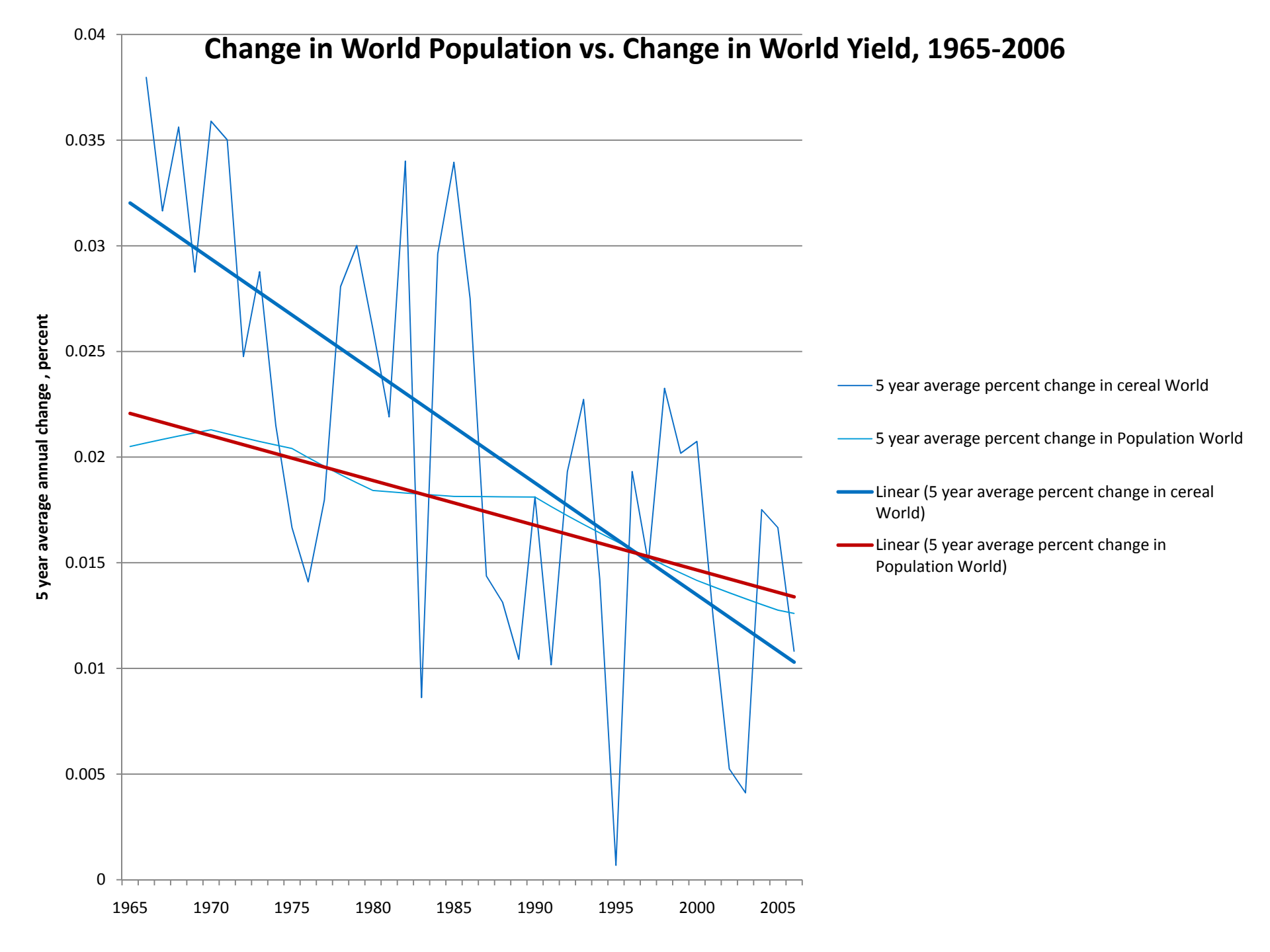
Through Fertilizer (assuming 7 extra additional lbs of fertilizer/bushel of corn)

N_2O Formation Rate	Greenhouse gases grams CO_2 eq./mega Joule
2%	132
3%	198
4%	264
5%	330
6%	396

Compare 104 g/MJ from land use

Implied Yield Growth by 2020 Scenario 10.2% Transport Fuel(Etech 4)

Crop	Biofuels, adjusted for by products	Non Biofuel food demand	Biofuel and Non Biofuel	1996-2006 Trend
Cereals (corn,wheat	0.8%	1.8%	2.6%	1.3%
Oilseeds (soy, rape)	0.9%	2.2%	3.2%	1.5%
Sugar (cane)	5.0%	0.6%	5.5%	0.8%
Palm	3.0%	3.9%	6.9%	1.9%


Change in World Population vs. Change in World Yield, 1965-2006
5 year average annual change , percent
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
1965
1970
1975
1980
1985
1990
1995
2000
2005
5 year average percent change in cereal World
5 year average percent change in Population World
Linear (5 year average percent change in cereal World)
Linear (5 year average percent change in Population World)

Land Use Context

- Deforestation ~20% of CO2 Emissions
- IPCC SRES scenarios are rosy v. FAO and trends
- Mitigation calls for 200 million hectares of afforestation
- Need to reduce agricultural production emissions
- Using land to produce biofuels hinders these goals

Indirect Effects Follow Markets – Businessmen Are Not Dumb

National Academy of Sciences (May 2009)

- "If food crops or lands used for food production are diverted to produce biofuels rather than food, additional land will probably be cleared elsewhere in the world and drawn into food production. The greenhouse gas emissions caused by such clearing of land, especially forests, will decrease or even negate the greenhouse-gas benefits of the resulting biofuels." p. 79

- "Producers need to grow biofuel feedstocks on degraded agricultural land to avoid direct and indirect competition with the food supply and also need to minimize land-use practices that result in substantial net greenhouse-gas emissions." p. 79

- 400 to 550 million tons of “sustainable biomass” - from stover, timber harvest wastes, municipal waste and careful use of CRP – potential 40 billion gallons of ethanol

Other 2008/09 Studies – Same Conclusion

- UK Renewable Fuels Agency (Gallagher Review)
- EU Joint Research Center
- World Bank
- FAO
- Netherlands Environmental Assessment Agency
- OECD
- European Economic and Social Committee
- International Energy Agency
- Scientific Committee on Problems of the Environment
- British Royal Society

Misconceptions

- Deforestation is complicated
- Baseline confusion

EPA Analysis

- Cellulosic the key
- Highly optimistic assumptions – no wetland conversion, soil carbon gain
- Multi-model approach is needed
- Time Discounting –
  - Social discount rate applies to economic returns not emissions
  - Effects of emissions must include: different environmental effects; lower future benefits; risk of future benefits