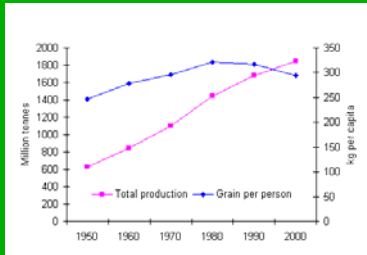


## Sustainable agriculture?



## World Commission on Environment and Development "Brundtland Commission"

Our Common Future (1988)

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Is there an ecological definition of sustainability?

## Non-renewable resources



## Many biological resources are renewable





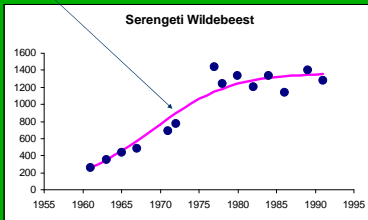
**Thomas Huxley**  
1825-1895

"...that the cod fishery, the herring fishery, the pilchard fishery, the mackerel fishery, and probably all the great sea-fisheries, are inexhaustible; that is to say that nothing we do seriously affects the number of fish. And any attempt to regulate these fisheries seems consequently ... to be useless."

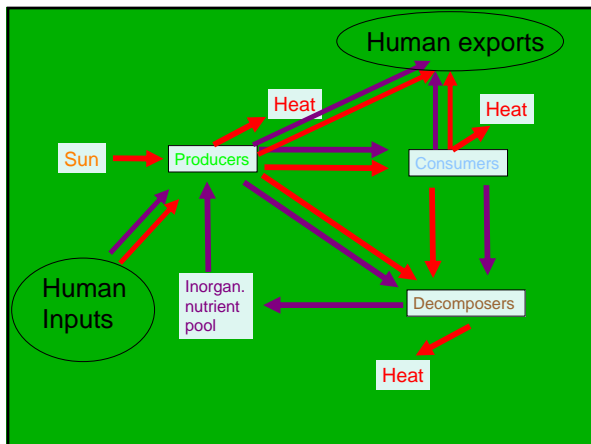
Atlantic cod fishery



Maximum sustainable yield:  
about 1/2 carrying capacity



Ecosystem sustainability?



How much NPP do humans use?

(Vitousek et al. 1986, Rostaczer et al. 2001)

Low (direct consumption):

3.2%

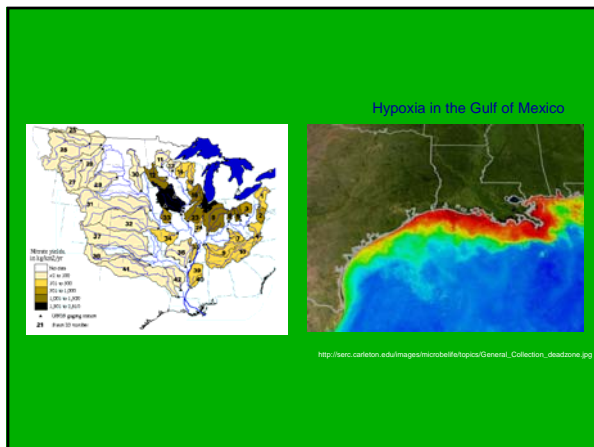
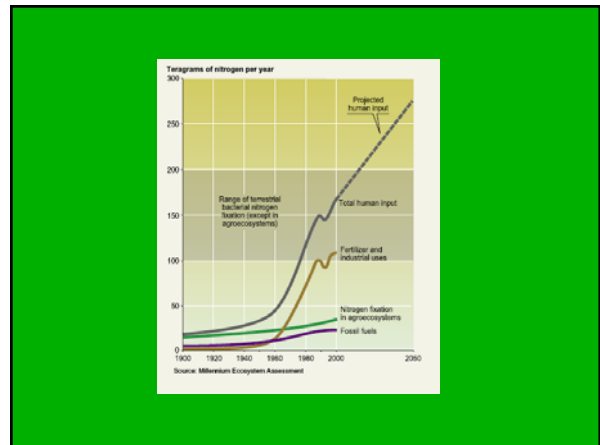
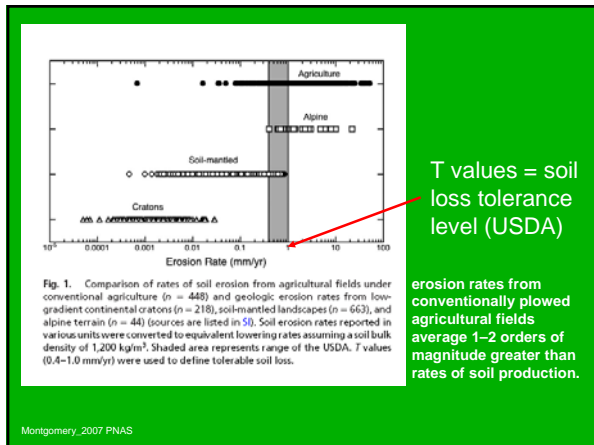
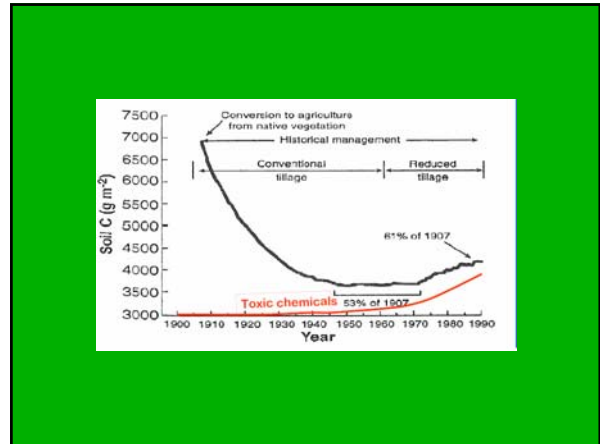
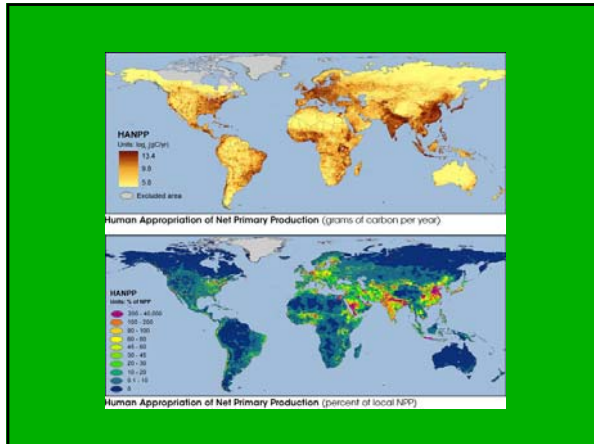
Intermediate (productivity of managed land)

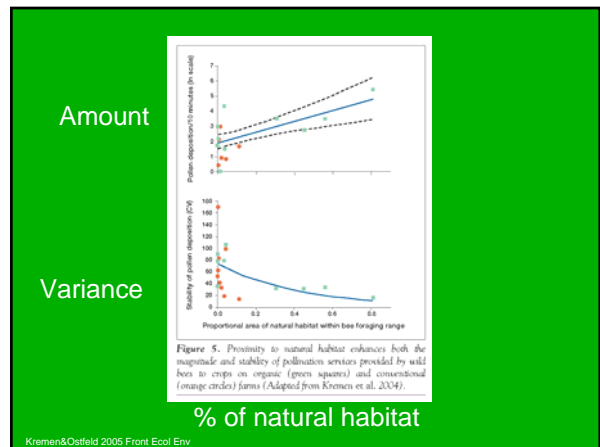
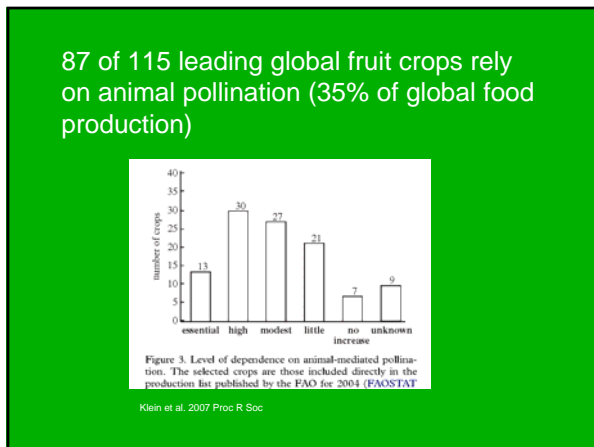
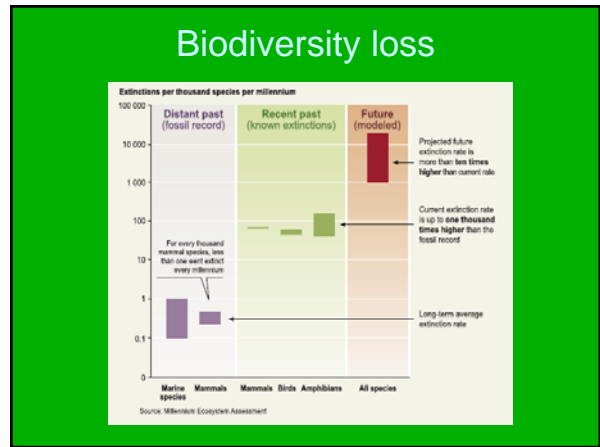
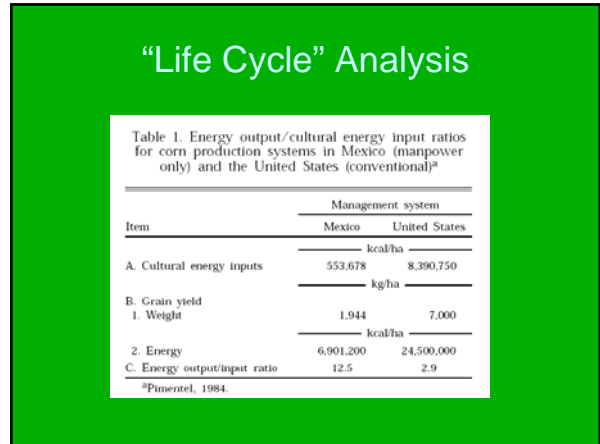
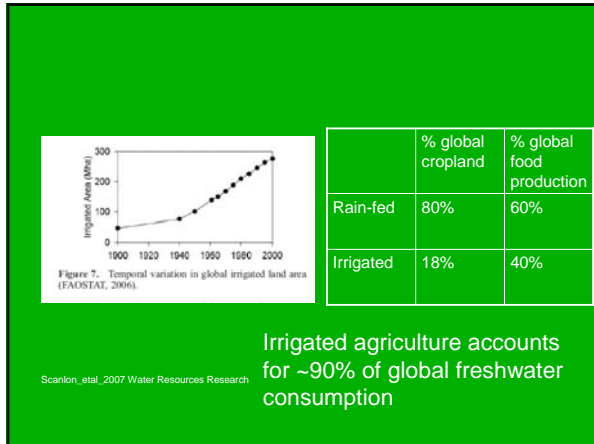
31%

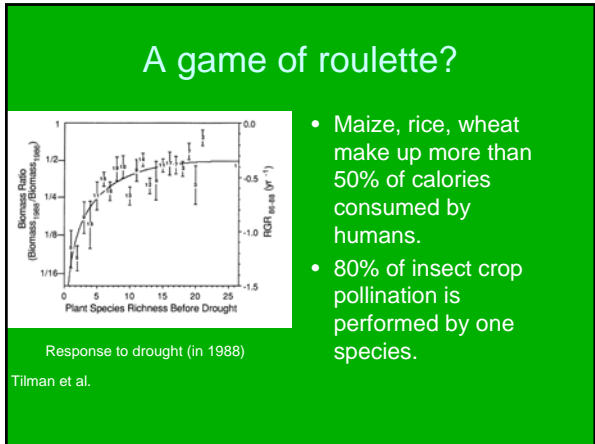
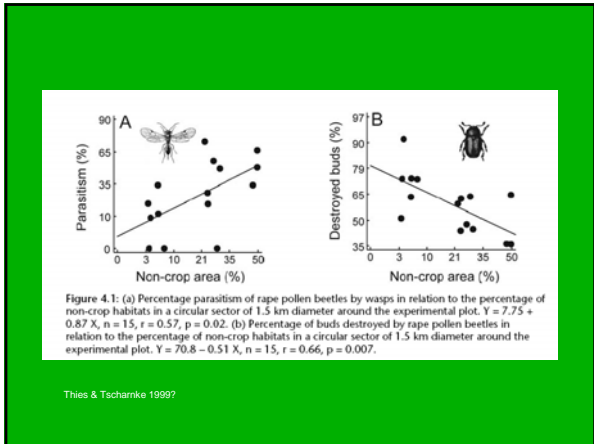
High (productivity lost due to degradation)

39%

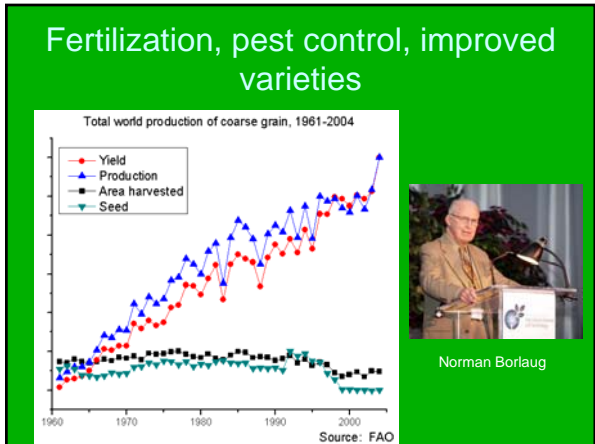
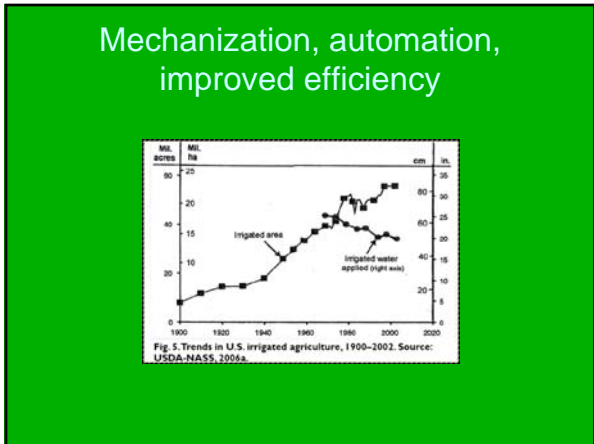
Humans = 0.5% of all consumer biomass







### Some past strategies...



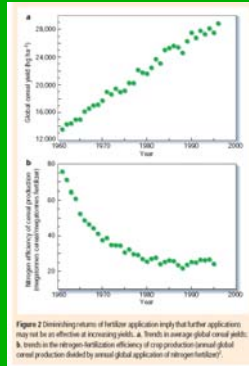


Figure 2 Decreasing returns of fertilizer application imply that further applications required for an increase in crop yield. a, trends in average global cereal yields; b, trends in the nitrogen-fertilization efficiency of crop production (annual global cereal production divided by annual global application of nitrogen fertilizer)

Tilman et al., 2002

Some new strategies?

## Reduce tillage

Table 1. Characteristics of erosion rate distributions for the compiled data presented in Figs. 1 and 2

Measurement type	Sample size, n	Median, mm/yr	Mean, mm/yr	Standard error, mm/yr
Conventional agriculture	446	1.537	3.939	0.321
Conservation agriculture	47	0.062	0.134	0.022
Native vegetation	65	0.013	0.053	0.016
Soil production	188	0.017	0.036	0.004
Geological	925	0.029	0.175	0.029

Data sources are listed in SI.

## Maintain biodiversity and associated ecosystem services



beetle bank



insectary planting



cover crop

## Crop diversification



The "three sisters"

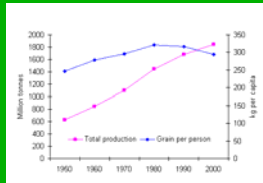
TABLE 1. Grain productivity of maize and cowpea in both systems and values of partial and total land equivalent ratio (LER).

Cropping system	Yield (kg ha <sup>-1</sup> )	Partial LER
Maize sole	2,208	-
Maize intercropped	1,500	0.68
Cowpea sole	1,550	-
Cowpea intercropped	700	0.45
Total LER		1.13

## Costs, yields, equitable, sustainable?



## Sustainable agriculture?



- Are you optimistic or pessimistic?
- What is the most promising technology?
- Is it more a social problem than a technical one?
- Should agriculture be non-profit?