Industrial Ecology of the Modern Biorefinery

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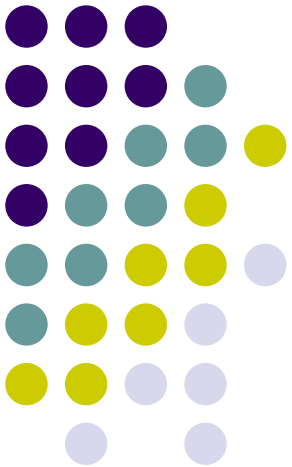
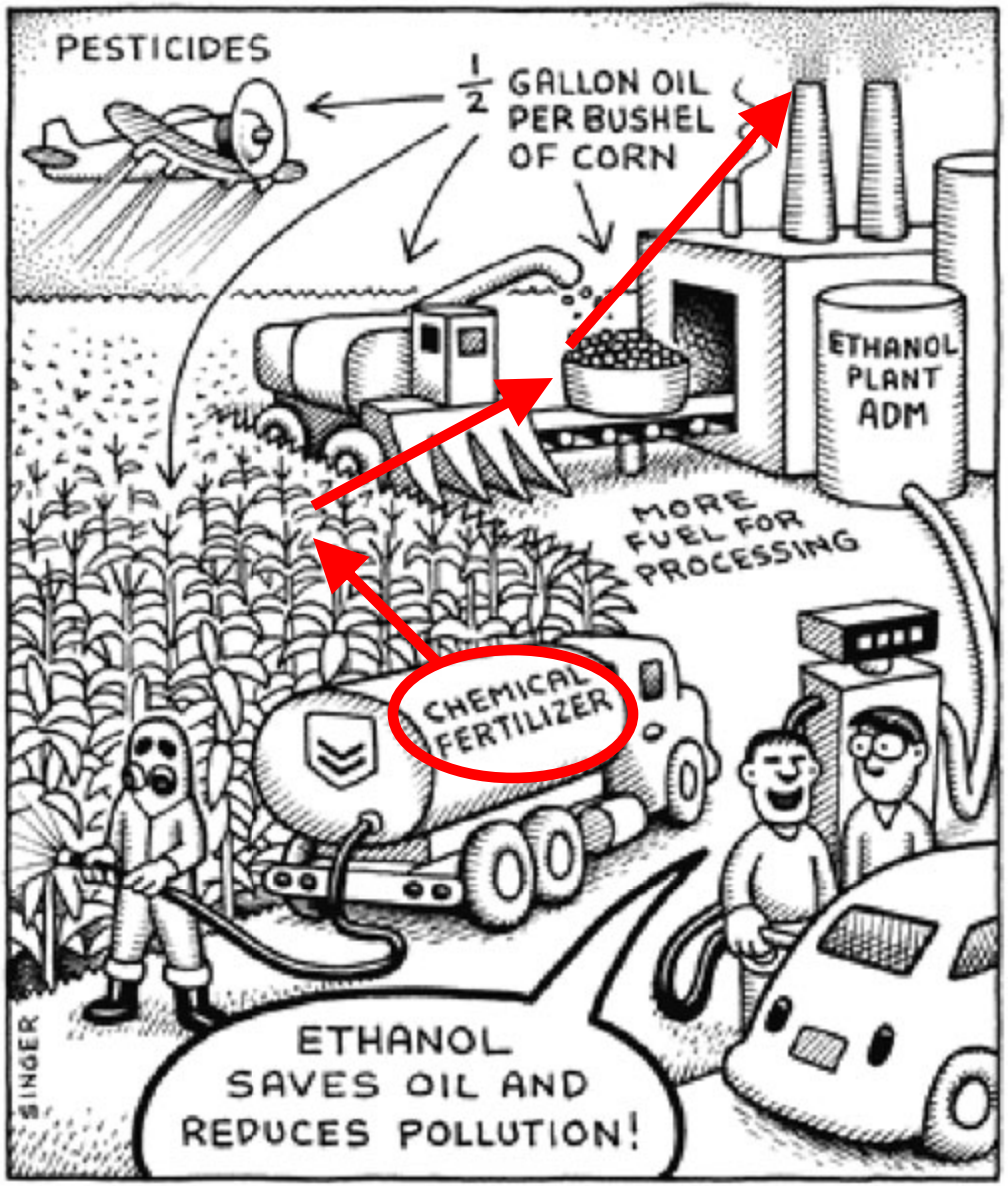
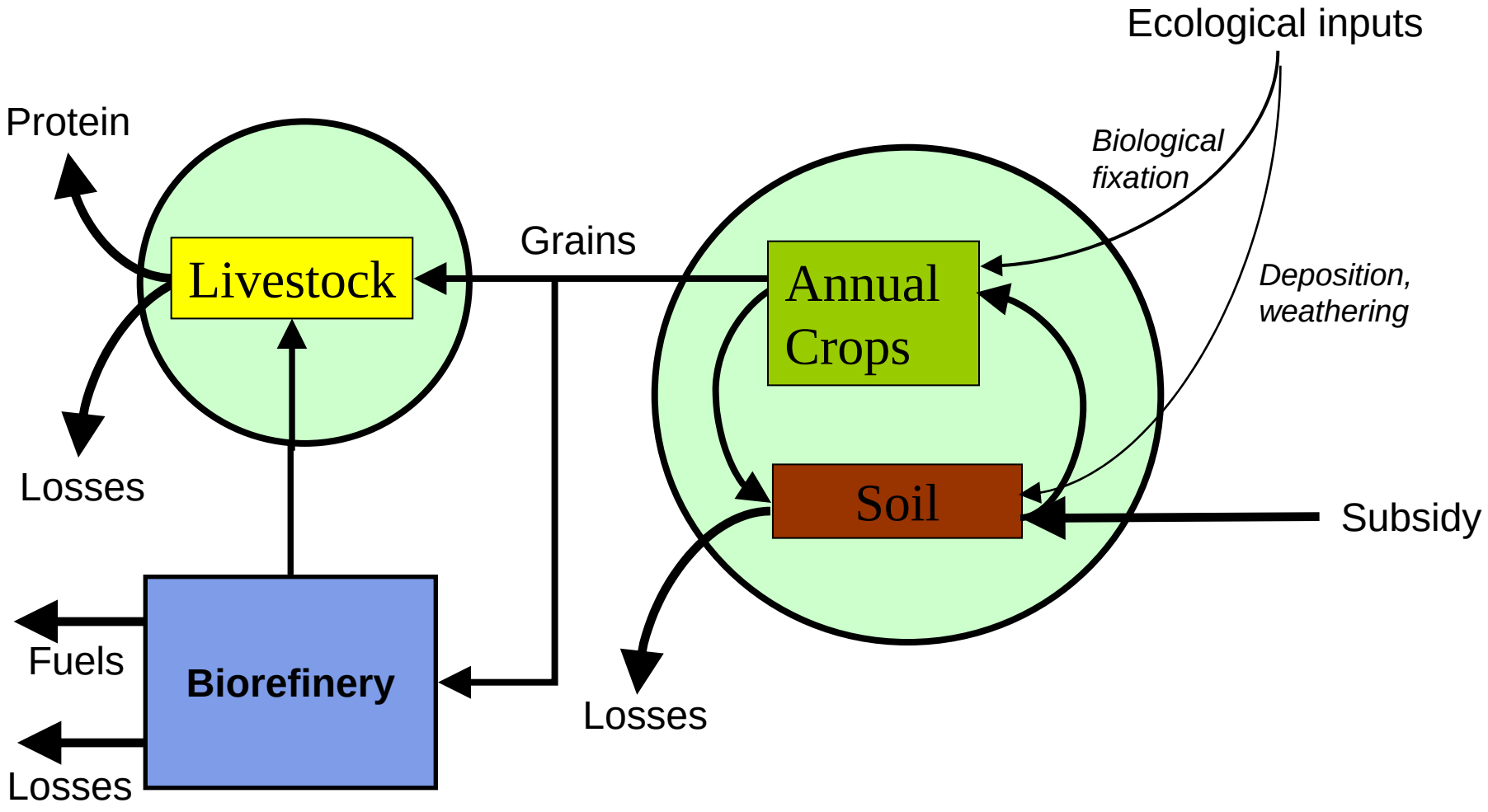
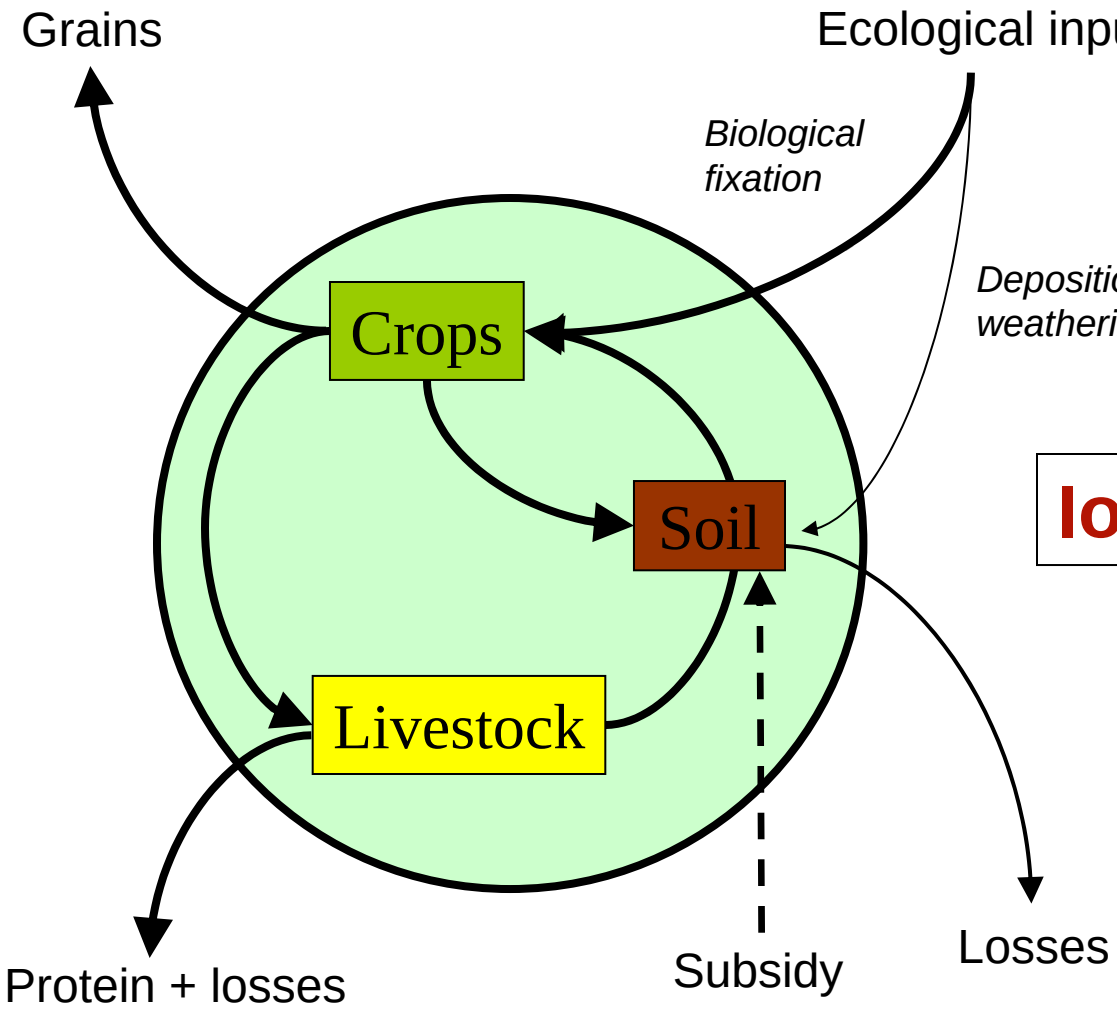



PESTICIDES
½ GALLON OIL PER BUSHEL OF CORN
ETHANOL PLANT ADM
MORE FUEL FOR PROCESSING
CHEMICAL FERTILIZER
ETHANOL SAVES OIL AND REDUCES POLLUTION!
SINGER

Problem: Disjunct agricultural biocycles

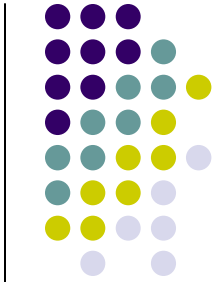


Integrated agricultural biocycles



Iowa: circa 1940

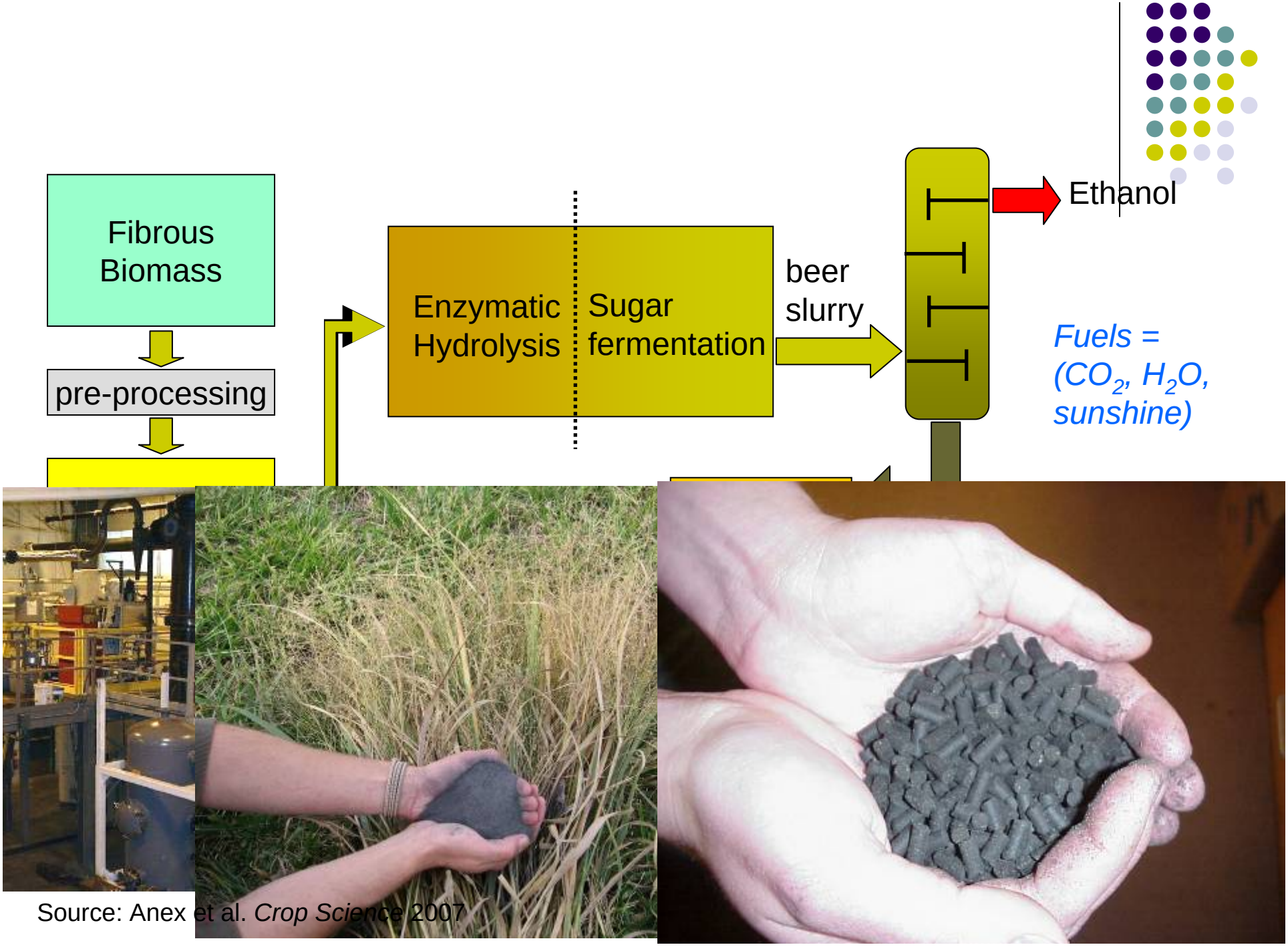
A return to integrated farming?



- No, probably not in the near-term
- Increasing utilization of **corn** for the production of **ethanol** will likely drive the continued intensification of grain→livestock based systems with concomitant impacts on agricultural biocycles
- **Soon:** Biofuels from lignocellulose (biomass)

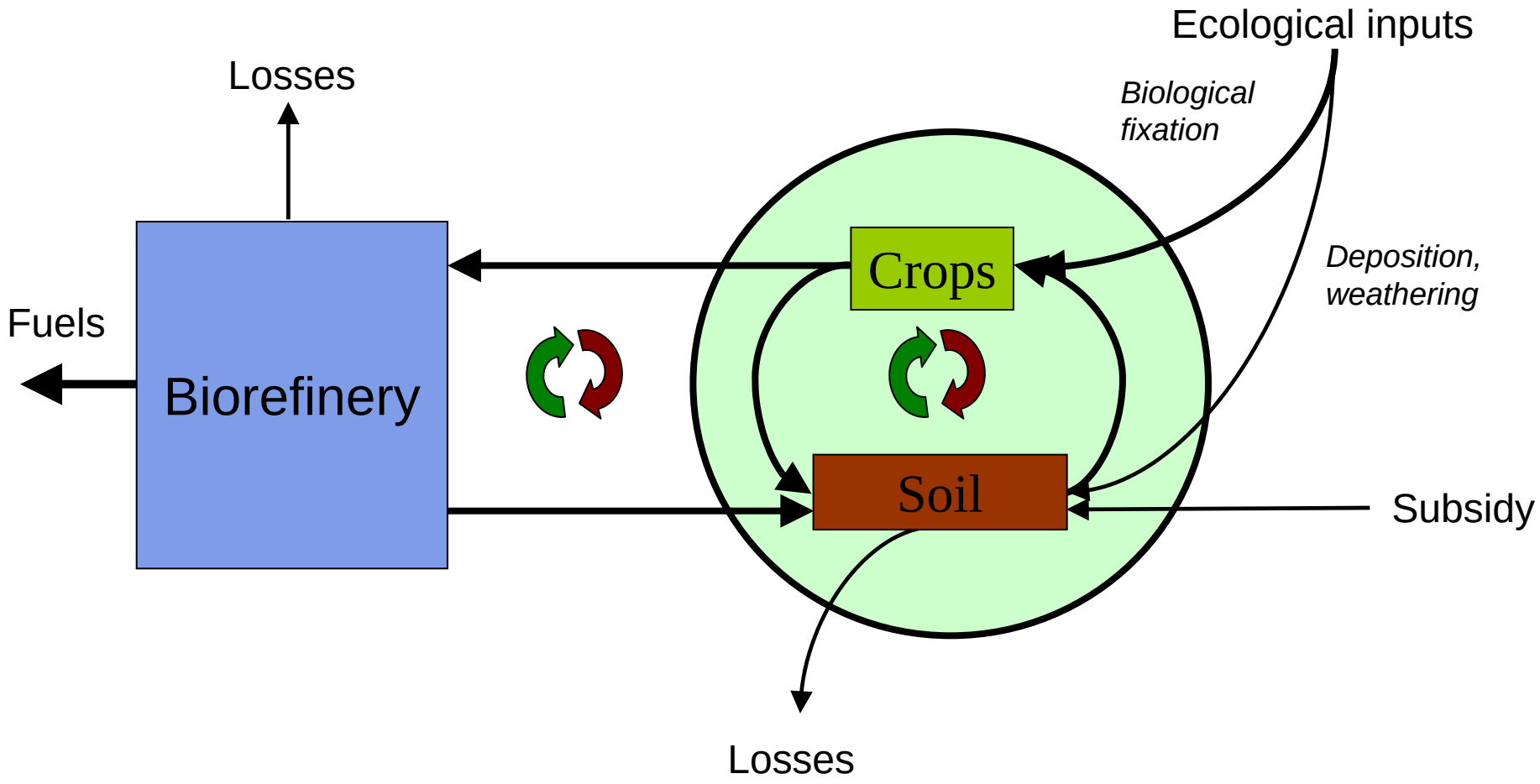
The promise of cellulosic biofuels

- Conversion of biomass into ethanol and other fuels via combined thermal and biological processes
- Vastly increases the volume of biofuels that can be produced
- Increased energetic efficiency of biofuel production
- New opportunities for improved biocycling in agricultural systems

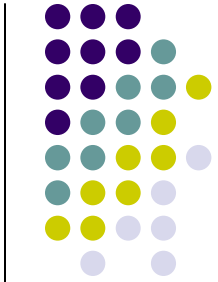


Source: Anex et al. *Crop Science* 2007

A new approach for reintegrating agricultural biocycles?



Potential mass recovery from switchgrass in a cellulosic biorefinery

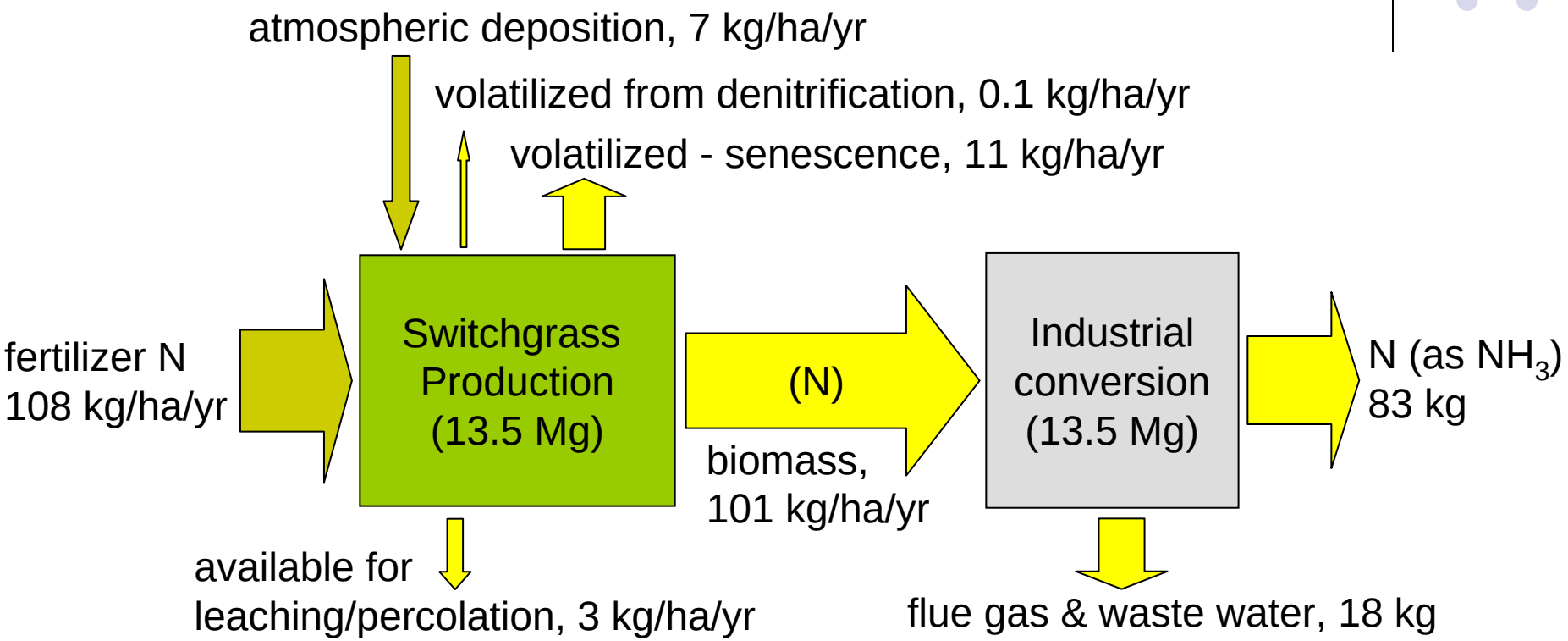


Biorefinery elemental recovery from switchgrass biomass

Element	Recovered form	Recovered mass (kg)
Nitrogen	NH_3	83
Potassium	K_2O	72
Phosphorus	P_2O_5	26
Calcium	CaO	43
Magnesium	MgO	18
Iron	Fe_2O_3	10
Sulfur	SO_3	6
Aluminum	Al_2O_3	3
Sodium	Na_2O	> 1

Source: Anex et al. (*in prep.)*

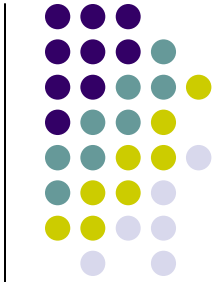
Example: Nitrogen mass balance



Recovery at processing of 78% of N input to system as fertilizer.

Source: Anex et al. *(in prep.)*

Key Questions



- Can we efficiently recover nutrients from biomass?
- What level of switchgrass production could be maintained with recycled nutrients alone?
- What are the implications of nutrient recycling on the overall energetic efficiency of the cellulose-ethanol fuel cycle
- Equivalent to 2,460 MJ as NH_4-NO_3 delivered to farm, or an additional 9 L EtOH per ton of biomass.

- ~8 % increase in EtOH conversion efficiency.

Source: Anex et al. *Crop Science* 2007

Acknowledgements

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