Carbon Sequestration in Agriculture: Hype or Reality?

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Kyoto Protocol, 1997

- U.N. Convention on Climate Change commits industrialized countries to binding targets for Greenhouse Gas (GHG) emissions
- 7% below 1990 emission levels for U.S., 8% below for E.U. and 6% below for Japan

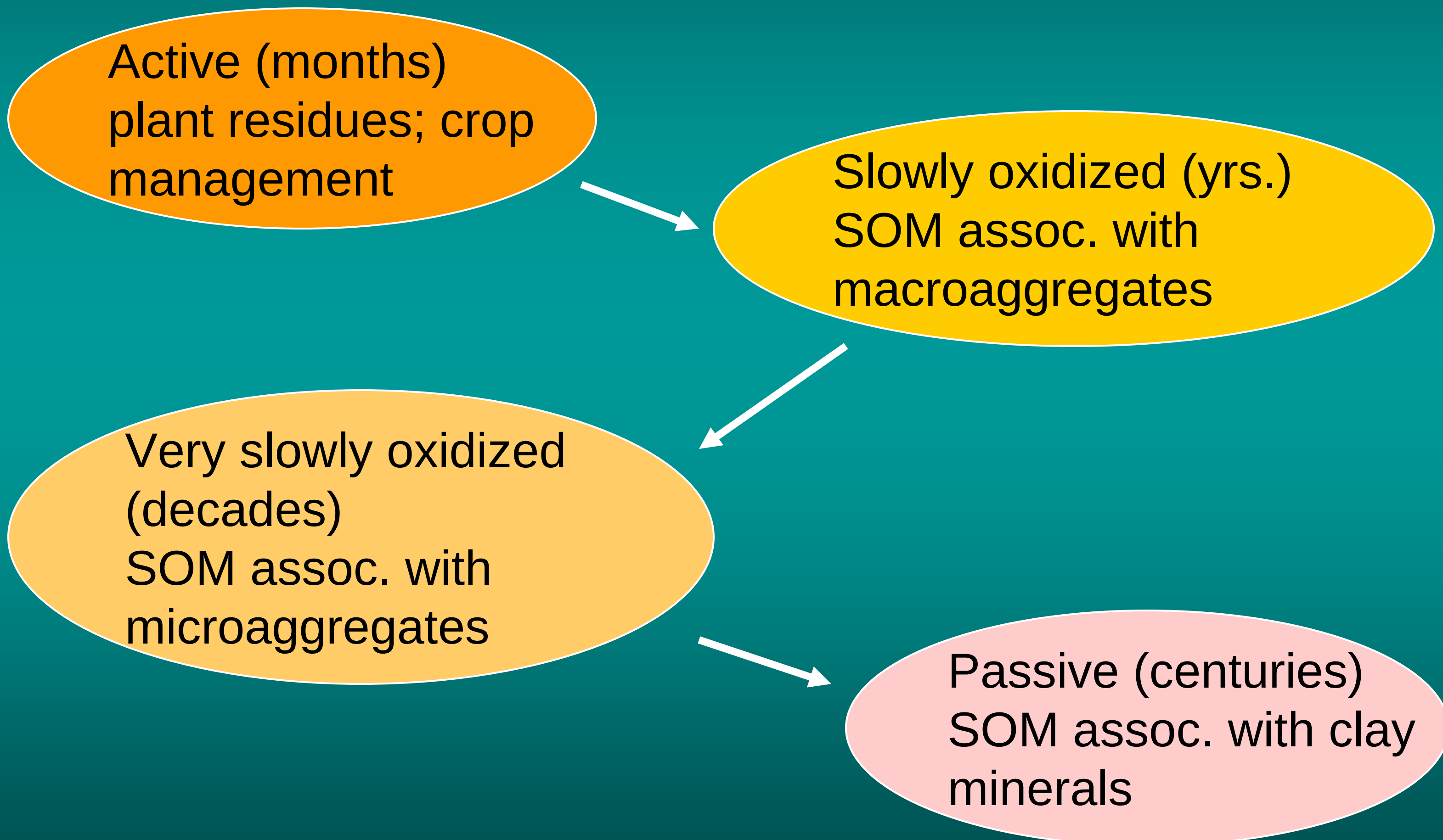
U.S. Senate Bill 547

- "Credit for Voluntary Reduction Act" 1999
- Independent of Kyoto Protocol, Senate introduced bill to recognize voluntary reductions of GHG emissions

Estimated Soil C Pool

- Estimated at 2300 Pg (billion grams)
- 1550 Pg Organic Carbon (SOC)
- 750 Pg Inorganic Carbon (SIC)
- Estimated atmospheric C pool is 750 Pg
- Conversion of native ecosystems to agriculture leads to 50-75% loss of SOC
- Historic loss of SOC estimated at 66-90 Pg (19-32 Pg from soil erosion)

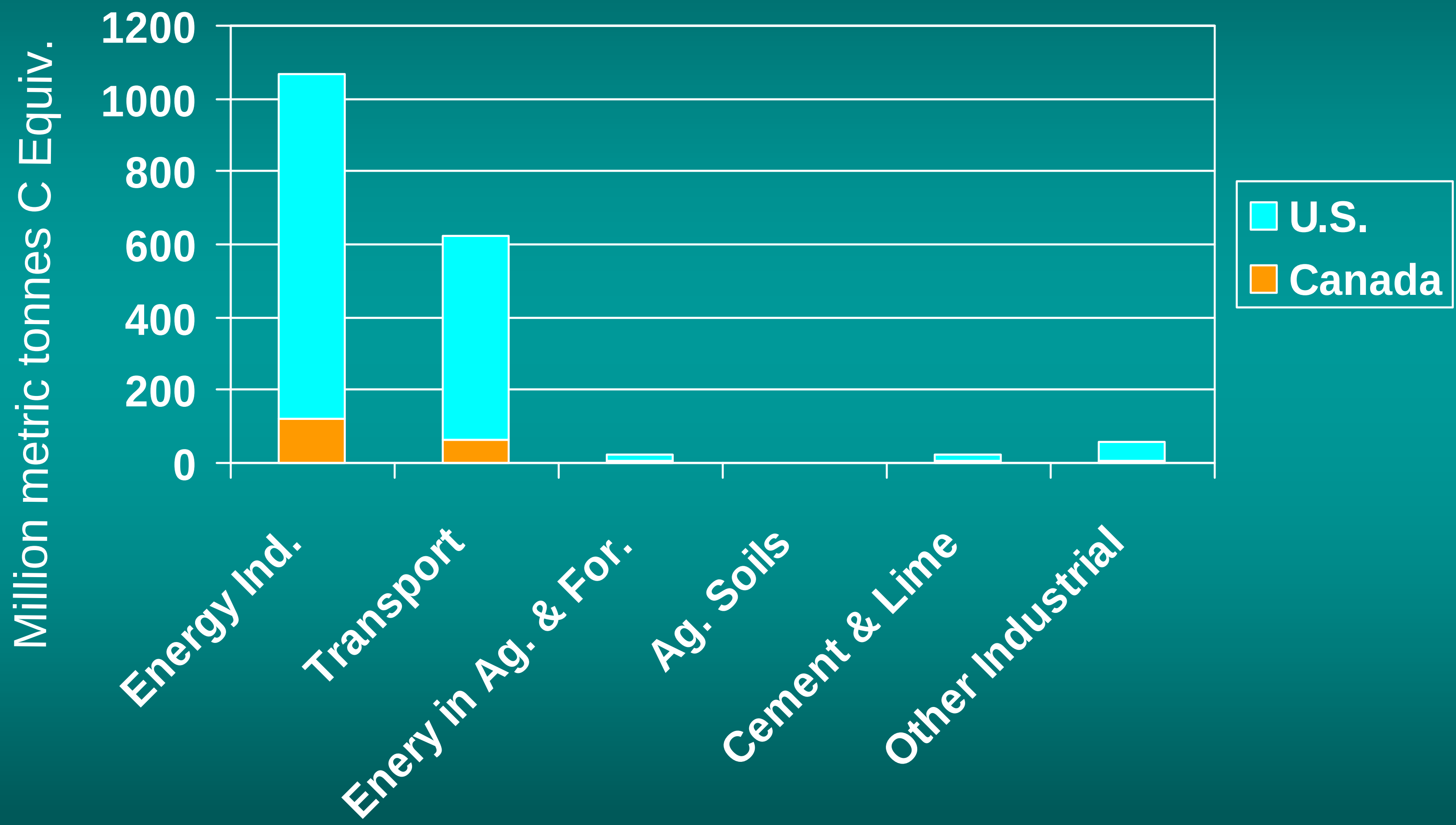
Relative Availabilities of Soil C Pools



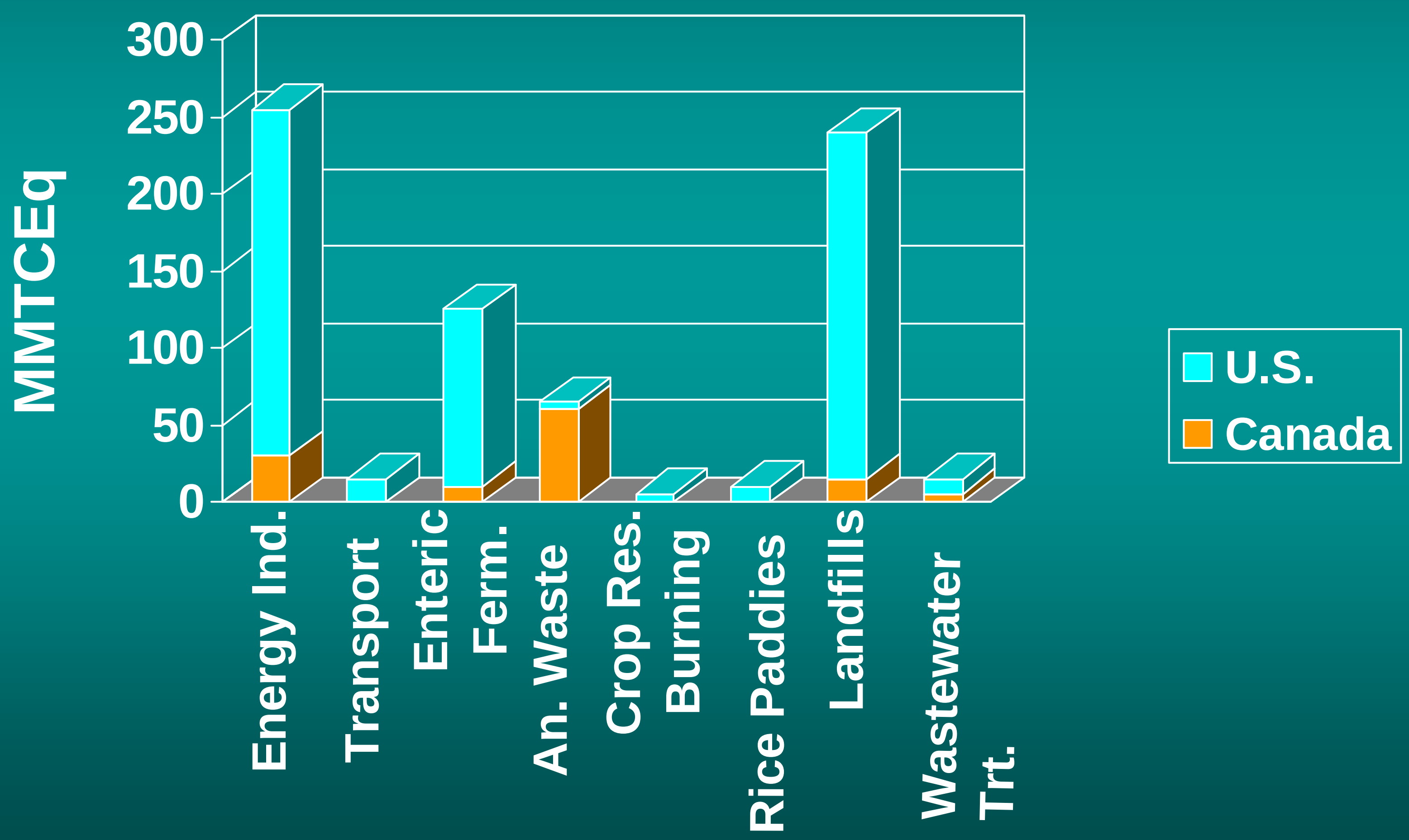
Global Carbon Flux Budget

Carbon Flows	**Pg C**
Annual atmospheric	3.4
increase of CO_2	
Sources: Fossil fuels	6.4
Land use change	1.1
Tropical	1.6
deforestation	
Sinks: Terrestrial	2.0
(temperate)	2.0
Oceans	1.7
“Missing”	
Potential sinks in croplands	40-80
alone (over 50-100 yrs.)	

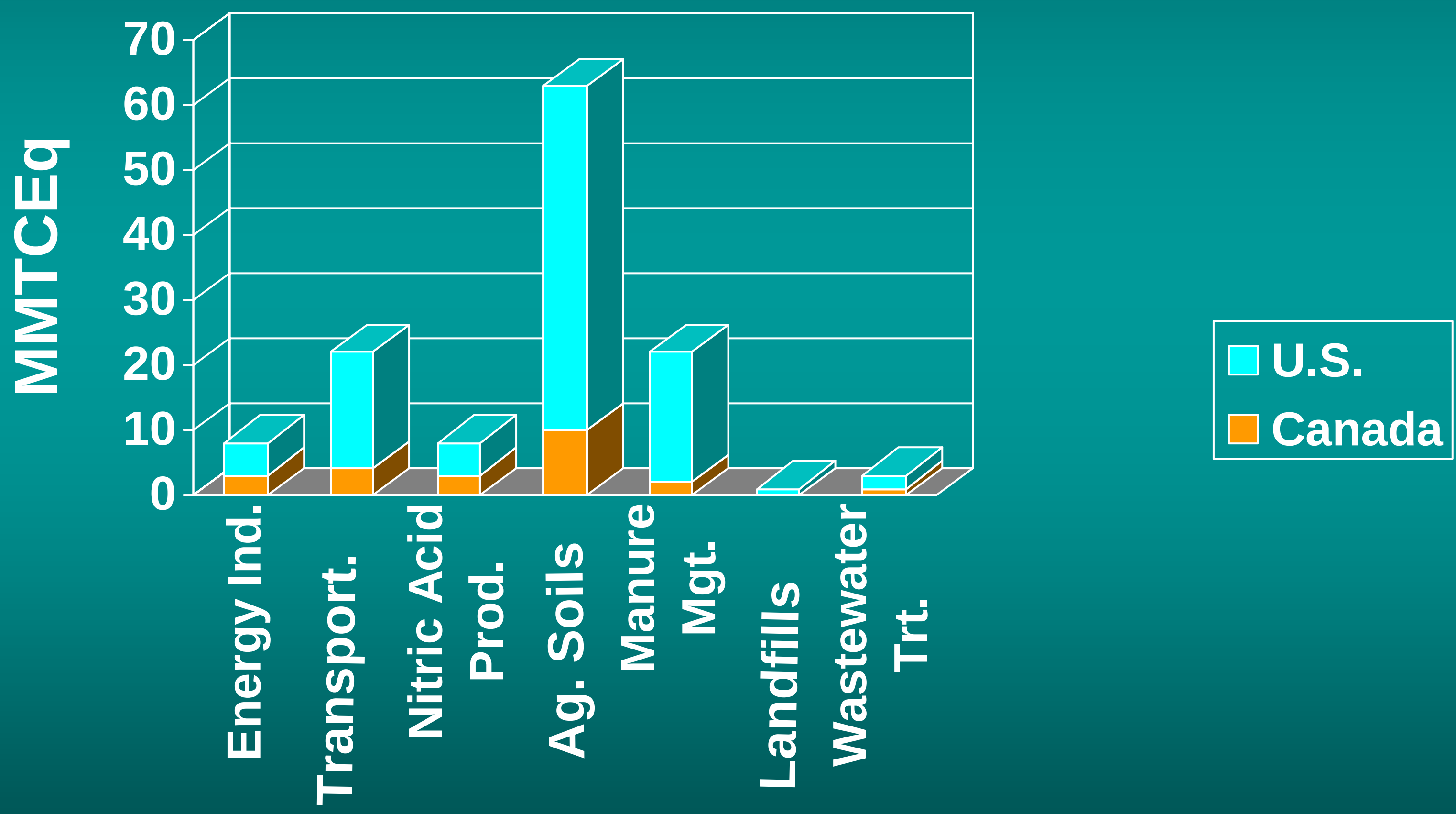
North American CO_2 Emissions



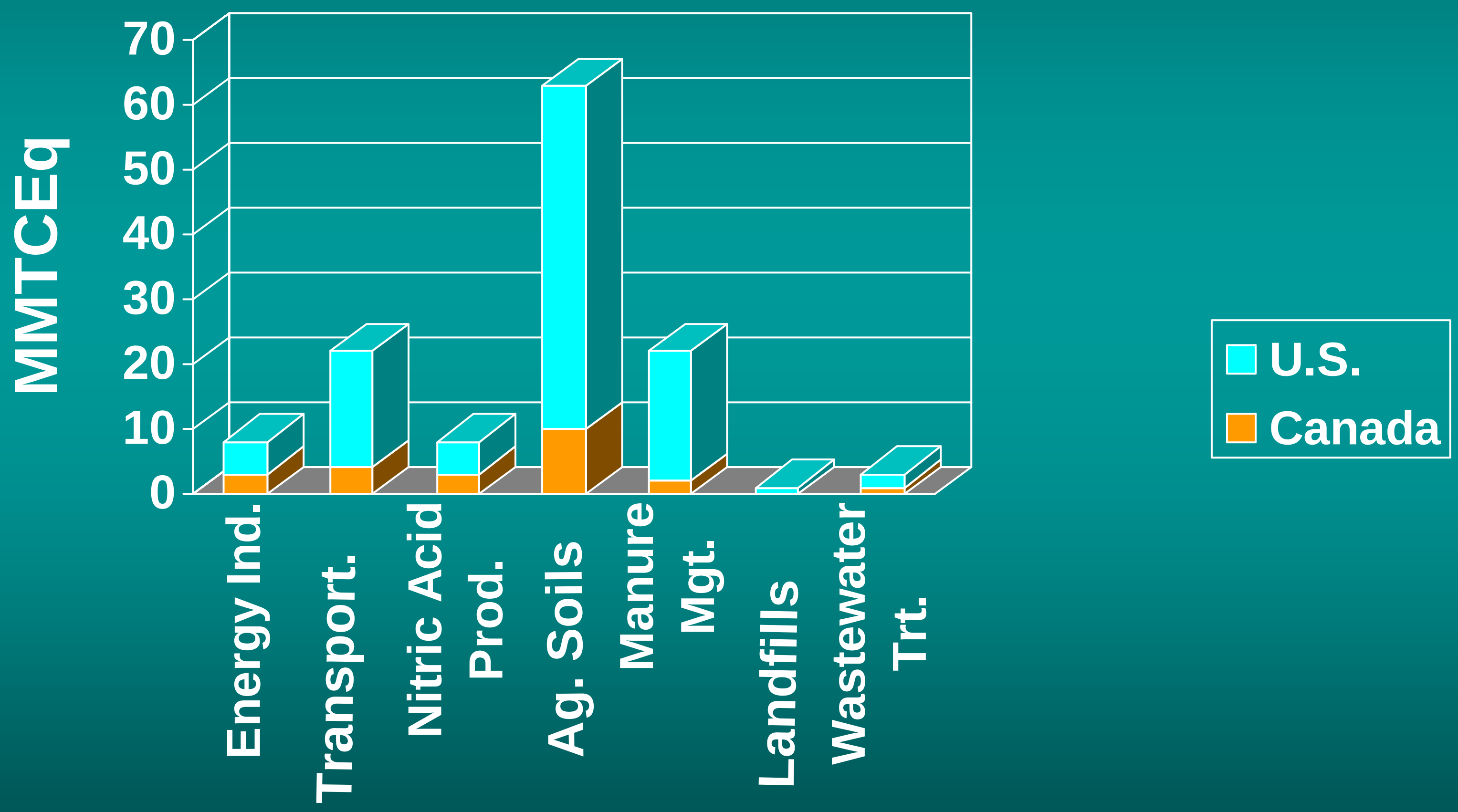
North American CH_4 Emissions



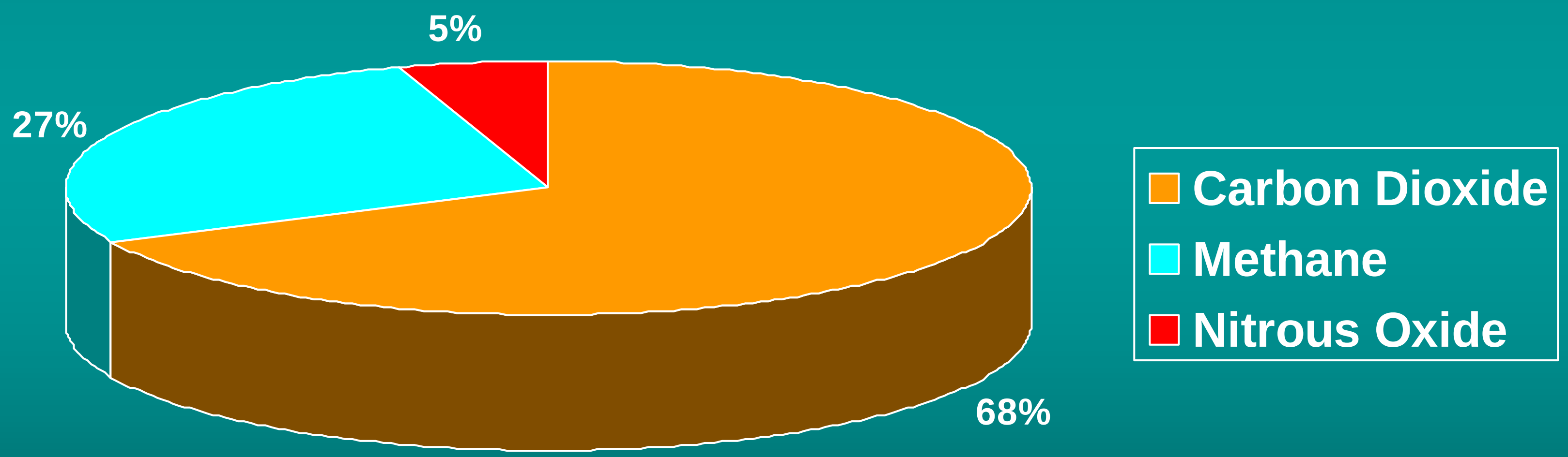
North American N_2O Emissions



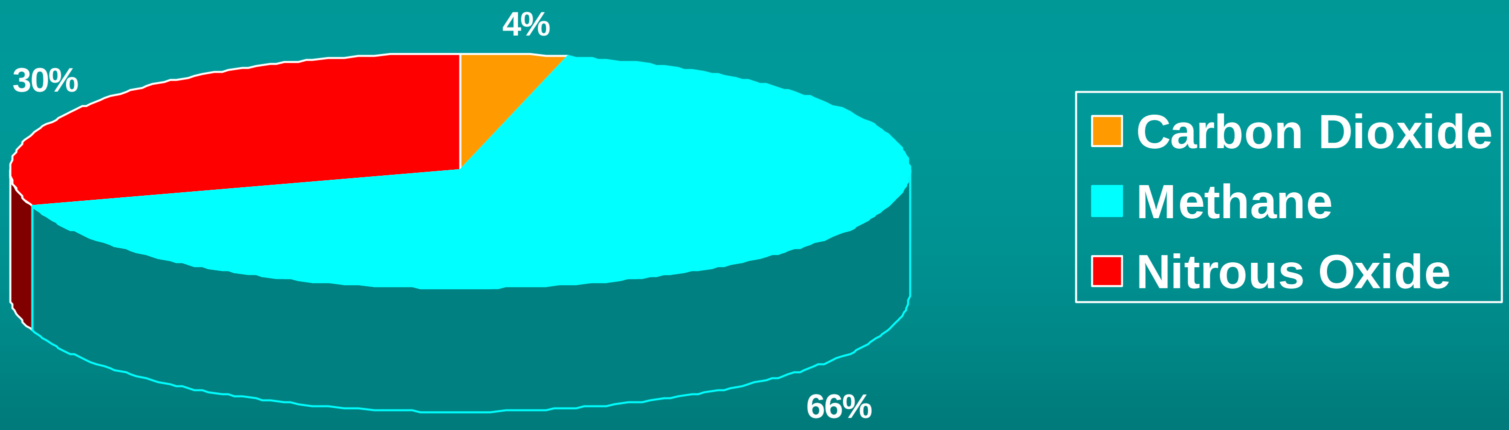
North American N_2O Emissions



Total North American GHG Emissions



North American Agricultural GHG Emissions



Carbon Credit Trading

- Reductions in GHG emissions purchased from farmers can be used to offset energy co. GHG emissions
- Consortium of Canadian energy cos. have project to buy C credits from Iowa farmers (GEMCo)
- Current value is $1-3/acre
- CarbonTrading.com initiated website July 2000 to match landowners with companies who want to trade C

Resources

- Local: Wisconsin Carbon Workgroup, Steve Bertjens, SW Badger RC &D is chair
- Met in July 2000
- “Growing Carbon: A new crop that helps agricultural producers and the climate too” NRCS publ.(www.nrcs.usda.gov)
- “Carbon Sequestration in Soils: Science, Monitoring and Beyond” Proceedings of St. Michael’s Workshop, Dec. 1998, N.J. Rosenberg, R. C. Izaurralde, E.L. Malone (eds.),Batelle Press

Uncertanties of Kyoto Protocol

- Article 3.3 allows parties to include stock changes from “afforestation” and “reforestation”
- Article 3.4 leaves open selection of additional “human-induced activities…in agricultural soils and land use change..”

Carbon Sources and Sinks from Ag. Soils

Source: NRDC Policy Paper

	Sources	Sinks
Transformations	Wetlands to croplands Grasslands to croplands Natural ecosystems to croplands	Set aside of cropland to grassland or woodland
Production	Lower residue yield Lower crop biomass Lower lignin content of crops Longer fallow	Higher residue yields Change to crops with higher biomass Higher lignin content Shorter fallow
Soil conservation	Intensive till Residue (straw) sales Stubble burning	No-till Residue incorp into soils Cover crops Soil water control
Other	Liming	Animal manure or biosolids storage

Environmental Impacts from Ag. Management:
Crop and residue yield increase through fertilizer inputs

Positive	Negative
None	N_2O emissions from N fertilizers Fossil fuel energy inputs to produce N fertilizers CH_4 emissions related to fertiliz. application Water pollution

Source: NRDC Policy Paper

Late-Breaking News on C Sequestration

- New York Times article Nov. 17, 2000 reported that 15-nation EU rejected proposal from U.S., Canada and Japan to allow nations to use C sinks to help meet targets of CO_2 reductions committed in Kyoto Protocol.
- Rejected because "does not ensure the environmental integrity of the Kyoto Protocol."
- Proposal called "too vague and open ended."
- Discussion now moves to U.N. Climate Conference scheduled for week of Nov. 27th.

Reliability of GHG Measurements

- CO_2 most accurate
- CH_4 less certain
- N_2O estimated to vary by greater than 10X the mean
- Global warming potential: CO_2=1; CH_4=21; N_20=310

Mitigating Global Climate Change

- Reducing greenhouse gas (GHG) emissions
- Storing or sequestering carbon in soils and vegetation
- Growing crops to substitute for fossil fuels

Potential of U.S. Agriculture to Sequester C

- 75-208 Billion metric tons C/yr.
- 22% land conversion and restoration
- 46% conservation tillage/residue management
- 7% improved practices
- 25% improved cropping systems

Other GHG: Methane (CH_4)

- Derived from enteric fermentation, animal wastes under anaerobic conditions (waste lagoons), rice paddies
- Growing plants have been observed to absorb and oxidize CH_4 (Robertson et al., 2000)

Other GHG: Nitrous Oxide (N_2O)

- By-product of denitrification (related to O_2 status of soil)
- As increase amount of nitrate in soil, increase probability for N_2O loss.
- Seasonal fluctuations great: Canada study showed 40-75% of N_2O loss occurred during spring thaw.

Michigan State Long-term Ag. Systems Study Findings

- 10-yr. study of several cropping systems, abandoned crop fields and mature forests.
- In conventional C-S-W rotation, N_2O is single greatest contributor to GHG emissions; remaining 50% comes from fuel and fertilizer use.
- None of annual cropping systems provided net GHG mitigation; but no-till cultivation resulted in sufficient C storage to offset most GHG sources.
- Use of cover crops, legumes in particular reduced GHG emissions even further.
- Abandoned fields were C sinks for up to 50 yrs., then became neutral.

Environmental Impacts of Ag. Management:

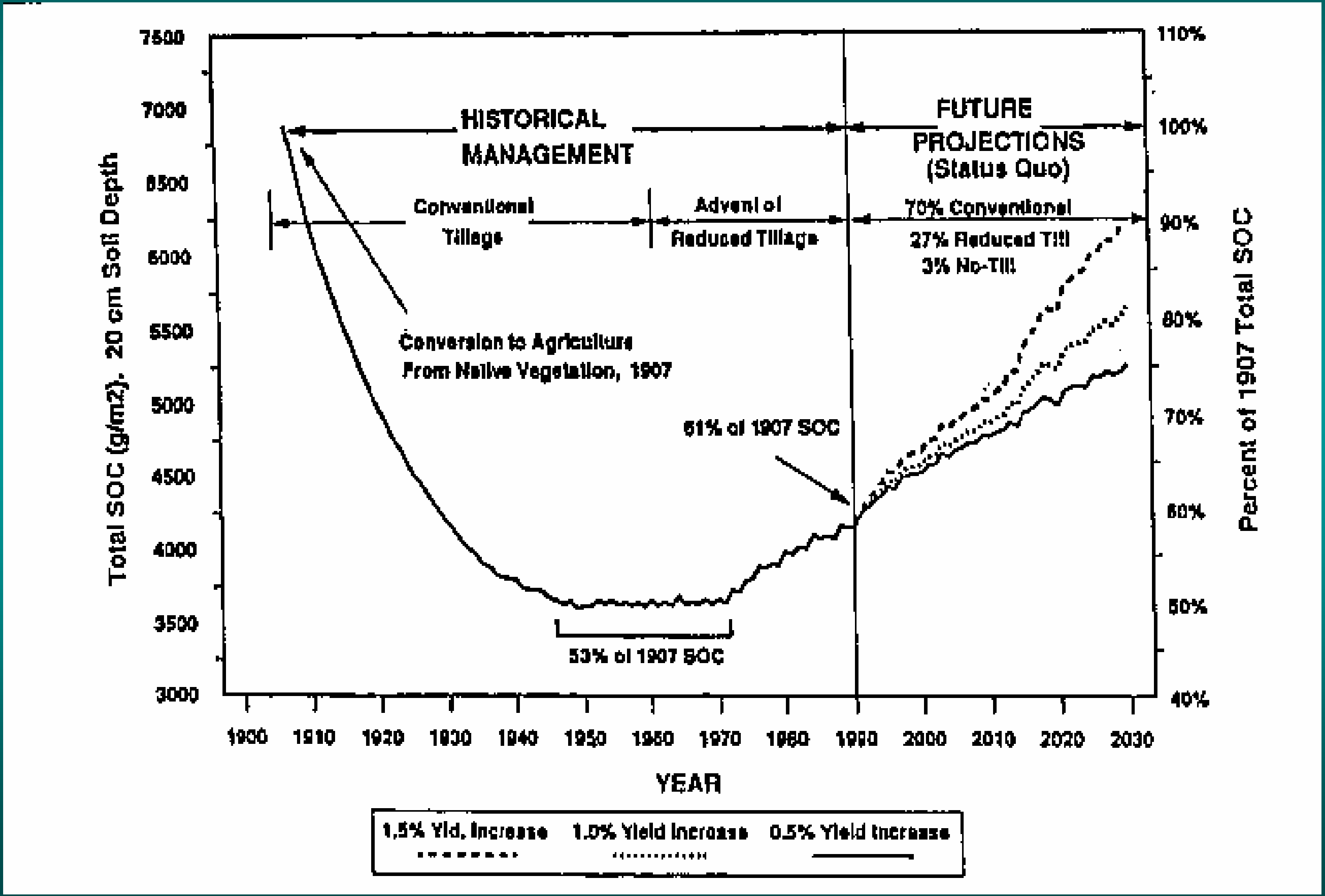
Soil Conservation Practices

	Positive	**Negative**
Cover Crops	N-fixing crops reduce fert. needs Some spp. reduce pesticide reqs. Reduce wind erosion	None
No-till	Reduce soil erosion Reduce fert. consumption Reduce fossil fuel emissions	Reduce rate of CH_4 consumption Increase herbicide use

NRDC Recommendations

- Farming practices that increase soil C accumulation without increasing input requirements or emissions of other GHG's should be encouraged.
- Need accurate assessment of C flux from ag. soils at a national scale; could cost $1 billion for extensive sampling and monitoring.
- Future incentives for soil C sequestration should not reward only crop yield increases but long-term strategies for soil C accumulation.

Century Model Simulated Soil Organic C for Midwest U.S. under Status Quo Scenario for Three Levels of Future Crop Yield Increases (Post et al., 1998)



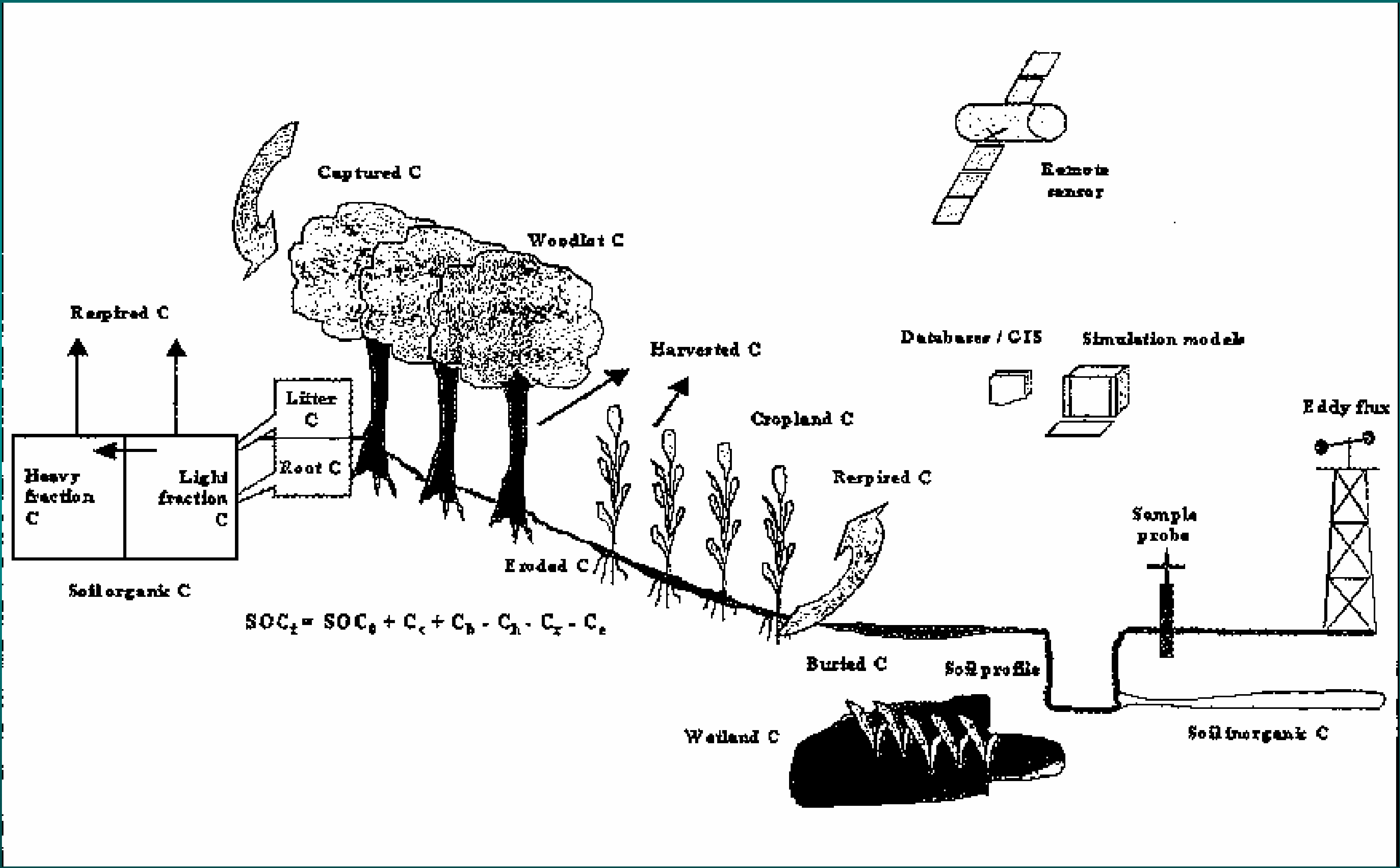
Questions about C Trading

- Will ag. soils be approved as means to meet GHG emissions commitments?
- Will incentives be adequate so that landowners will maintain practices that sequester C?
- Can incentives be designed so that countervailing C losses aren't stimulated?
- How will emissions reductions be integrated into total fabric of ag. policy?
- How will international ag. activities come into play?

St. Michael's Workshop Recommendations

- Use and improve current methods/programs to monitor and verify soil C changes
- Focus initial C sequestration projects on systems with highest potential for gains in soil C
- Establish benchmark monitoring sites
- Use models to scale from field to nation

Carbon dynamics in a landscape and assessment tools



Resources, cont.

- “Greenhouse gases in intensive agriculture: Contributions of individual gases to the radiative forcing of the atmosphere” G.P. Robertson, E.A. Paul, R.R. Harwood, Science Sept. 15,2000
- “Agricultural soil carbon accumulation in North America: Considerations for climate policy” Nat. Resources Defense Council (www.nrdc.org)

Questions about C Credit Trading

- Who has control over C?
- What are consequences if no-till field gets plowed?
- What is level of precision in measurement of soil C?
- What are precise impacts of increased C sequestration on emission of other GHG?

"Predicting the impact of GHG reductions, with the current level of knowledge, is a bit like shoveling fog."

D. Keith Reid, Ontario Ministry of Agriculture, Food and Rural Affairs, Ontario, Canada

Questions about Soil C Storage

- Can we increase duration that C resides in soils?
- Can opportunities for C sequestration be extended beyond currently farmed lands to degraded and desertified soils?
- Can we develop quick, reliable and inexpensive methods to monitor and verify soil C storage?
- What are political and economic problems assoc. with implementing soil C sequestration programs worldwide?

Key Findings from St. Michael's Workshop on C Sequestration

- Reductions in atmos. C content can be achieved by large-scale application of "tried and true" sound land management practices
  - reduced tillage
  - diversified rotations
  - efficient manure application to soils
- Planting forests and grasslands on former cropland and restoration of degraded lands are means to increase C sink potential of terrestrial systems