Soil C steady state, interannual variation, and permanence: implications for a carbon sequestration implementation plan

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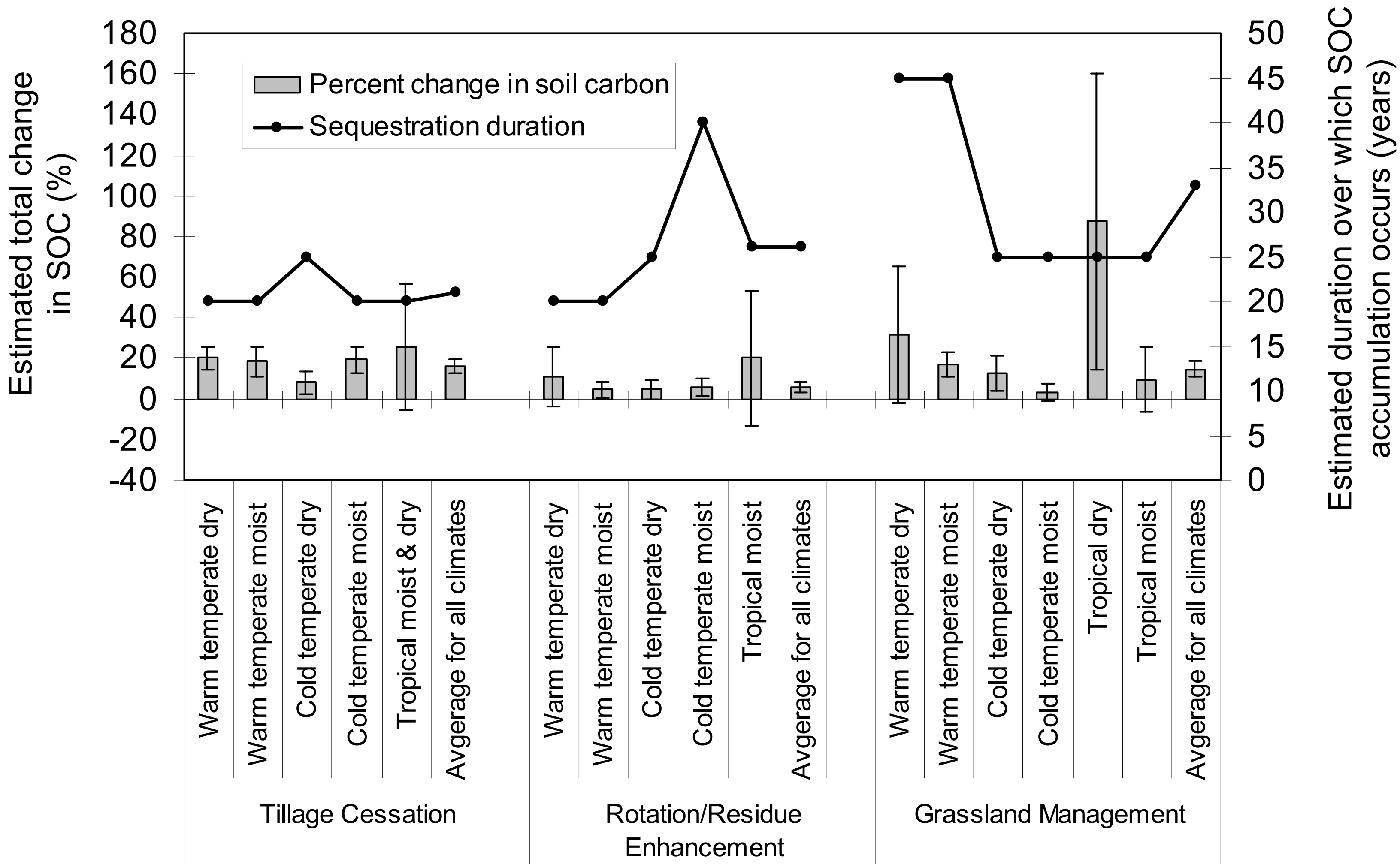
Presentation outline

I. Soil C dynamics: steady state, interannual variation, and permanence
   - Steady state vs. saturation
   - Interannual variation
   - Permanence (recent results from literature)

II. Consideration of soil C dynamics in a sequestration implementation plan (policy implications of soil C dynamics)
   - Impact of active sequestration duration on economic incentives
   - Impact of interannual variation on economic incentives
   - Handling of impermanence

Soil C steady state – biophysical implications

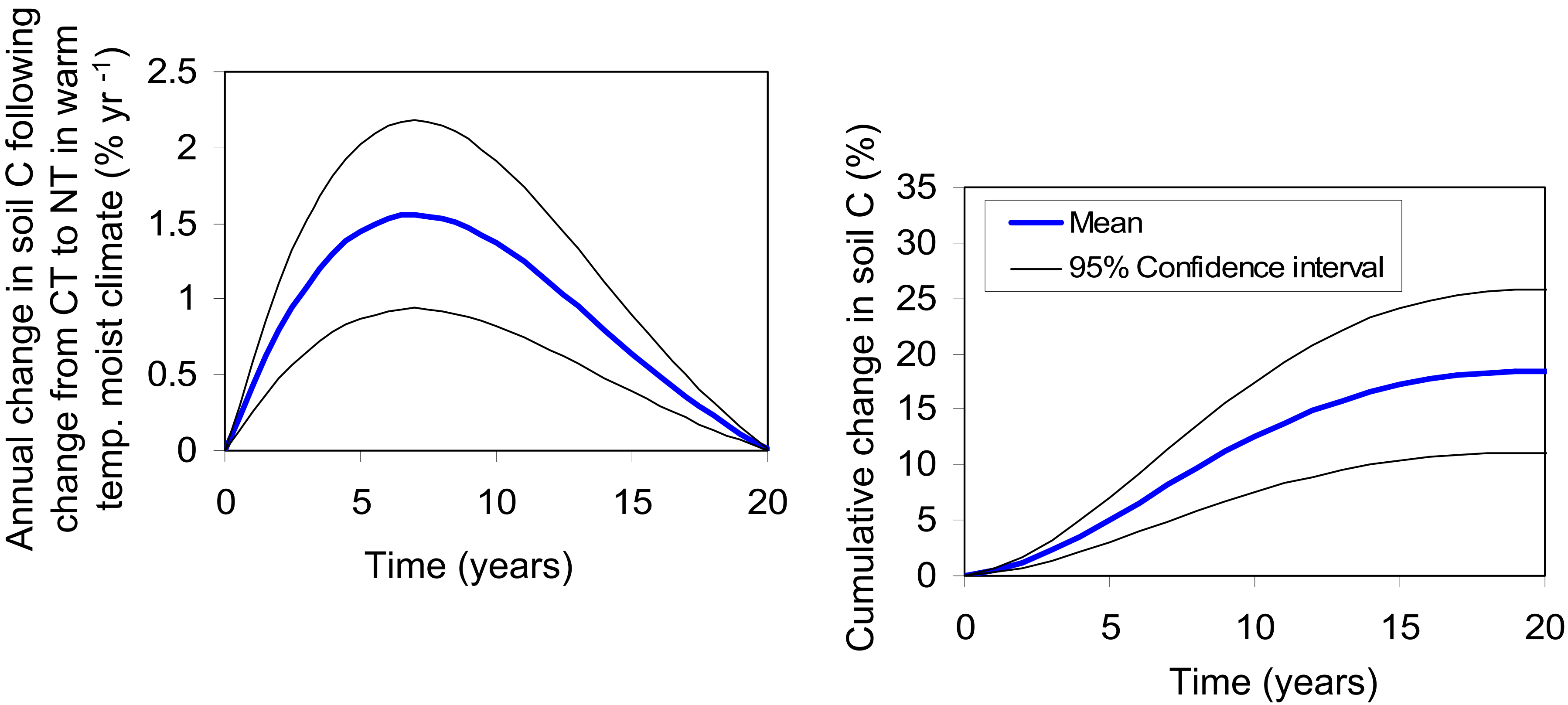
Estimating sequestration rates and sequestration duration



Data from West and Post (2002) & Conant et al. (2001)

Soil C steady state – biophysical implications

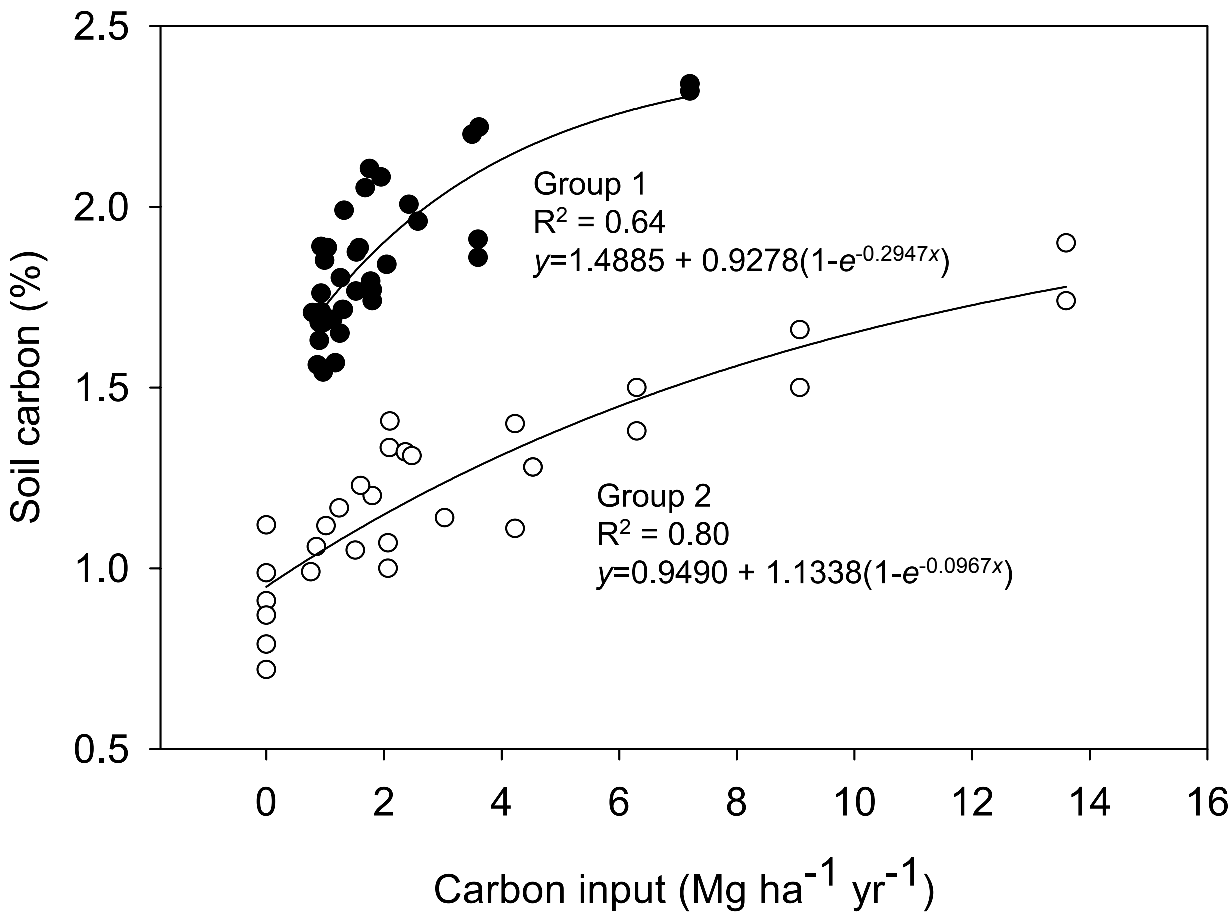
Estimating total sequestration and time to new steady state



West et al. 2004. Environmental Management 33:507-518.

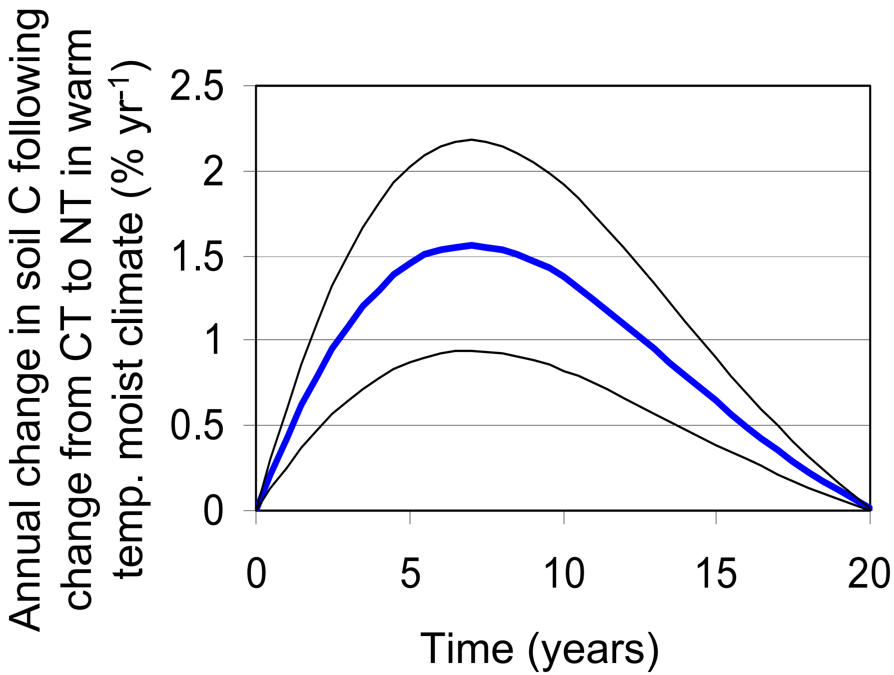
Soil C saturation – biophysical implications

Estimating sequestration as a function of C inputs



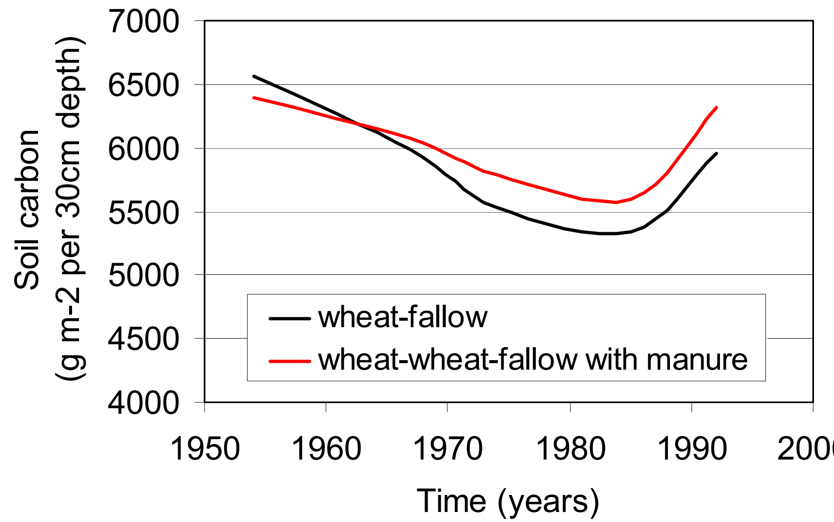
West, T.O. and J. Six (in preparation).

Interannual variation – biophysical implications



Generalized soil C dynamics based on land management is predictable.

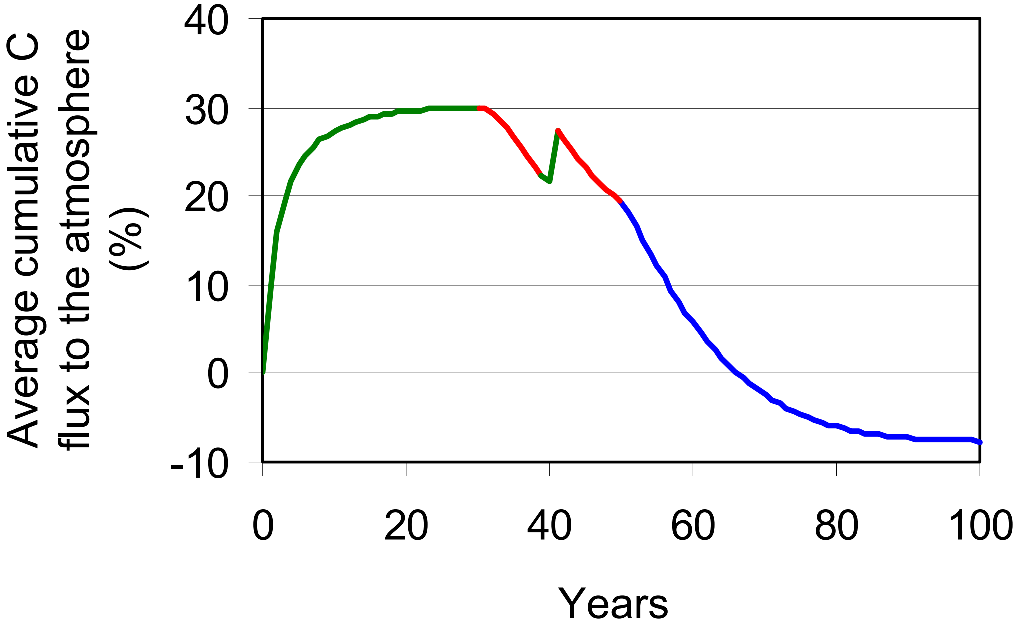
Changes in soil C dynamics caused by annual changes in weather (e.g., dry vs. wet growing season) are not predictable.



Data from Lethbridge, Alberta (Janzen, 1997)

Soil C permanence – biophysical implications

How much C is lost when intermittently reverting back to non-sequestration practices? How do we account for lost C?



Scenario: Deforest, cultivate with CT for 20 yr (green), change to NT for 10 yr (red), use CT for 1 year, change back to NT for 10 yr, reforest at year 50 (blue).

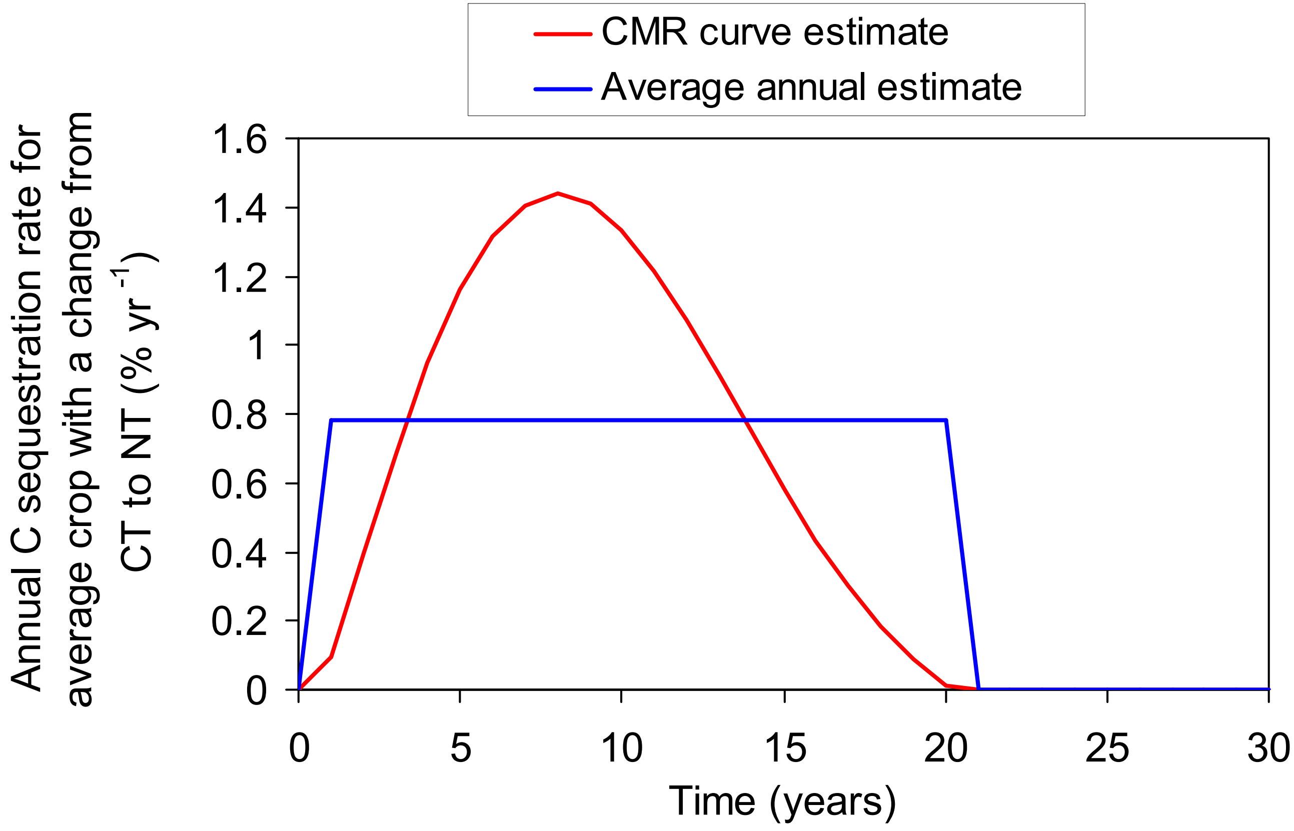
Soil C permanence – biophysical implications

Results from intermittent tillage experiments

	Location	Change in total soil C	Change relative to previously seq. C
VandenBygaart and Kay (2004)	**Ontario, Canada; 22yr NT; (after 18 mo)**		
Sandy loam (HC)		0	0
Sandy loam (LC)		-10%	about -66%
Sandy clay loam		0	0
Silty clay loam		0	0
Pierce et al. (1994)	**East Lancing, MI; 6 yr NT; (after 4-5 yr)**		
1986 plot		+3.7%	
1987 plot		-2%	-16%
Kettler et al. (2000)	**Sidney, NE, 20yr NT (after 5 yr)**	0	0
Stockfish et al. (1999)	**Saxony, Germany, 20 yr NT (after 2 yr)**	-10%	-142%

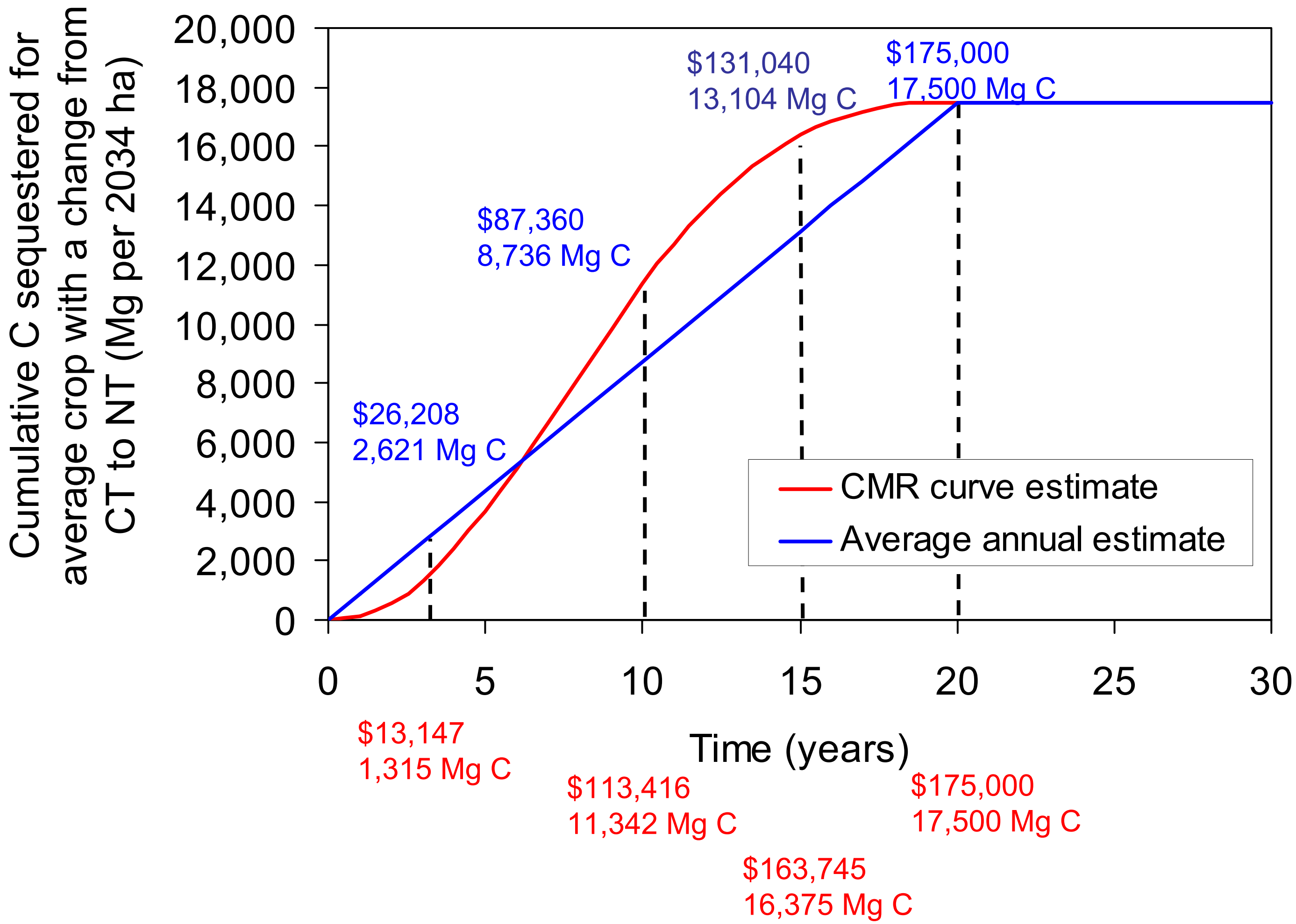
Interannual variation – policy implications

Estimated annual C sequestration rate using Carbon Management Response Curve versus average annual estimate



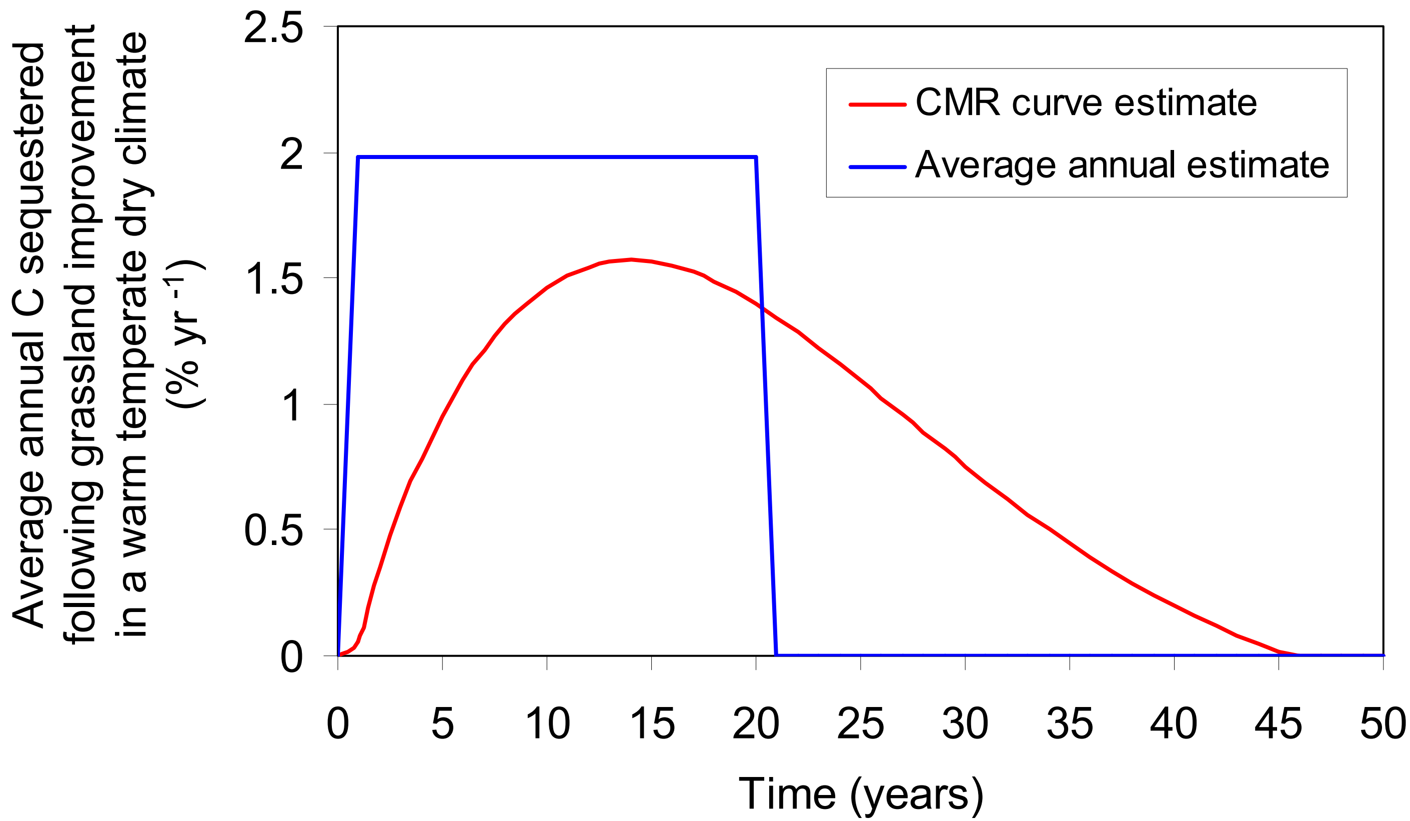
Interannual variation – policy implications

Estimated C sequestered over time differs depending on whether interannual differences in sequestration rates are considered.



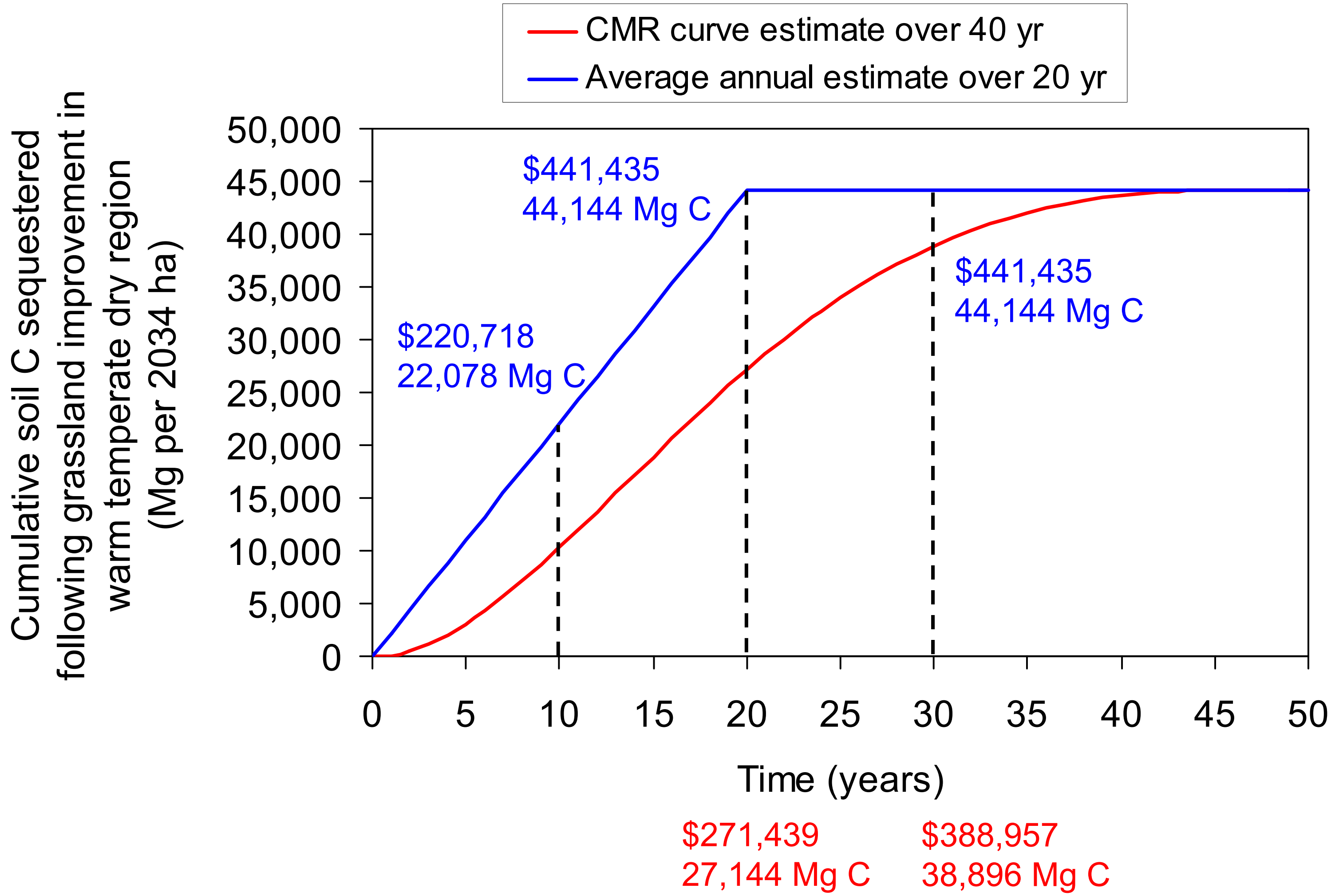
Soil C steady state – policy implications

CMR curve with 40 yr duration versus annual estimate averaged over 20 yr



Soil C steady state – policy implications

Estimated C sequestered differs depending on whether differences in time to steady state are considered versus default of 20 yr.



Soil C permanence – policy implications

- Include mechanisms in accounting framework that account for carbon impermanence.
  - 5 out of 8 experiments indicate no net loss of C following one annual plow event.
  - 28 ± 43% (n = 8) of originally sequestered C is lost following one annual plow event.
  - Not enough data to provide any estimate with reasonable accuracy.
  - However, it appears unlikely that all C is lost following one annual plow event.
  - Amount lost following plowing may primarily depend on soil texture and land-use history.

Conclusions

- Soil C does not likely accumulate at an average annual rate. Using an average annual rate may result in too much money paid for too little carbon in short-term contracts or vice versa in long-term contracts.

- Averaging over a shorter period than what actually occurs (e.g., 20 yr vs. 40 yr) may result in too much paid for too little carbon in contracts which last less than the total expected sequestration period (i.e., 40 yr for grassland improvement).

- The amount of C that can be sequestered largely depends on the potential soil C capacity (saturation) and land-use history (what has already been sequestered). This emphasizes the need for good baseline estimates of soil C.

- Plow tilling once every five years does not appear to substantially offset C gains. More field experiments will help to quantify impermanence.

Future projects – national full C/GHG accounting