Effect of forages in crop rotations on soil carbon levels at the UofA Breton Plots

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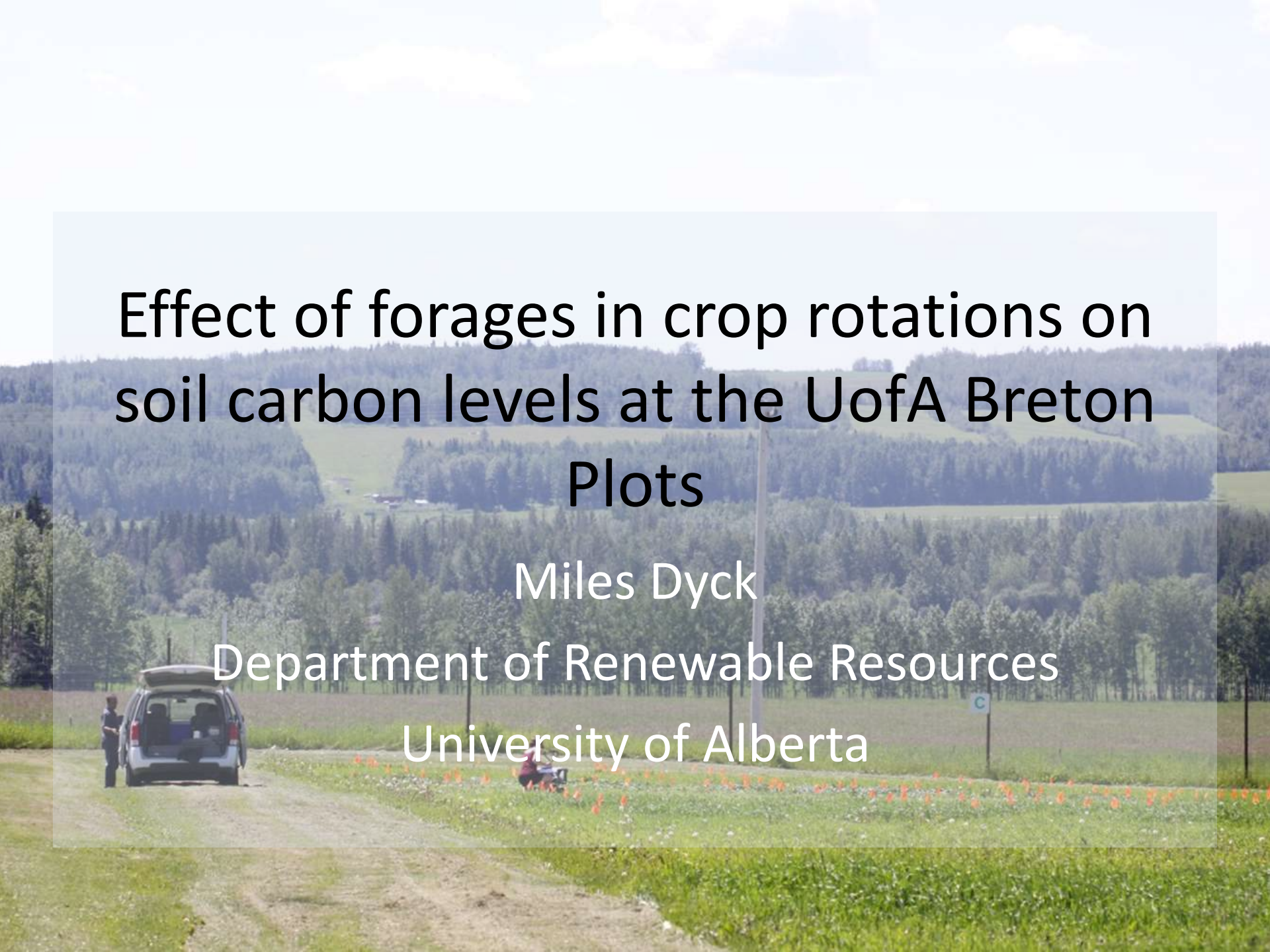


Ackowledgements

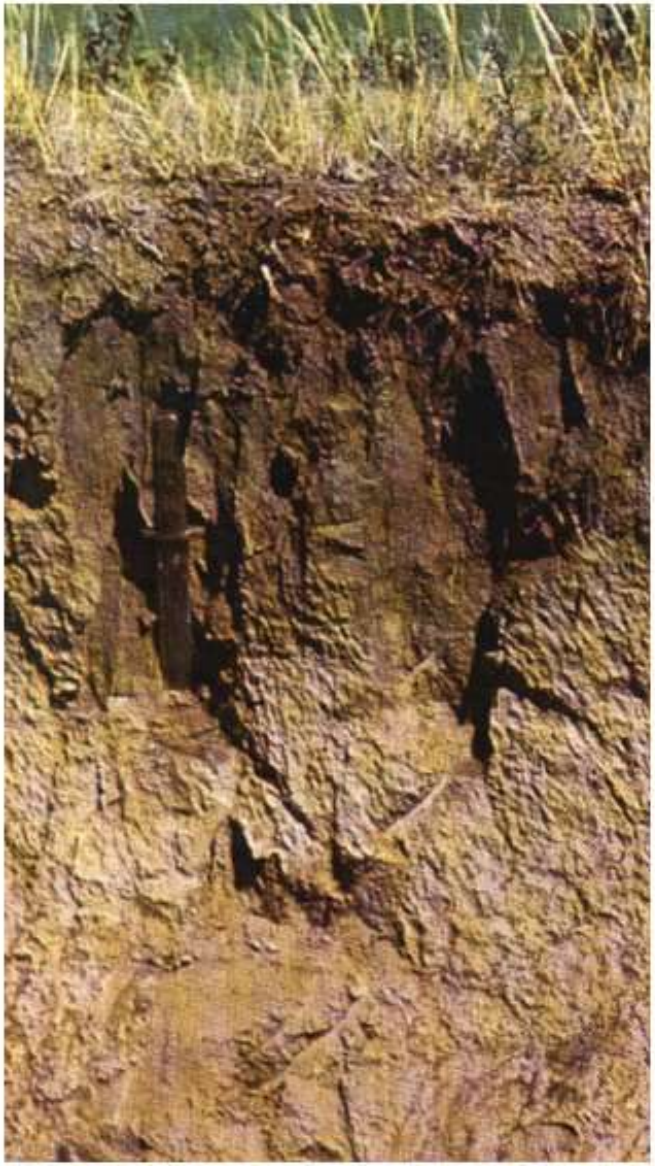
- Dick Puurveen, Manager, Breton Plots
- UofA Breton Plots Endowment and Donors. Canadian Fertilizer Institute.
- Jim Robertson, Bill McGill
- Previous Breton Plots Researchers

Welcome to The Breton Plots:
An Alberta Registered Historic Resource

A Research Site for Several
Medium- & Long-Term Field Experiments

Gray Luvisol

D. Brown Chernozem



Breton Classical (est. 1929) and Hendrigan/Agro-eco (est. 1979) Plots 2011

Classicals

	F	E	D	C	B	A	
	Bly/hay	Wheat(E)-Fallow	Hay-1	Hay-2	Wheat	Oats	
1	Check	Check	Check	Check	Check	Check	1
2	(Manure)	(Manure)	(Manure)	(Manure)	(Manure)	(Manure)	2
3	50-22-46-20	90-22-46-20	0-22-46-20	0-22-46-20	50-22-46-20	75-22-46-20	3
4	50-0-46-20	90-0-46-20	0-0-46-20	0-0-46-20	50-0-46-20	75-0-46-20	4
5	Check	Check	Check	Check	Check	Check	5
6	Lime	Lime	Lime	Lime	Lime	Lime	6
7	50-22-46-0	90-22-46-0	0-22-46-0	0-22-46-0	50-22-46-0	75-22-46-0	7
8	0-22-46-20	0-22-46-20	0-22-46-20	0-22-46-20	0-22-46-20	0-22-46-20	8
9	50-22-46-20	90-22-46-20	0-22-46-20	0-22-46-20	50-22-46-20	75-22-46-20	9
10	50-22-0-20	90-22-0-20	0-22-0-20	0-22-0-20	50-22-0-20	75-22-0-20	10
11	Check	Check	Check	Check	Check	Check	11

Agro-eco

2 Barley m-22-46-20	5 Bly/hay m-22-46-20	CG Barley 90-22-46-20	13
CF Fescue 17-9-0-16	CF Fescue 17-9-0-16	8 Hay 0-22-46-20	14
7 Hay 0-22-46-20	CG Barley 90-22-46-20	CF Fescue 17-9-0-16	15
6 Hay 0-22-46-20	1 Barley m-22-46-20	3 Fabas 0-22-46-20	16
CG Barley 90-22-46-20	CF Fescue 17-9-0-16	4 Barley m-22-46-20	17

Half plot= 0.01347 ha= 0.0333ac

Whole plot= 0.02694ha= 0.0666ac

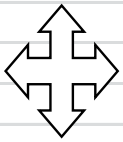
Plots each 28 ft. X 103.7 ft.

Roadways between Series 28.3 ft.

Plot borders 2 ft.

These latter figures from 1964 revision of plots.

Rates expressed as elemental N-P-K-S (kg/ha)



East half Classicals = Limed; Classical Rotation Sequence: Wheat- Oats -Barley/Hay-Hay-Hay

Hendrigan Rotation Sequence: Barley-Barley-Fababeans-Barley-Barley/Hay-Hay-Hay-Hay

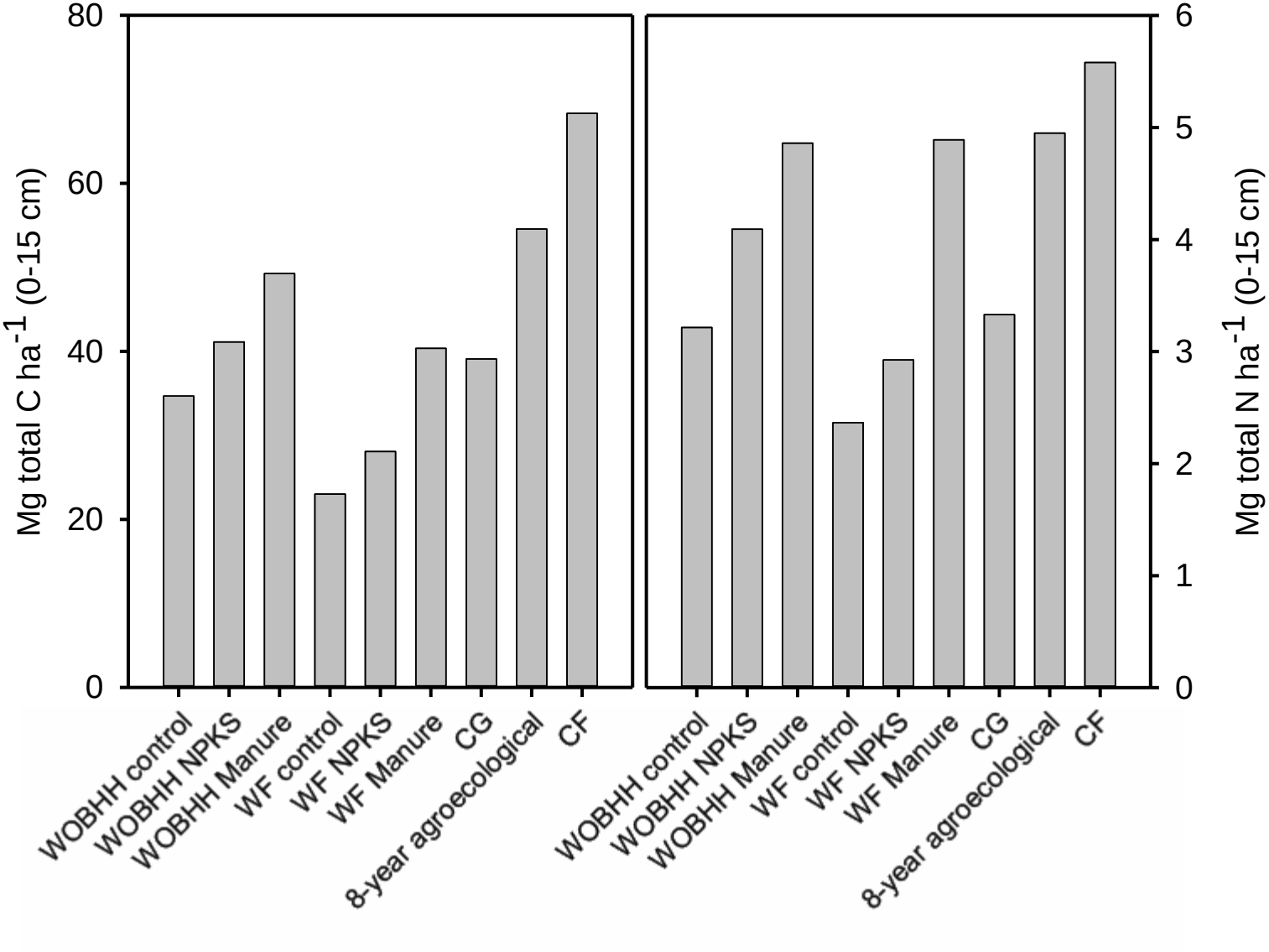
CG=Continuous Grain; CF=Continuous Fescue; m=manure

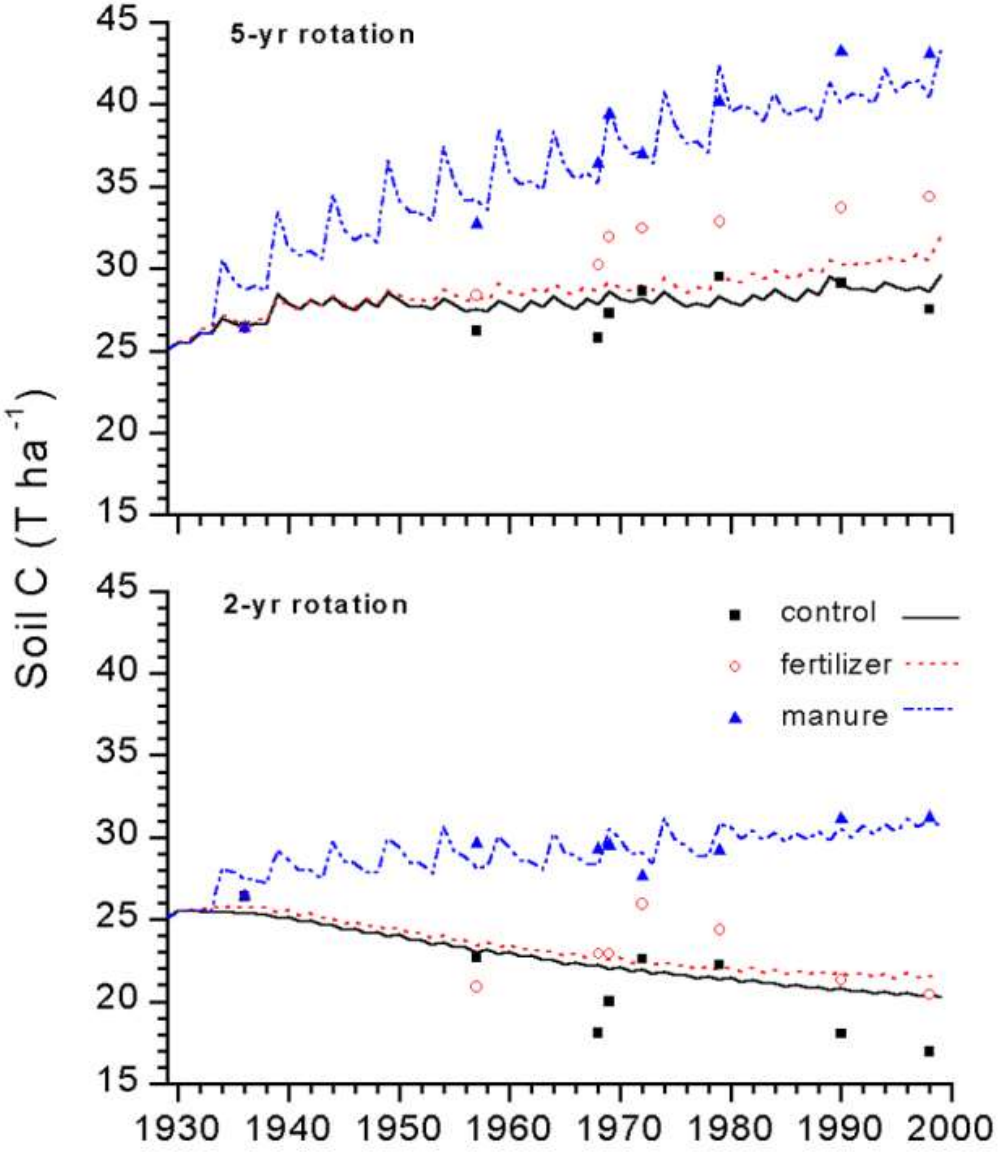
Perennials in rotations

- Classial Plots: ***Alfalfa-Brome***
  - year 4 and 5 of 5-year Wheat-Oats-Barley-Hay-Hay (WOBHH) rotation
  - year 3 Barley under-seeded to Alfalfa-Brome
  - ploughed under after year 5 harvest

- Hendrigan Plots
  - Hendrigan rotation: continuous ***creeping red fescue, tall fescue and white "Dutch" clover***.
  - 8-year cereal-cereal-fababean-cereal-cereal-hay-hay-hay
    - ***alfalfa-brome hay***

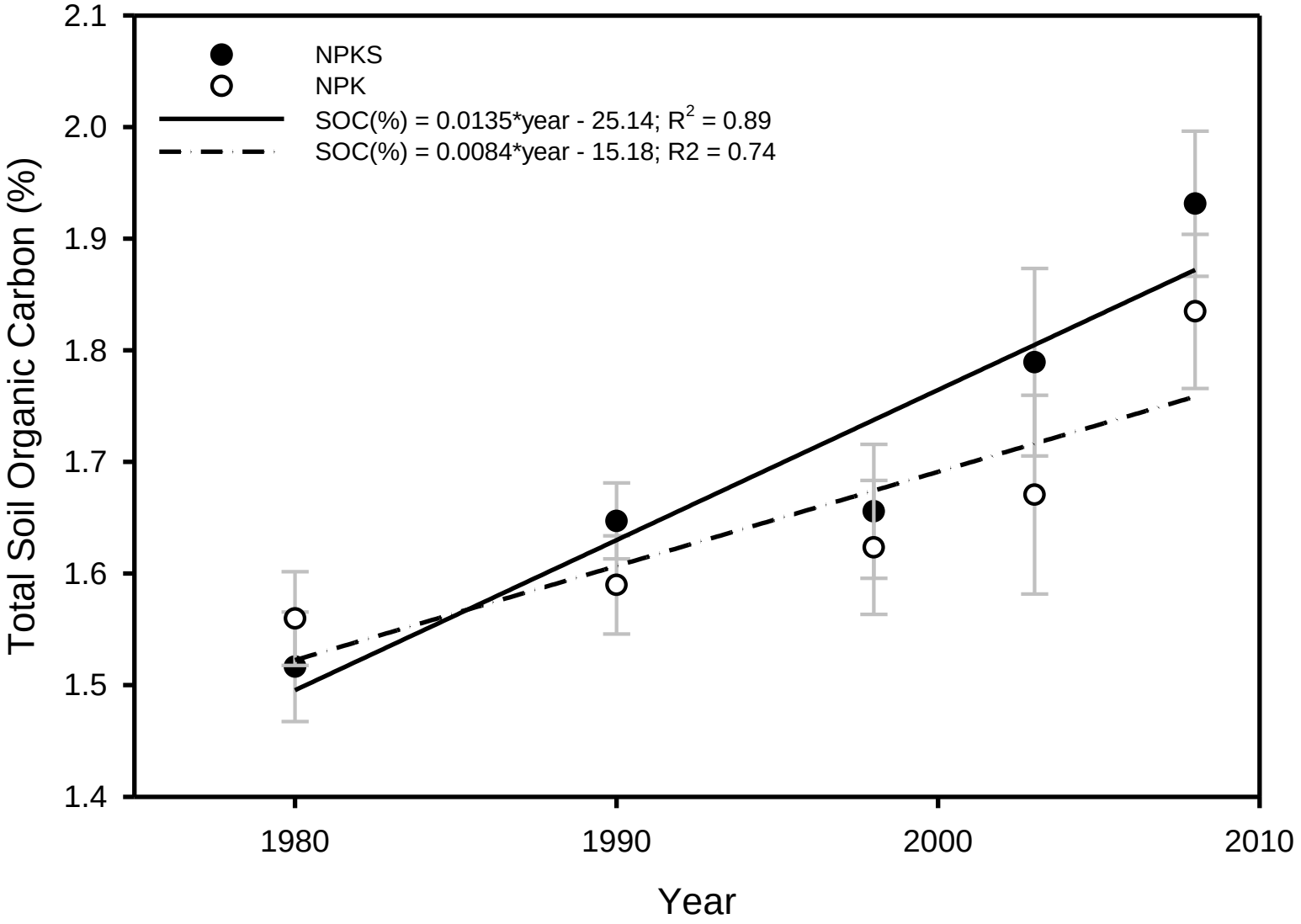
2008 Total C and N





Grant et al. 2001. Long-Term Changes in Soil Carbon under Different Fertilizer, Manure, and Rotation. Soil Sci. Soc. Am. J. 65:205-214.

C sequestration in WOBHH

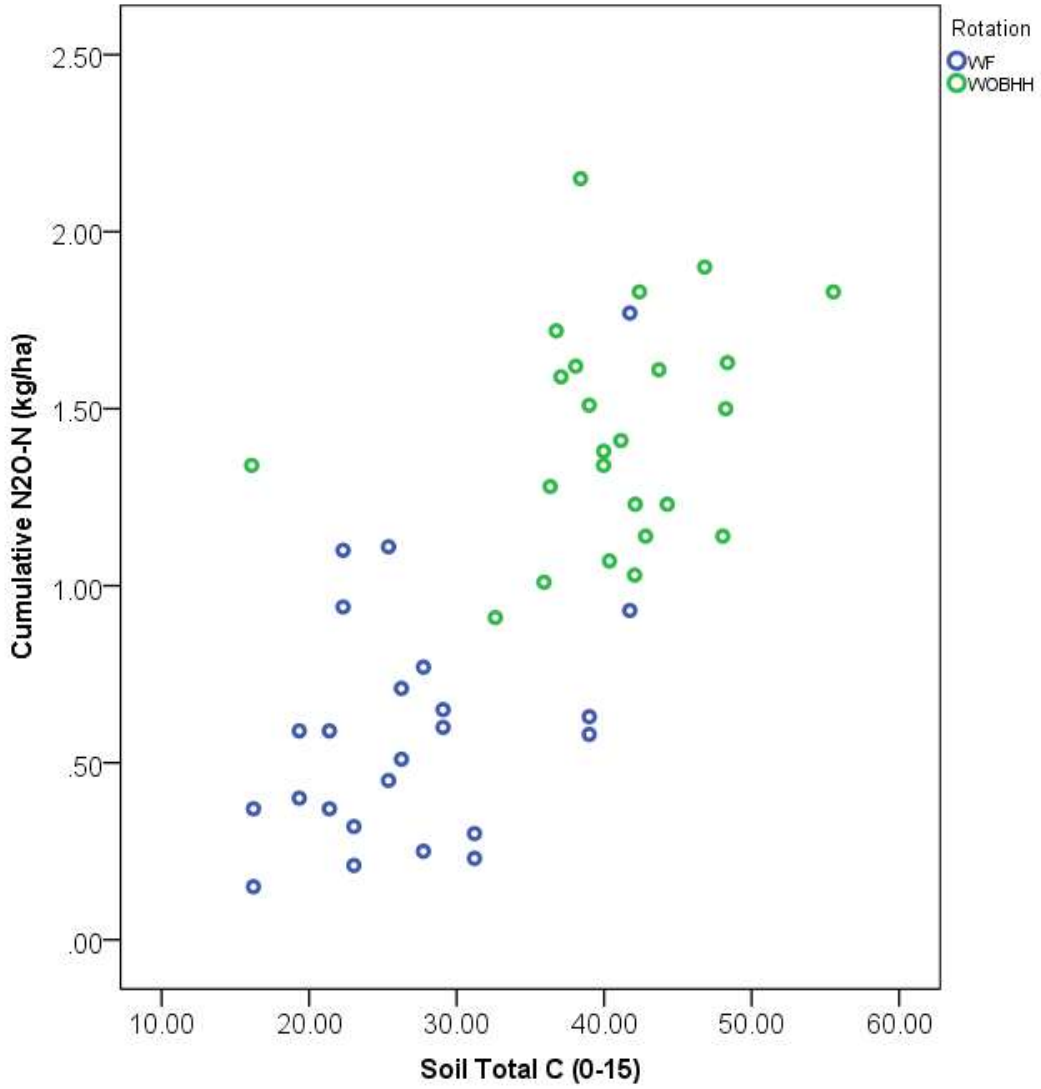


Giweta, M., M. F. Dyck, S. S. Malhi and D. Puurveen. Long-term S-fertilization increases carbon sequestration in a sulfur-deficient soil. Can. J. Soil Sci.. 94:1-7. 2014

- NPKS → 0.0135 % yr^{-1} ~ 0.28 Mg C ha^{-1} yr^{-1}
- NPK → 0.0084 % yr^{-1} ~ 0.18 Mg C ha^{-1} yr^{-1}

- don’t have reliable estimates for CF, CW, and Agroecological rotation, but we have archived samples from 1980, 2003, 2008, 2013

2013, 2014 Growing Season cumulative N_2O emissions



r = 0.7; P<0.01

discussion

- source of N_2O fluxes include fertilizers, biologically fixed N, previous crop residues
- Farrell et al. (2014)* → more N_2O from crop residues than from fertilizer (lab incubation)
- including perennials in rotations (2 – 5 years) increases soil carbon, but requires intermittent disturbance – stimulates nitrification and N_2O emissions

*Farrell, R. E., J. Carvehill, R. Lemke and J. D. Knight. 2014. Partitioning residue-induced emissions of N2O using ^{15}N labelled crop residues. AGU 2014 Annual meeting.

discussion cont'd

- may not be the same relationship between total soil carbon and N_2O emissions in "permanent" perennial cover and/or other soil types. If there is a land use change in the future, there is potential for increase N_2O emissions at that time which needs to be included in the C balance

- more efficient nutrient cycling at Breton (Gray Luvisol) compared to Ellerslie (Black Chernozem)
  - twice as much C and N mineralization per total soil C and N in Breton soil compared to Ellerslie in a 10-day incubation (Rutherford and Juma, 1989ab*)
  - "Breton microbes are lean and mean; Ellerslie microbes are fat and lazy" (Tom Goddard)

*Rutherford and Juma. Biol. Fertil Soils 8: 134-153

WOBHH soil C balance

- 0.28 Mg C ha^{-1} yr^{-1} = 1.0 Mg CO_2 ha^{-1} yr^{-1} (Maybe some methane?)
- 0.003 Mg N_2O ha^{-1} yr^{-1} or ***3 kg N_2O ha^{-1} yr^{-1}*** would offset this sequestration.
- cumulative growing season N_2O flux in NPKS from WOBHH is 2.5 kg N_20 ha^{-1} yr^{-1}
- more N_2O is released during freezing and thawing.

Conclusions

- continuous forage had greatest Soil C levels after 30 years
- soil still sequestering C after 80 years of agriculture in some treatments of the Breton Classical plots, but this may be offset by increased N_2O emissions.
- N_2O fluxes need to be considered in C balance of mixed annual-perennial and permanent perennial systems (cradle to grave)