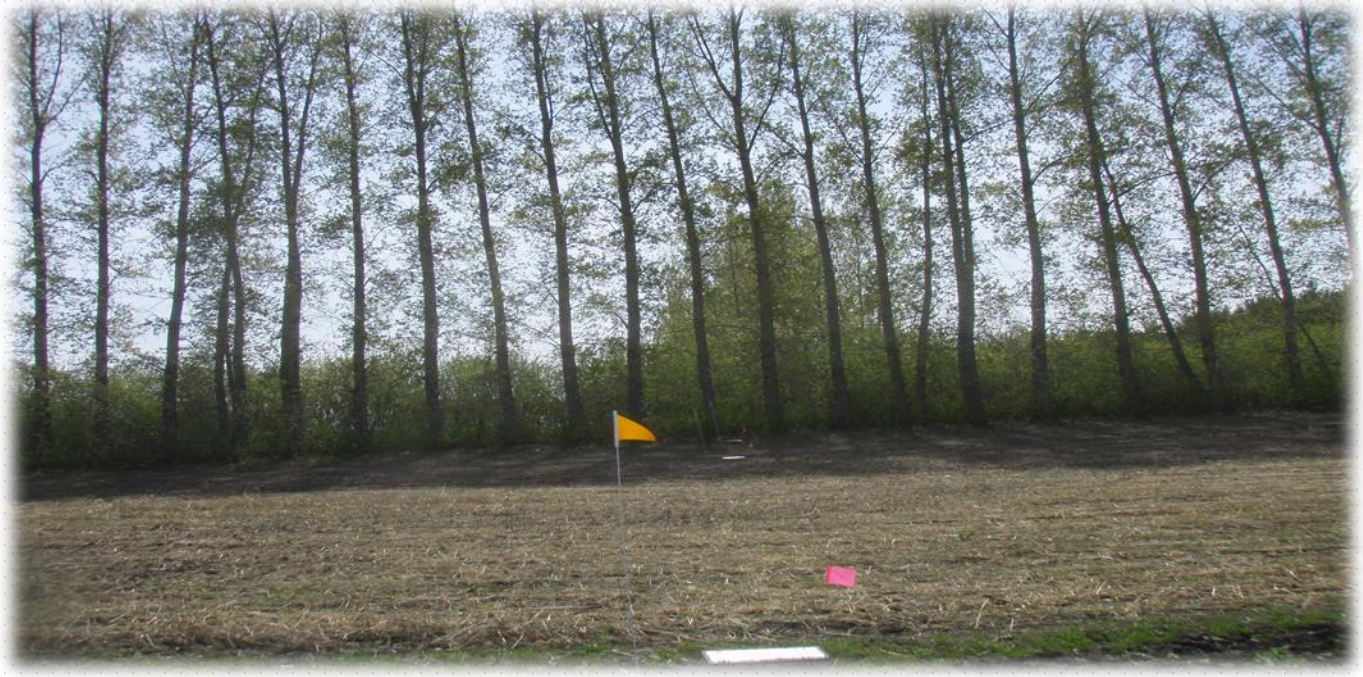
Farm-scale modelling of C sequestration and GHG mitigation by shelterbelts: Holos, 3PG and CBM-CFS3 simulations

Amadi, C.*, R. Farrell and K. Van Rees

Department of Soil Science, University of Saskatchewan, Saskatoon, SK. Canada.



UNIVERSITY OF SASKATCHEWAN

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

Centre for Northern Agroforestry and Afforestation

Environmental benefits of shelterbelts on agricultural farmlands

- ❑ Shelterbelts accumulate atmospheric C in plant biomass
- ❑ Increase soil carbon
- ❑ Reduce N_2O emissions due to deep roots
- ❑ Increase soil CH_4 oxidation

Knowledge gap – Changes on total farm GHG emissions due to the integration of shelterbelts is not well understood

Objective

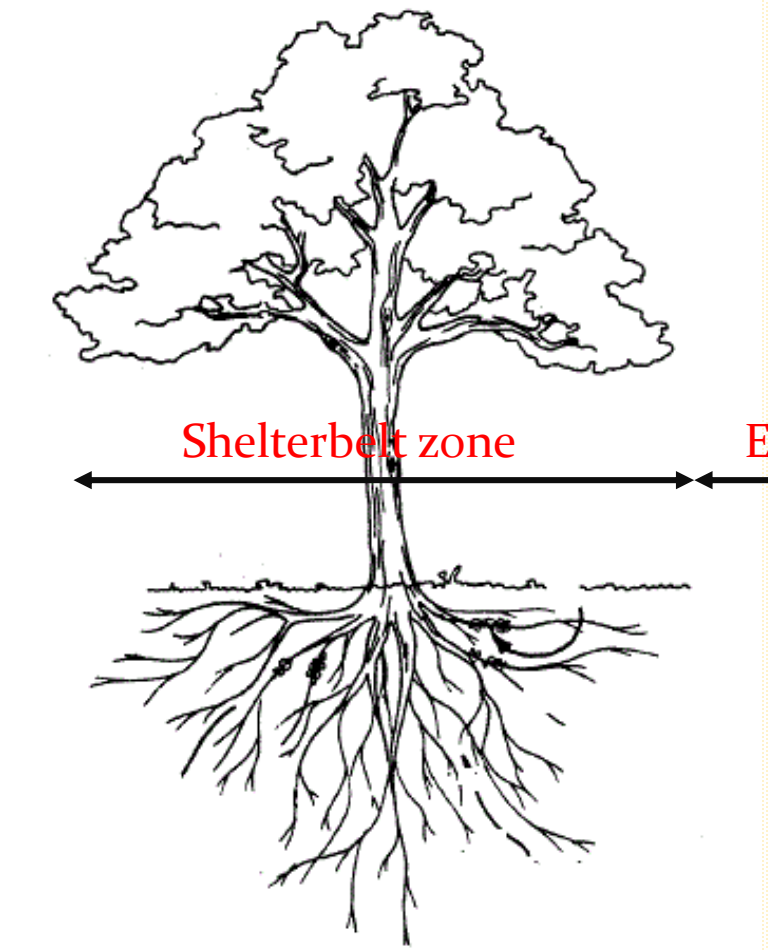
To assess the impact of five levels of white spruce (*Picea glauca*) shelterbelt establishment on the global warming potential of a model farm after 60 years of cultivation

- ✓ Farm carbon change
- ✓ Soil N_2O emissions
- ✓ Soil CH_4 fluxes

Model Farm Information

- ❑ Wheat field cultivated for 60 years
- ❑ Farm size – 688 ha (average farm size in Saskatchewan)
- ❑ Dark brown chernozem, Ecodistrict 772, Semiarid Prairies in Saskatchewan
- ❑ Fertilizer N input – 45 kg ha^{-1} yr^{-1}
- ❑ N_2O emission factors calculated using precipitation and evapotranspiration 30-year normal = 0.0047

Farm Elements – Shelterbelt area, Ecotone area and Unsheltered zone



Shelterbelt area = Shelterbelt length x crown width

Ecotone zone = 1.5 x tree height (H) – crown width

Source: http://permaculturenews.org/2008/09/29/nitrogen-fixing-trees-the-multipurpose-pioneers/

Basic Assumptions

- ❑ All trees are alive and healthy
- ❑ Annual soil C change in unsheltered zone is negligible (i.e. has reached equilibrium)
- ❑ Soil CH_4 from shelterbelt is a function of root biomass
- ❑ Soil N_2O in shelterbelts is a function of N input in foliar and below ground biomass

Scenarios – shelterbelt area per 688 ha farm ratio (%)

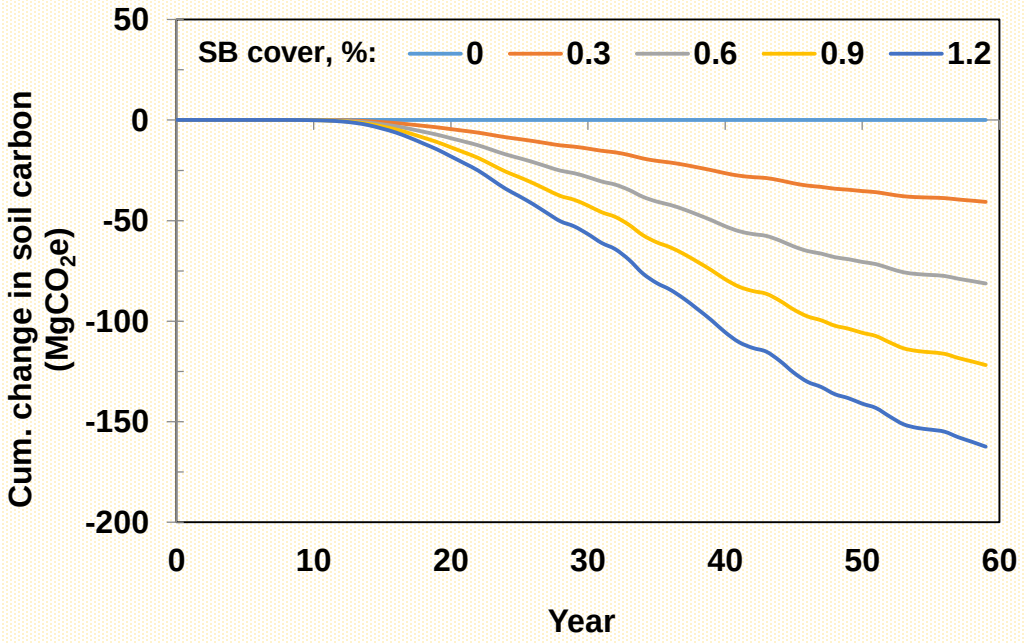
Total farm size (ha)	Shelterbelt area (ha)	Wooded area (%)
688	0	0
688	2.1	0.3
688	4.1	0.6
688	6.2	0.9
688	8.2	1.2

Farm GHG Models

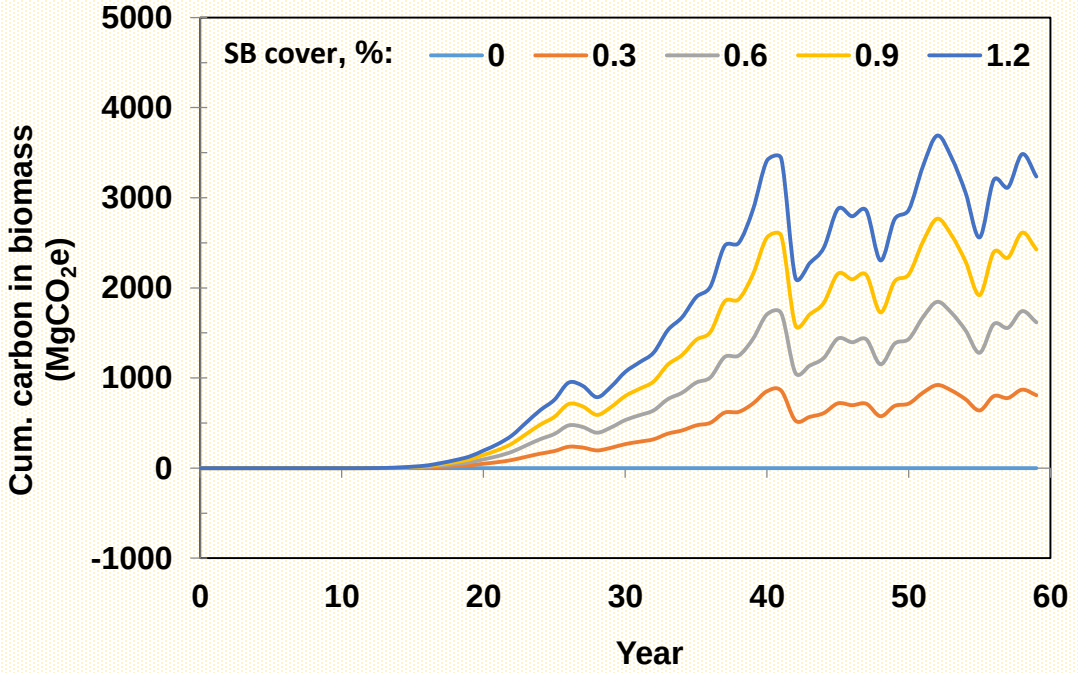
- White spruce Growth – 3PG Model
- Soil C simulations – CBM-CFS3 Model
- Soil N_2O and CH_4 emissions – Holos Model

Biomass and soil C fluxes (Mg CO_2 equivalents)

Soil C

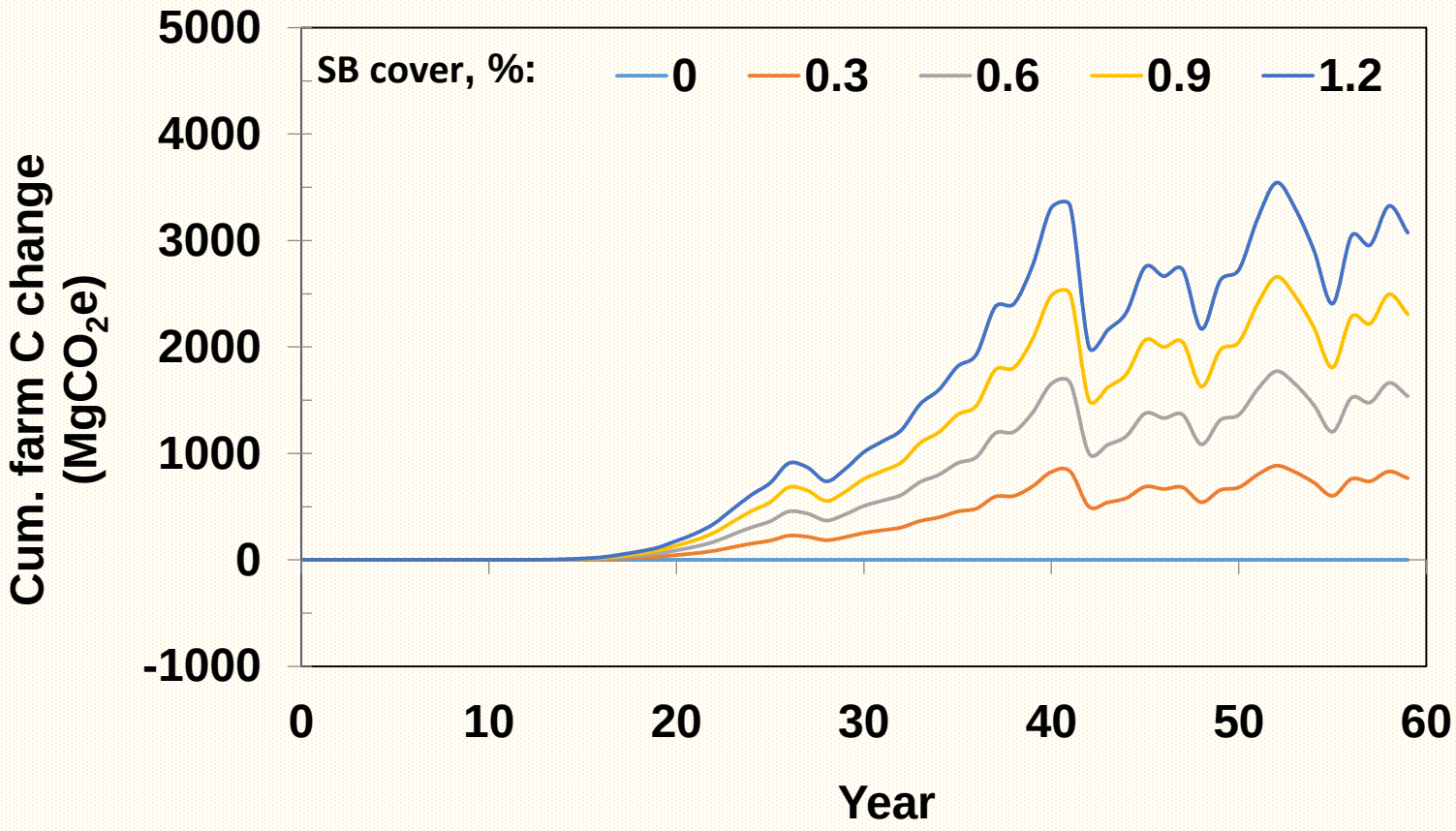


Biomass C

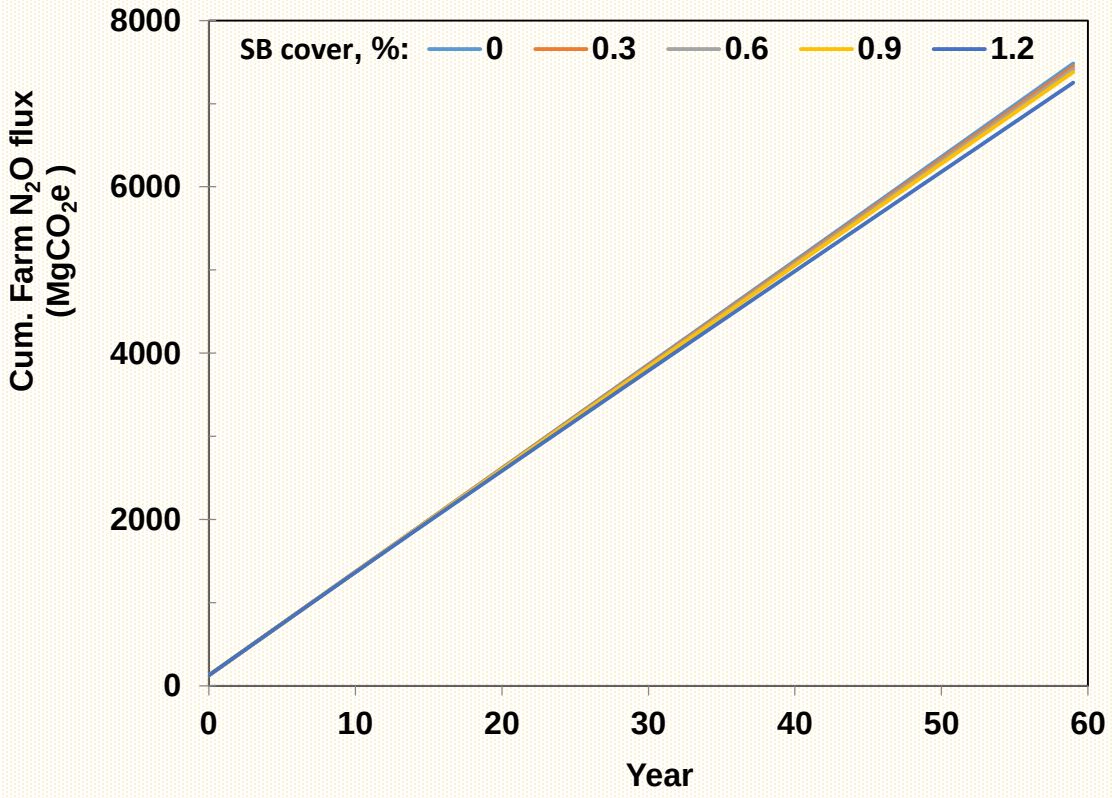


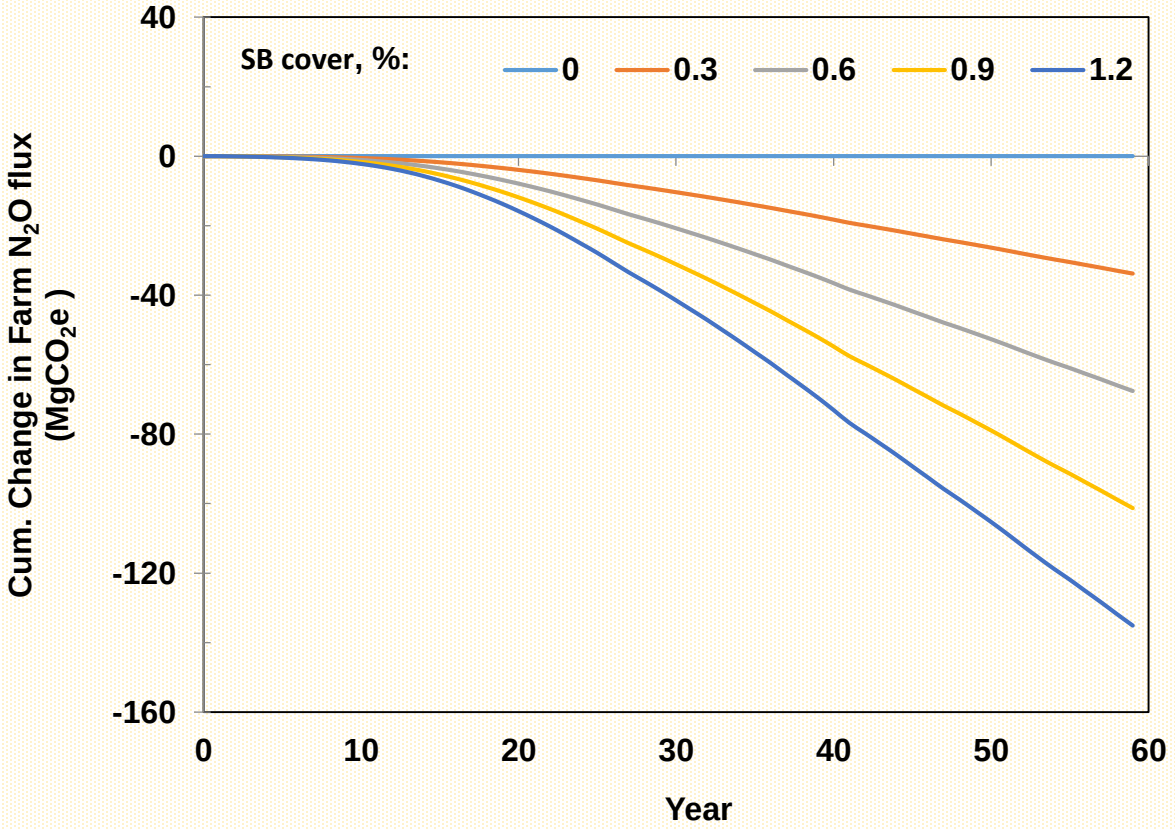
Total farm C fluxes (Mg CO_2 equivalents)

Total Farm C = Biomass C + Soil C

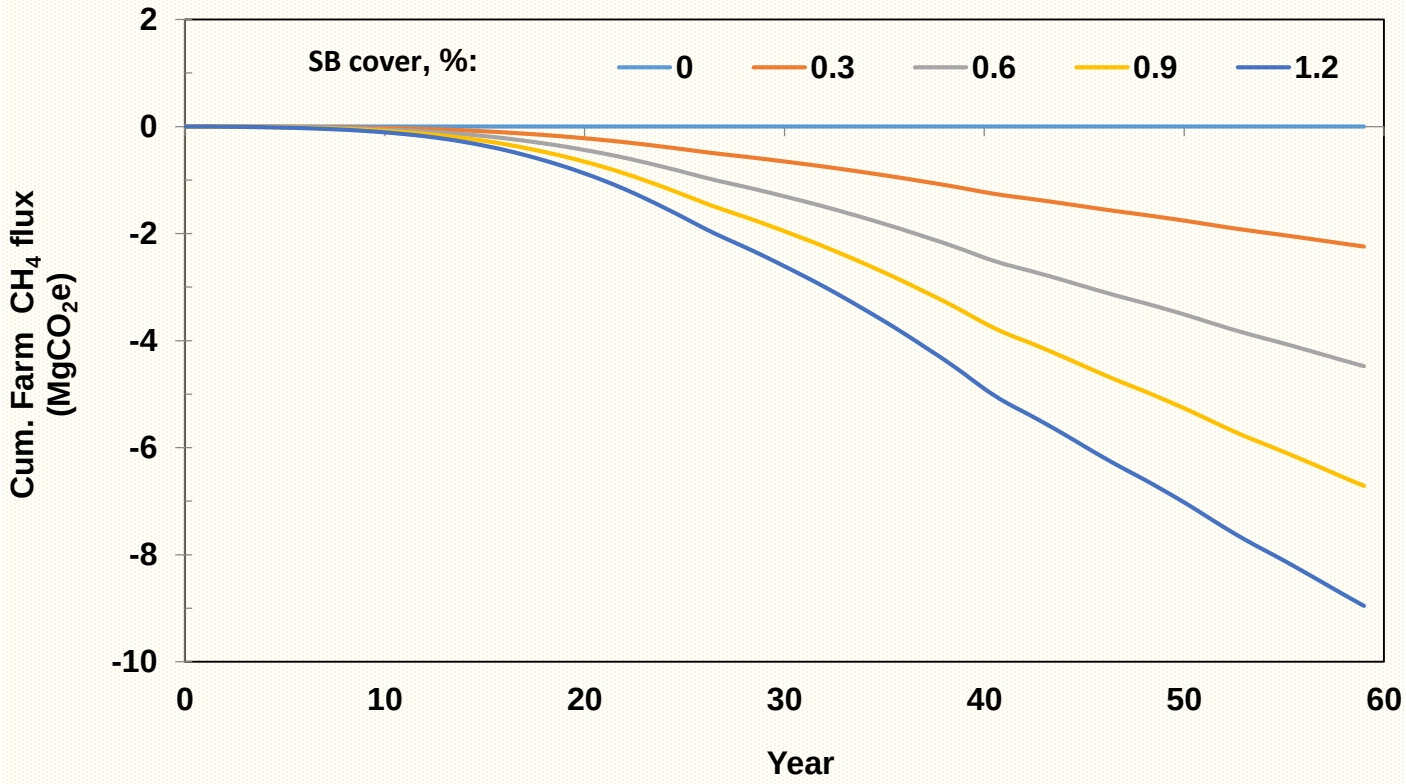


Total farm N_2O fluxes (Mg CO_2 equivalents)





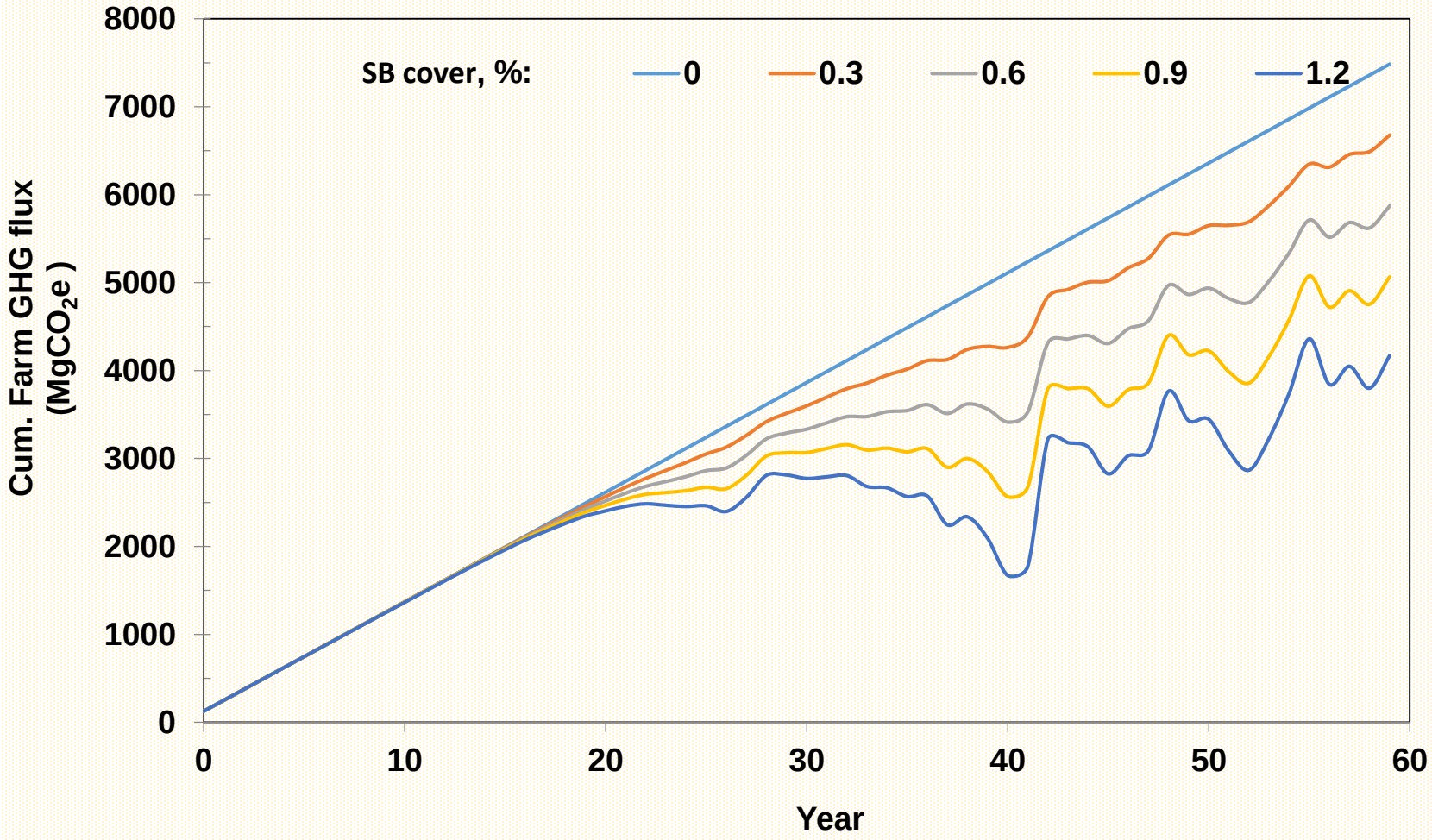
Total farm CH_4 fluxes (Mg CO_2 equivalents)



Overall Farm emissions

Total GHG emissions = Total farm C emissions + N_2O fluxes + CH_4 fluxes

Overall Farm emissions (Mg CO_2 equivalents)



Summary of Results

- Cumulative total farm emissions after 60 years of cultivation decreased with increasing levels of shelterbelt cover.
- An initial loss of soil C was compensated by biomass C associated with tree growth.
- Biomass and soil C accounted for 10 – 41% of decrease in cumulative total farm emissions
- Reduced soil N_2O as well as increased soil CH_4 sink in shelterbelts accounted for 0.5 – 3.2 % of decrease in farm emissions.

Acknowledgement

We appreciate support and technical assistance from D. Jackson, D. Richman, F. Krignen, M. Cooke, M. Jones, S. Poppy and C. Braaten.

Funding was provided by Agriculture and Agri-Food Canada – Agricultural Greenhouse Gas Program (AGGP).

Additional support was provided by the Saskatchewan Ministry of Agriculture – Strategic Research Program – Soils & Environment

University of Saskatchewan

Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada

Thank you