Silvopastures Promote Carbon Storage and Reduce Greenhouse Gas Emissions

Prepared by E.W. Bork, University of Alberta

Concerns over rising CO_2 levels and associated global temperatures have raised questions about the impact of land use management practices on carbon (C) stores and the flux of greenhouse gasses (GHGs) such as CO_2, as well as more potent gasses such as methane (CH_4) and nitrous oxide (N_2O). A recent study completed at the University of Alberta by Dr. Scott Chang and colleagues examined the effects of three different agroforestry systems on GHG emissions, and provided unique insights into the benefits of not only forests, but also perennial grassland, in helping counteract emissions of GHG.

An example of an agroforestry system, canola field with shelterbelt.
Photo by Ferrah Fatemi.

Forest understory grazing by cattle.
Photo by Ferrah Fatemi.

Agroforestry systems are land areas where trees and either cropland, pasture, or a combination thereof, are deliberately combined in the landscape to maintain greater production efficiency and environmental sustainability. Across western Canada, agroforestry takes many forms, and includes the retention of woody hedgerows at field margins, the planting of shelterbelts, and in moister areas, the grazing of silvopastures, wherein cattle are provided access to a mosaic of grassland and patches of naturally occurring forest. The study, which included a comparison of hedgerow-cropland, shelterbelt-cropland, and natural parkland silvopastures at 36 sites across a climatic gradient in central Alberta, revealed that those agroforestry systems containing annual cropland were more likely to have lower surface soil C stocks, increased GHG emissions, and therefore a net increase in the global warming potential. Increased warming potential in turn, has implications for the rate of climate

change and the ability of agroecosystems to support sustainable socioeconomic activities. As expected, forested components of these systems stored large amounts of C. An unexpected finding, however, was that the silvopasture system, comprised of a mix of aspen forest and perennial grassland, resulted in up to 24% greater shallow soil C. When combined with a 15% higher CH_4 uptake and 44% lower N_2O emissions, the silvopasture had the greatest ability to counteract global warming. Enhanced C storage and reduced GHG emissions in silvopastures were attributed to the presence of perennial vegetation throughout this agroforestry system, with large C inputs and retention likely to maximize C accumulation.

Collection of air samples for greenhouse gas emissions studies using a static chamber. Photo by Ferrah Fatemi.

These findings are particularly important as they reveal that agricultural management strategies seeking to maximize C storage should strive to both maintain and enhance forests where possible, but also retain perennial pastures and minimize their conversion to cropland. This in turn, further highlights the compatibility of silvopastures and associated livestock production with maintaining this important ecosystem service. For more information on this project, please contact Dr. Scott Chang (scott.chang@ualberta.ca).

This work is published:

Kwak, J.H., Lim, S-S., Baah-Acheamfour, M., Choi, W.J., Fatemi, F., Carlyle, C.N., Bork, E.W., Chang, S.X. 2019. Introducing trees to agricultural lands increases greenhouse gas emission during spring thaw in Canadian agroforestry systems. Science of the Total Environment 652: 800-809.

Lim, S-S., Baah-Acheamfour, M., Choi, W.J., Arshad, M.A., Fatemi, F., Barerjee, S., Carlyle, C.N., Bork, E.W., Park, H.J., Chang, S.X. 2018. Soil organic carbon stocks in three Canadian agroforestry systems: From surface organic to deeper mineral soils. Forest Ecology and Management 417: 103-109.

Baah-Acheamfour, M., Chang, S.X., Bork, E.W., Carlyle, C.N. 2017. The potential of agroforestry to reduce atmospheric greenhouse gases in Canada: Insight from pairwise comparisons with traditional agriculture, data gaps and future research. Forestry Chronicle 93(2): 180-189.

Banerjee, S., Baah-Acheamfour, M., Carlyle, C.N., Bisset, A., Richardson, A.E., Siddique, T. Bork, E.W., Chang, S.X. 2016. Determinants of bacterial communities in Canadian agroforestry systems. Environmental Microbiology 18(6): 1805-1816.

Baah-Acheamfour, M., Carlyle, C.N., Lim, S-S., Bork, E.W., Chang, S.X. 2016. Forest and grassland cover types reduce net greenhouse gas emissions from agricultural soils. Science of the Total Environment 571: 1115-1127.

Baah-Acheamfour, M., Chang, S.X., Carlyle, C.N., Bork, E.W. 2015. Carbon pool size and stability are affected by trees and grassland cover types within agroforestry systems of western Canada. Agriculture Ecosystems & Environment 213: 105-113.

Baah-Acheamfour, M., Carlyle, C.N., Bork, E.W., Chang, S.X. 2014.Trees increase soil carbon and its stability in three agroforestry systems in central Alberta, Canada. Forest Ecology & Management 328: 131-139.