Carbon dynamics and mitigation of methane and nitrous oxide emissions in agroecosystems with *Pinus ponderosa* (Dougl . Ex Laws) and native pastures established on degraded volcanic soils in the Chilean Patagonia

Francis Dube[1] , *Neal Stolpe*[2] , *Erick Zagal Venegas*[2] *and Miguel Espinosa Bancalari*[1]
[1] *Facultad de Ciencias Forestales , Universidad de Concepción , Victoria 631 , Casilla 160-C , Chile*
[2] *Departamento de Suelos , Facultad de Agronomía , Universidad de Concepción , Vicente Méndez 595 , Casilla 537 , Chillan , Chile . Corresponding author : fdube@udec.cl*

Key words : carbon sequestration , silvopastoral systems , volcanic soils , CO_2 FIX

Introduction During the 1990s , terrestrial ecosystems captured approximately 36% of the total carbon liberated to the atmosphere by combustion of fossil fuels . Consequently , there is a growing interest to study the potential of carbon sequestration in presently non-sustainable agro-ecosystems worldwide , including remote regions such as Patagonia , where large areas of degraded pastures and eroded soils are also encountered , and ranchers face increasing pressures to maintain the cattle-raising productivity of their land . They are encouraged to adopt silvopastoral systems as more sustainable practices that satisfy their socioeconomic necessities and contribute to mitigate atmospheric CO_2 . According to the 3rd IPCC report (2001) , the use of agroforestry systems in degraded lands constitute effective C sinks , especially with the use of perennial pasture and fast growing trees . The objective of this study is to investigate and model the potential to sequester C in an exotic short rotation forest plantation and degraded grasslands of the Chilean Patagonia .

Materials and methods The site was located at 730 m altitude at S 45°25′ W 72°00′ near Coyhaique , Chile . The soil had low bulk density (< 0.9 g cm^{-3}) and high P fixation values (65-89%) . It is classified as medial , amorphic , mesic Typic Hapludands . Treatments were imposed in a randomized complete design with three replicates . Soil samples were analyzed to determine soil organic carbon (SOC) , microbial C and N , and soil respiration (C-CO_2 evolution) . Measured parameters included tree and pasture biomass . Measured SOC values were compared with those predicted by CO_2 FIX , previously calibrated to the site conditions . Mean monthly temperature and rainfall during tree growth period , current annual increment of trees , and proportions of C in stems , leaves , branches and roots were used to calibrate the model .

Results Preliminary results show that the contents of SOC are greater than those predicted by the model (Figure 1) , which indicate the need to adjust the soil parameters so that simulations better reflect reality . The unexpected result may be due to the presence of volcanic soils which have distinctive properties including allophanic clays , and higher C contents in surface soil compared to non-volcanic soils . Additionally , soil respiration was highest in the pine plantation (Figure 2) and microbial biomass was highest in the prairie (Figure 3) . Between agroecosystems , soil respiration was not correlated to SOC nor microbial biomass , perhaps due to the larger amount of roots and the presence of mycorrhizae in the plantation . Estimates of CH_4 and N_2O emissions were highest in the prairie . However , pine-based silvopastoral systems would permit addressing cattle-raising and timber production needs and allow for the sequestration of larger amounts of C in above and belowground components of plants and soil of the agroecosystem .

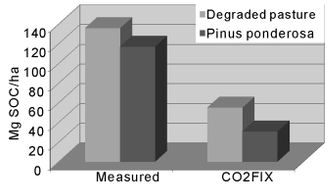

Figure 1 *SOC measured and simulated at 0 to 40 cm depth , Chilean Patagonia .*

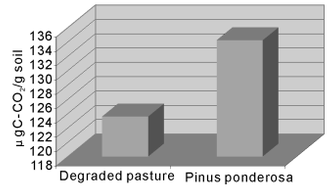

Figure 2 *Mean soil respiration at 0-40 cm depth , Chilean Patagonia .*

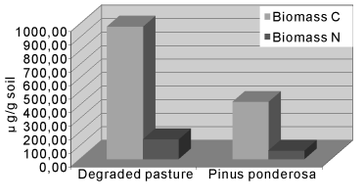

Figure 3 *Mean C and N microbial biomass at 0 to 40 cm depth .*

Conclusions Once the model is recalibrated to soil conditions , it will be used with an adjacent six-year-old pine-based silvopastoral system arranged in strips to estimate total carbon balance , and the results will be used to construct C cycling models . Given the more efficient utilization of site resources and the presence of favorable microclimate , the silvopastoral system will permit a higher annual total biomass production and C capture in comparison with the prairie and the plantation ; also , the presence of highly active aerial and subterranean C cycles will result in a large increase in C capture . The silvopastoral system will have the better potential to mitigate global warming through increased sequestration of greenhouse gases , while also being a more sustainable form of land use in the long term .

Reference

IPCC . 2001 . Climate change 2001 : the scientific basis . Cambridge Univ . Press , Cambridge , UK , 881p .