AGROFORESTRY AND GRASS BUFFERS FOR IMPROVING SOIL HYDRAULIC PROPERTIES AND REDUCING RUNOFF AND SEDIMENT LOSSES FROM GRAZED PASTURES

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ABSTRACT

Agroforestry buffers, a system of land use in which harvestable trees or shrubs are grown among or around crops or on pastureland, have been proposed for improving water quality in watersheds. The objectives of this study were (i) to evaluate saturated hydraulic conductivity (K_{sat}) and water retention for soils managed under rotationally-grazed pasture (RG), continuously grazed pasture (CG), grass buffers (GB), and agroforestry buffers (AgB); (ii) to compare differences in computed tomography (CT)-measured macropore (>1000-µm diam.) and coarse mesopore (200- to 1000-µm diam.) parameters for AgB, GB, RG and CG treatments, and to examine relationships between CT-measured pore parameters and K_{sat} ; (iii) to compare the influence of AgB and GB systems under rotationally stocked (RG) and continuously stocked (CG) pasture systems on water infiltration measured using ponded infiltration and tension infiltration methods; (iv) to evaluate differences in root length density (RLD) and root and soil carbon content within GB, AgB, RG and CG treatments; and (v) to model runoff and sediment losses for grazed pasture watersheds with and without AgB buffers. Pasture and GB areas included red clover (*Trifolium pretense* L.) and lespedeza (*Kummerowia stipulacea* Maxim.) planted into fescue (*Festuca arundinacea* Schreb.) while AgB included Eastern

cottonwood trees (*Populus deltoids* Bortr. ex Marsh.) planted into fescue. Soil bulk density was 12.6% higher for the pasture treatments compared to buffer treatments. Soil water content at high soil water potentials (0 and -0.4 kPa) was greater in the buffer treatments relative to pasture treatments for the 0-10 cm soil depth. Soil macroporosity (>1000 µm diam.) was 5.7, 4.5, and 3.9 times higher, respectively, for the AgB, GB, and RG treatments compared to the CG treatment for the 0-10 cm soil depth. Buffer treatments had greater macroporosity (>1000-µm diam.), coarse (60- to 1000-µm diam.) and fine mesoporosity (10 to 60 µm diam.) but lower microporosity (< 10 µm diam.) compared to pasture treatments. The K_{sat} for the buffer treatments was 16.7 times higher compared with pasture treatments. The CT-measured soil macroporosity was 13 times higher (0.053 m^3m^{-3}) for the buffer treatments compared to the pasture treatments (0.004 m^3m^{-3}) for the surface 0-10 cm soil depth. Buffer treatments had greater CT-measured macroporosity (0.019 m^3m^{-3}) compared to pasture (0.0045 m^3m^{-3}) treatments. The CT-measured pore parameters (except macropore circularity) were positively correlated with K_{sat}. Quasi-steady state infiltration rates (q_s) and field-saturated hydraulic conductivity (K_{fs}) for buffers were about 30 and 40 times higher compared to pasture treatments, respectively. Green-Ampt and Parlange models appeared to fit measured data with r^2 values ranging from 0.91 to 0.98. The infiltration rate in 2007 for the GB treatment was the highest (221 mm h^{-1}) and for the CG treatment was the lowest (3.7 mm h^{-1}). Estimated sorptivity (S) and saturated hydraulic conductivity (K_s) parameters were higher for buffer areas compared to the stocked pasture areas. Grazing reduced the infiltration rate for the pasture treatments. Buffer treatments had 4.5 times higher RLD as compared to pasture treatments. The AgB treatment had the highest (173.5 cm/100 cm^3) and CG had the lowest (10.8 cm/100 cm^3) RLD. Root carbon was about 3% higher for the buffers compared to RG treatment. Soil carbon was about 115% higher for the buffers compared to pasture treatments. This study illustrates that agroforestry and grass buffers maintained higher values for soil hydraulic properties compared to grazed pasture systems. The CT-study illustrates the benefits of agroforestry and grass buffers for maintaining soil pore parameters critical for soil water transport. Results from the infiltration study conclude that the buffer areas have higher infiltration rates which imply lower runoff compared to pasture areas. The root study implies that establishment of agroforestry and grass buffers on grazed pasture watersheds improves soil carbon accumulation and root parameters which enhance soil physical and chemical properties, thus improving the environmental quality of the landscape. The Agricultural Policy Extender (APEX) model was used to simulate runoff and sediment losses from the AgB watersheds and control (CW) watersheds. The model was calibrated from 2002 to 2005 and was validated from 2005 to 2008. The r^2 and NSE values for the calibration and validation period of the runoff varied from 0.52 to 0.78 and 0.51 to 0.74, respectively. The model did not predict sediment loss very well (NSE values were less than 0.19) because of insufficient measured events. The measured runoff was 36% lower for AgB watersheds compared to CW watersheds. The measured sediment loss for the AgB watersheds was about 49% lower compared to CW watersheds. The model was run for long-term scenario analyses from 1999 to 2008. The runoff decreased 24% when the buffer width was doubled. The runoff from the AgB watersheds was 9.8% lower with double stocking densities compared to CW watersheds with double stocking densities. Results of these studies indicate that establishment of agroforestry and grass buffers on grazed pasture watersheds improve soil hydraulic properties, pore parameters, soil carbon sequestration and water quality indices and thus contribute to enhance overall environmental quality.