Water Quality at the Soil/Bedrock Interface in Conventional and Silvo Pasture

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Abstract

A major limitation to efficient forage-based livestock production in Appalachia is asynchrony of forage availability and quality with nutritional requirements of the grazer. Producers require dependable plant resources and management practices that improve the seasonal distribution and persistence of high quality herbage, sustainability and environmental integrity of the agricultural landscape. Producers also require a fundamental knowledge of the impacts of agricultural practices on water quality to address personal goals and societal concerns. Piezometers were used to monitor water quality at the soil/bedrock interface under conventional pasture (CP), silvopasture (SP), and hardwood forest (HF). The pasture and silvopasture were rotationally grazed by sheep during the spring to fall grazing season. Geometric mean fecal coliform bacteria concentrations were greatest in SP with no difference between CP and HF. Total N was greatest in HF, but mean NO_3-N concentration was greatest in HF and CP and NH_4-N was greatest in HF and SP. Cl^- concentrations were greatest in SP. There were no differences in mean total dissolved organic carbon. The observations will be important inputs to the development of decision support tools for maximizing forage and livestock productivity while protecting surface and groundwater quality.

INTRODUCTION

The landscape diversity and rough topography of the central Appalachian Region presents livestock producers with several challenges to economically manage their land and livestock in an environmentally benign way. Silvopasture is one way that producers can diversify production from grazed lands while protecting soil and water quality. Rapid infiltration rates cause much of the stormflow and precipitation not used in evapotranspiration to flow by subsurface routes to local streams. Little information about the quality of infiltrating water in silvopastoral systems of the Region is available.

STUDY AREA AND METHODS

Four pairs of 1.9 cm diameter piezometers were installed in each of three adjoining areas of the USDA-AFSRC research farm in southern West Virginia (37º 48' N latitude, 80º 59' W longitude, 890 m elevation). One area was mixed Appalachian hardwood forest with no grazing. The other two areas were conventional pasture and silvopasture, both rotationally grazed by sheep during the growing season. The piezometers were screened at the bottom 30 cm and were installed by driving to the soil/bedrock interface, which averaged about 1.5 m below the surface. The temporary water table perched on the bedrock was sampled during or immediately following storms. Each of the samples was analyzed for fecal coliforms by membrane filtration and growth on mFc agar. Filtered samples (0.45 µm) were analyzed for dissolved inorganic and organic carbon on a total organic carbon analyzer and for NO_3-N, NH_4-N, and Cl^- by suppressed ion chromatography. Depth of the water table above the bedrock surface was measured in two piezometers in the forest and conventional pasture sites. Water table depth was measured by vibrating wire piezometers and recorded every five minutes on a data logger. Statistical differences are reported at the $P < 0.05$ level.

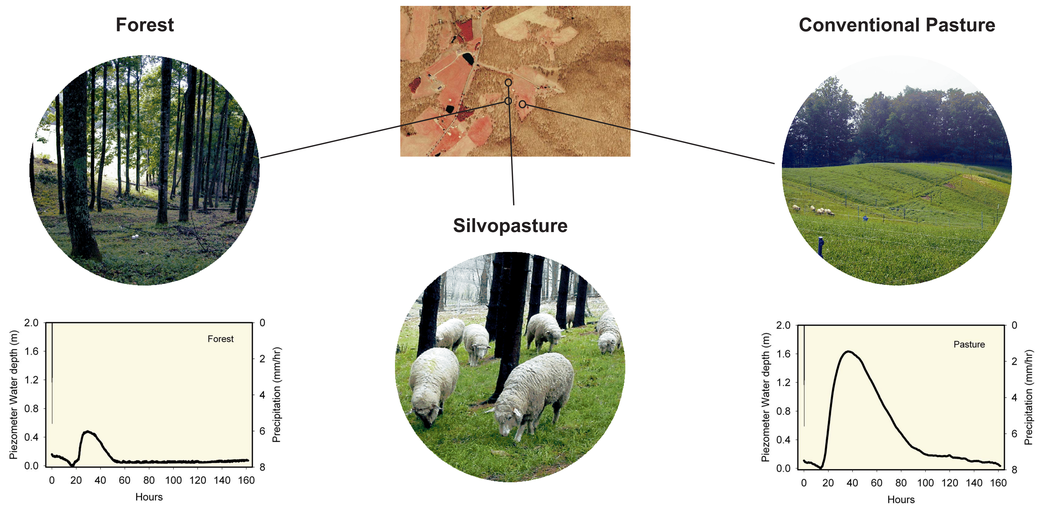
RESULTS

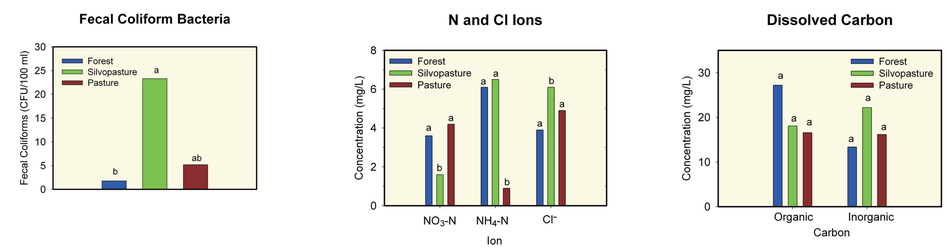
The perched water table occurred more frequently and to a greater depth in the conventional pasture than in the forest. The graphs of water depth vs. time shown above represent a typical storm (29 mm precipitation). The water table reached a depth of ~ 0.5 meters in the forest and ~ 1.6 m in the conventional pasture.

Geometric mean fecal coliform concentrations were greatest in the silvopasture area (~ 25 CFU 100 ml^{-1}). Geometric mean coliform concentrations were ~ 5 CFU 100 ml^{-1} and 2 CFU 100 ml^{-1} in the conventional pasture and forest sites, respectively.

Mean NO_3-N concentrations in the forest and conventional pasture sites (~ 4 mg L^{-1}) were about twice as great as the mean concentration in the silvopasture site (~ 2 mg L^{-1}). Mean NH_4-N concentrations were much greater in the forest and silvopasture sites (~ 6 mg L^{-1}) than in the conventional pasture site (~ 1 mg L^{-1}). Mean Cl^- concentration was greatest in the silvopasture area (~ 6 mg L^{-1}) than in the forest (~ 4 mg L^{-1}) or conventional pasture (~ 5 mg L^{-1}) areas.

There were no significant differences in dissolved organic carbon concentrations between the areas. The absolute mean dissolved organic carbon concentration was greatest in the forest area (~ 28 mg L^{-1}). The absolute mean dissolved inorganic carbon concentration was greatest in the silvopasture area (~ 23 mg L^{-1}).





DISCUSSION

The lack of water table response in the forest might be a result of storm water being diverted laterally away from the soil by a 'shingling' effect created by the layers of broadleaf duff. The high organic matter content of the upper soil layer also increases the water holding capacity thereby delaying vertical movement of water. The duff layer has been disturbed and largely removed by grazing livestock in the silvopasture thus allowing water to move vertically and carry fecal coliform bacteria through the large macropores created by tree roots. Fecal coliform bacteria in the conventional pasture appear to be filtered near the surface and do not readily move to the soil/bedrock interface. Movement of Cl^- to the soil/bedrock interface in the silvopasture area might also be a result of fecal material easily moving to deeper soil layers.

Reduced NO_3-N concentrations in the silvopasture area is probably a result of grasses using the nitrogen released by mineralization of organic matter. A lack of grass in the forest area allows nitrogen released by organic matter mineralization to leach. Higher NO_3-N concentrations in the conventional pasture percolate probably resulted from fertilization with inorganic fertilizer (~ 33.5 kg ha^{-1} yr^{-1}) and mineralization of manure and urine deposited by grazing livestock.

As decision support tools for optimizing forage and livestock productivity while protecting surface and groundwater quality are developed for the central Appalachian Region these observations will be important inputs.

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