Problems in predicting transport of cryptosporidium from grazinglands in the Southern Piedmont of the US

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The Piedmont

The Southern Piedmont extends along the eastern face of the Appalachian Mountains from Virginia to Alabama (Figure 1). This 42 million-acre region has rolling land, long growing seasons, and abundant precipitation and surface water. The Piedmont was historically agricultural but has made rapid growth in manufacturing, service, transportation, and tourism.

Erosion was negligible in the Piedmont prior to 1700 (Trimble, 1974). Early naturalists described the soils as dark and rich. This was probably a result of higher organic matter content than is found in the bright red soils of today. In addition, most streams were reported to be transparent and clear by early explorers. This indicated a low rate of erosion and stable topsoil at the arrival of European settlers. As European settlers moved up into the Piedmont, land was converted from forest and meadow maintained with fire by Native Americans to cropland maintained by plowing. Land was abandoned when it became unproductive. Erosion increased from 1700 until 1860 and was relatively constant until 1920 (Trimble, 1974). After 1920, erosion declined until it reached a relatively low level in 1970. The Piedmont lost an average of 18 cm (7 inches) of soil as a result of agricultural land use during this era. A total of 6 cubic miles of soil was lost by erosion. The land continues to recover from these events as creeks and rivers cut down through sediment to historic riverbeds and possible sediment-oocyte interactions may need to be considered in predicting cryptosporidium transport.

Figure 1. Location of the Southern Piedmont of the United States.

The Piedmont has had vastly different levels of runoff from the same acreage. Land use practices have had long-term impacts on infiltration and runoff. Even today in the humid, warm, and highly sloped Piedmont, conventional tillage can reverse years of carbon accumulation from pasture or no-till cropping. Since infiltration and runoff can vary so greatly from the same acreage it will be important to account for land use history, as well as current land use, in order to accurately predict runoff and potential cryptosporidium oocyte loading of surface waters.

Agriculture is now actively interacting with urban development within the Piedmont. Urban dwellers value the open space that agricultural lands provide but development is proceeding rapidly. Surface water provides the majority of the drinking water in this region and is required for development. Agricultural water use is small but the potential impact of agriculture on urban water supplies via overland transport of pathogens is still large (Fisher et al., 1998).

Piedmont Agriculture

Economics dictated a transition to pasture and forest from traditional row crops. Pasture based beef production has lower requirements for capital investment than row crop production. Rural open land is now predominantly permanent pasture. Grazing can increase soil carbon and increase infiltration. This effect complicates predicting runoff events. More than 75% of the Piedmont farms report incomes below $10,000 annually. Even though these farms are individually small these producers are stewards of a significant portion of the Piedmont. Suggested conservation practices for these landholders should not require significant capital investment

Cow-calf production is common with calving occurring in the early spring (January-February). This means that the calf "crop" would be exposed in the spring of each year to infection by cryptosporidium and this may result in an annual cycle of shedding of oocysts from grazinglands. Cattle are typically watered with surface water and contamination, or recontamination, by wildlife would complicate treatment of a herd to control cryptosporidium infection.

Producers select a pasture for calving that meets multiple management objectives. It should be well drained and located to simplify finding and inspecting the cows as they give birth. The cow-calf pair is relatively immobile for a few weeks after calving and calving pastures can become degraded before animals are moved to another area. This process occurs during a portion of the year in which high rainfall and limited evapotranspiration makes runoff more likely. Therefore the position of these pastures in the landscape could be disproportionately important in predicting runoff and cryptosporidium loading.

It is common to find grazing operations integrated with poultry or swine production. The waste from the confined animal operation (poultry or swine) is applied to pastures as an inexpensive source of nitrogen and phosphorus fertility. Unfortunately, grazing is often widely distributed in a watershed while poultry and swine production may be concentrated (Fisher et al., 1998). Waste is rarely moved more than 6 miles (10 km) from the confined animal operation and therefore waste may be applied at higher levels than would be needed for pasture production. Dairy operations may also be clustered in a watershed. Dairy production systems are quite variable in their use of pasture, which would complicate predicting their potential impact on cryptosporidium loading of surface water. Some dairymen use a minimum of grazing which might make the cow's exercise yard a significant source of oocytes if it was positioned near to a body of water. Other dairymen make extensive use of pasture and would distribute animals in a manner similar to a beef producer.

Our Current Work

We have found that farm ponds can be used as effective tools to reduce total coliform, E. coli, and enterococci bacteria moving from grazinglands. We found bacteria numbers in water flowing from a pond surrounded by grazinglands to be lower bacterial numbers than a creek in a wooded area without domestic grazing animals (Fisher and Endale, 1999). The possible impact of farm ponds on oocyte numbers may also complicate predicting movement of cryptosporidium from agricultural areas. Farm ponds are very common in pasture based beef production systems and they are often positioned low in the landscape to collect water flowing from the owner's land.

We recently updated monitoring instruments for a research catchment first utilized in 1940 that now has a long history of use as a pasture. Runoff event frequency and severity as related to changing land use will be compared with historical data. In a sister catchment, we are studying the possibility of movement of cryptosporidium surrogates in shallow ground water near perennial springs. Research in both areas is designed to improve prediction of runoff from grazinglands and subsequently to test the efficacy of conservation practices.

Summary

- The land and surface waters of the Southern Piedmont are dynamic and have not yet recovered from traditional tillage practices. The erosion of the land only started declining 80 years ago and only reached a baseline level 30 years ago.

- In the Piedmont, soil carbon is variable, accumulates slowly, and can be reduced rapidly by plowing. How do we estimate soil carbon in 42 million acres of the Piedmont so that we predict the spatial and temporal variation in infiltration and runoff?

- Urbanization is reducing infiltration and increasing runoff. How will this impact agricultural land and the sewage treatment plants designed to serve the urban population?

- Calves are typically born in a “crop” in the early spring. Does this result in a predictable annual cycle of cryptosporidium oocyte loading? Could additional precautions in treatment of water be taken during this season?

- If farm ponds reduce bacterial levels do they also reduce levels of cryptosporidium? If they do, could animals be positioned during rainfall events likely to produce runoff so that the runoff would flow through a pond? Is pond treatment a viable possibility?

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