United States Department of Agriculture

CEAP Science Note

Natural Resources Conservation Service
Conservation Effects Assessment Project

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Water Quality Effects and Placement of Pasture BMPs in the Spring Creek Watershed (Centre County, PA)

Summary of Findings

- Long-term benefits of pasture-based best management practices (BMPs) (e.g., streambank fencing, stream crossings, bank stabilization), include improved water quality through reduced sediment loading, while reductions in nitrogen and phosphorus were not observed.
- Abundance and diversity of aquatic macro-invertebrates increased, and more 1 year old and adult brown trout were found in BMP-treated sub-watersheds 10 years after BMPs were installed.
- Topographic flow paths should be used as a planning tool for placing future BMPs to mitigate effects on streams, as water does not typically follow the most direct path to the streams. BMPs placed along the shortest path from concentration area to stream missed flow capture by more than 20 meters in most cases.
- Landowner attitudes about riparian buffer conservation vary with parcel size, location within the watershed, and historical links to traditional agricultural programs.

The Conservation Effects Assessment Project (CEAP) Grazing Lands national assessment is designed to quantify the environmental effects of conservation practices on U.S. non-Federal grazing lands. There are numerous ways that a conservation practice may be applied, depending upon site factors, such as specific goals, cost, availability of materials, and practicality. Some methods offer more optimal effects than others. Best Management Practices (BMPs) are those practices (or application methods of a conservation practice) determined to be the most efficient, practical, and cost-effective measures identified to guide a particular activity or to address a particular problem.

This study, a joint project among Penn State, Cornell, and USDA Agricultural Research Service (ARS) scientists, demonstrated pasture BMP effectiveness on improving water quality and aquatic diversity. A second component demonstrated how BMP placement can be improved by analyzing graphic estimates of local drainages and flow path attributes in conjunction with on-site assessments by managers.

BMP Effects

Best management practices such as streambank fencing, stream crossings, and bank stabilization are intended to reduce negative effects of animal agriculture on water quality, but little information is available on the long-term consequences of these practices. Penn State scientists measured water quality in an agricultural watershed in the early 1990s, after which BMPs, mainly streambank fencing and cattle crossings, were installed. Streambank fencing covered 91 percent and 61 percent of the pastures in two sub-watersheds of Spring Creek (Centre County, PA; fig. 1). A third, predominantly forested sub-watershed remained ungrazed and was used as a control.

BMP effectiveness was determined by monitoring macro-invertebrate, fish, and water quality across the three sub-watersheds. Water quality measurements included orthophosphate, nitrate nitrogen, and total suspended solids (TSS) Long term changes in fish and macro-invertebrate density and diversity were determined via surveys of nine sites in the treated sub-watersheds and one in the “control” sub-watershed in May and August of 1992 prior to BMP installation, and again in May and August of 2007. Water quality was monitored at USGS gauging stations at each sub-watershed outlet (fig. 1). BMPs improved water quality by decreasing total suspended solids, but had little effect on nitrogen and phosphorus concentrations (Table 1).

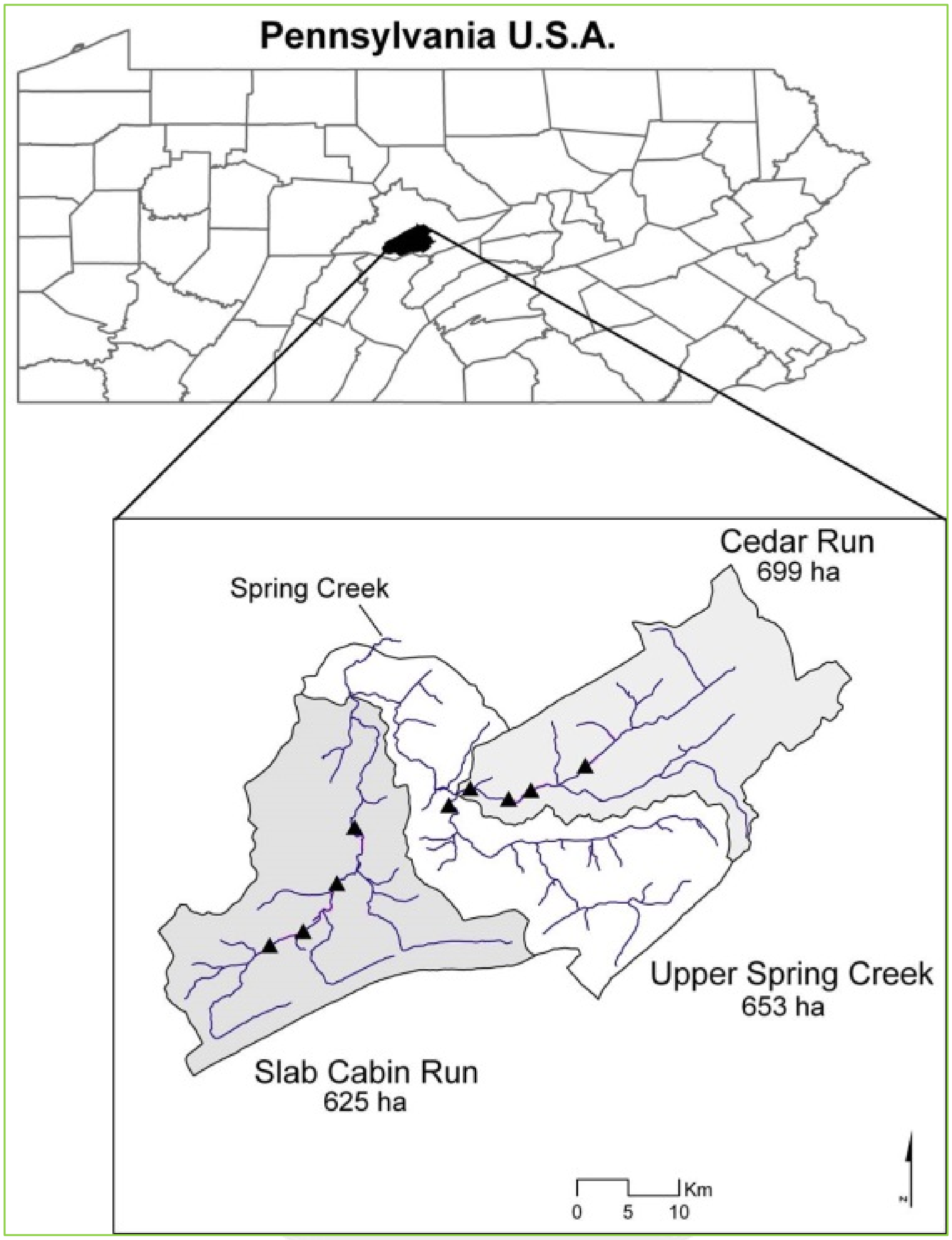

Figure 1. Location of Spring Creek Watershed and Monitoring Sites.

Table 1. Water quality of the sub-watersheds. Median sediment and nutrient concentrations (mg/L) in baseflow samples.

Sub-watershed Name	Total Suspended Solids (TSS) mg/L		Organophosphate (Ortho-P) mg/L		Nitrate-Nitrogen mg/L	
	Pre-BMP	2007 - 2008	Pre-BMP	2007 - 2008	Pre-BMP	2007 - 2008
Upper Spring Creek	4.00	1.0	0.003	0.005	2.40	2.85
Cedar Run	17.75	1.0	0.003	0.005	4.45	4.58
Slab Cabin Run*	29.30	1.0	*	*0.016	*	*3.17

* Slab Cabin Run Orthophosphate (Ortho-P) and Nitrate-N measurements were taken in 2001 after treatment. No pre-treatment measurements were taken in this sub-watershed.

With BMPs, macro-invertebrate density and richness increased to levels comparable to those of reference sub-watersheds. As compared to Spring Creek (the reference stream), Cedar Run density of macro-invertebrates increased from less-than-half to an equal amount; Slab Cabin Run values increased from less-than-half to almost 2.5 times greater, depending upon the year sampled. In addition, BMPs increased density of juvenile and adult brown trout (*Salmo trutta*), but did not impact fish diversity

BMP Placement

Using topography to model water flow paths could make it possible to make BMPs even more effective via optimal placement, ensuring that runoff from animal concentration areas and other important source areas is intercepted. Conversely, topographic modeling could also improve placement of new heavy-use areas such as waterers, such that runoff would enter existing riparian buffers.

The locations of all riparian BMPs and near-stream concentration areas in three sub-watersheds of Spring Creek were mapped. Water flow paths were modeled using elevation data at 1m, 10m, and 30m horizontal resolution.

BMP placement was evaluated by examining the size of the near-stream (within 100m) area draining into each section of treated or untreated streambank, and by comparing absolute distances with modeled topographic water flow paths between both animal concentration areas and all agricultural use areas to the stream (fig. 2).

Not only were the topographic water flow paths longer than the direct routes, the places where water entered the stream differed, in many cases by more than 20m. Most drainage areas were very small; only a few streambank areas had the potential for large amounts of runoff flowing through into the stream. Choice of digital elevation model (DEM) resolution was important: The 30m DEMs were too coarse to give realistic results, while the 1m DEMs were overly sensitive to small variations and measurement errors. The 10m DEM data were the most effective for characterizing flow paths and identifying optimal sites for BMP placement. Modeling topographic flow paths improves placement accuracy, reduces the area of streambank coverage required, lowers cost, and enables better informed placement of future heavy-use sites to best capitalize on benefits of existing BMPs.

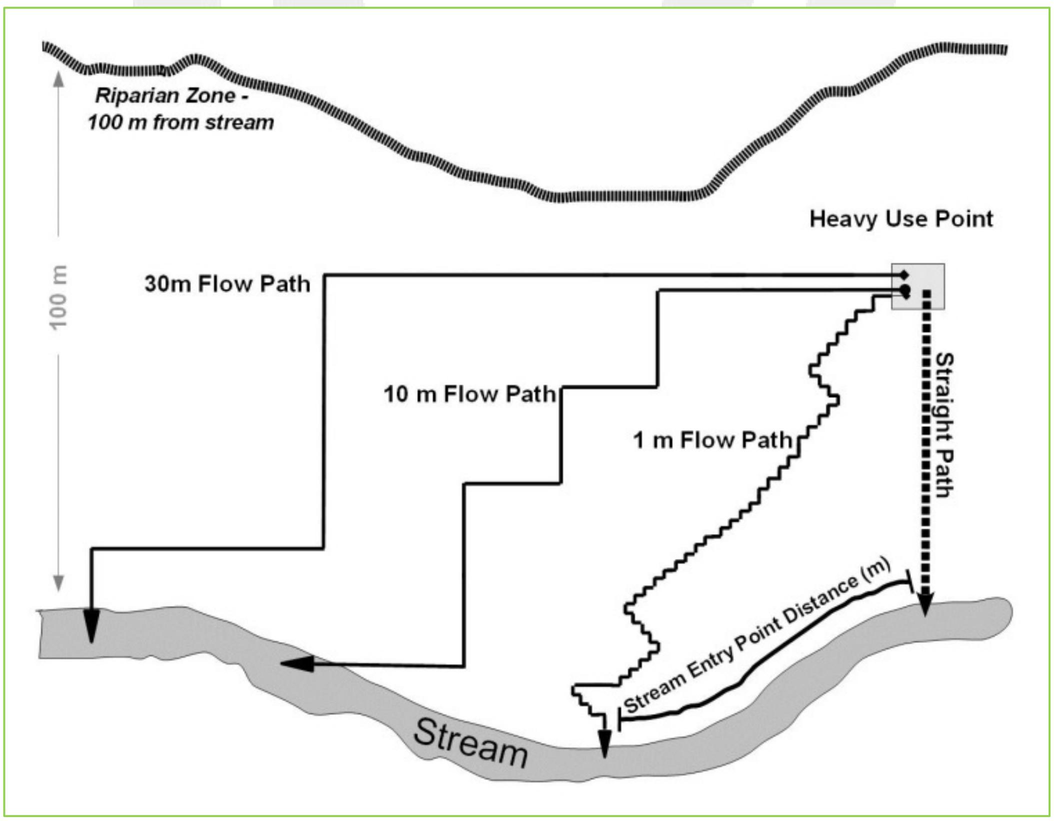

Figure 2. Riparian buffer with straight (no elevation) and topographic flow paths (elevation) and resulting stream entry points for 1m, 10m and 30m DEMs.

Landowner Attitudes

Penn State and Cornell scientists combined social science survey data, aerial imagery, and an analysis of spatial point processes to assess the relationship between stream flow regularity and riparian landowner perceptions and attitudes.

Stream flow regularity directly and positively shapes landowners' water quality concerns, and also positively influences landowners' attitudes of stream importance—a key determinant of water quality concern as identified in a path analysis.

Riparian landowners who do not notice or perceive a stream on their property are often located in headwater regions, which are critical areas for watershed-scale water quality. These landowners are less likely to manage for water quality than landowners with perennial streams in an obvious, natural channel. Also, traditional farmers are more likely to be aware of and connected with available conservation incentive programs than are residents on smaller riparian parcels.

Conclusions

Applying BMPs to all streambank pastures within a watershed improved water quality and invertebrate and fish populations, but is not a generally feasible approach. Instead, topographic analysis can be used to identify the most effective sites for BMP treatment, where they will intercept the greatest proportion of runoff with the minimum effort and reasonable cost. Landowner attitudes about riparian buffer conservation vary with parcel size, location of their acreage within the stream hydrology, and links to traditional agricultural programs.

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The Conservation Effects Assessment Project (CEAP) is a multi-agency effort to build the science base for conservation policy and program development, and help farmers and ranchers make more informed conservation choices.

The CEAP Grazing Lands national assessment is designed to quantify the environmental effects of conservation practices on U.S. non-Federal grazing lands. The 584 million acres of non-Federal grazing lands in the contiguous 48 states are composed of 409 million acres of rangeland, 119 million acres of pastureland, and 56 million acres of grazed forest land.

Development of CEAP Grazing Lands processes and findings must address a number of unique challenges that are typically not present on croplands at management scales. Grazing lands typically have more diversity in climate (especially precipitation), soils, and topography than does cropland. Management practices and their effects are less precise and less well-defined, making the results of specific studies more difficult to extrapolate. There are three scales of investigation for CEAP Grazing Lands. Ecological sites will be used to stratify assessments at all three levels for the rangeland portion.

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For more information: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/ceap/?cid=stelprdb1080581

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