RUNOFF FROM PAIRED BASINS AT THE PIONEER FARM

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Introduction

The paired-basin approach was developed to evaluate impacts of forestry management on water quality, and has been adopted by researchers to evaluate management practices in agricultural land use settings. The methodology requires that two basins (control and treatment) are monitored for two time periods (calibration period and treatment period). If the two basins react in a consistent predictable manner while under similar management and climate during the calibration period, an alternate practice can be applied to one basin during the treatment period, and if the relationship between the basins changes, it is due to the treatment (Clausen 1993). The University of Wisconsin-Platteville's Pioneer Farm has installed surface-water monitoring gauging stations in four agricultural basins and collected surface-water quality and quantity data for use in calibrating the basins for paired-basin research.

Methods

The University of Wisconsin-Platteville's Pioneer Farm is a 430 acre production farm located in the driftless area of Wisconsin, seven miles southeast of Platteville in sections 20, 21, and 29 of Elk Grove Township (T3N-R1E) in Lafayette County. The farm is comprised of 330 acres of cropland, 73 acres of pasture, and 27 acres in buildings, roads, and other areas associated with the farmstead. Dominant soil is a moderately eroded Tama soil series with B and C slope classes. Soils are underlain by Galena Dolomite bedrock. The seven-year crop rotation includes one year of oats followed by three years of alfalfa and three years of corn. Livestock enterprises include a Holstein dairy cow herd (125 milking), a farrow-to-finish swine herd, and a beef cow-calf herd. Manure from the dairy herd is collected from alleyways with mechanical scrapers, stored in an earthen basin, and land-applied in the fall using a towed-hose system. Manure from beef and swine facilities are handled as a solid which is composted and land applied year-round.

Surface-water runoff gauging stations and automated samplers were installed at Pioneer Farm in cooperation with the United States Geological Survey to monitor quality and quantity of runoff from agricultural basins. After installation of monitoring equipment, a two-year calibration period was conducted for paired basins 3 and 5 in the water-years (WY) 2003 and 2004, and basins 5, 10, and 11 were calibrated during the 2007 and 2008 WYs. The WY starts October 1st and ends September 31st.

Discharge (quantity) from basins was determined using a pre-calibrated flow control structure (H-flume) coupled with a nitrogen gas pressure transducer stage monitoring device. Time-based discrete samples of surface-water runoff were collected using an ISCO automated sampler. Discrete samples were then composited using a churn splitter and samples analyzed at the UW-Stevens Point Water and Environmental Analysis Laboratory (WEAL). Samples were analyzed for the following: total solids, total suspended solids, nitrate + nitrite N, ammonium, total keldahl nitrogen, total phosphorus-dissolved filtered, and total phosphorus- unfiltered.

The sample concentrations (mg l^{-1}) provided by WEAL were multiplied with USGS flow (l) data to calculate event loads (mg) and multiplied by 1,000 (kg). Event loads (kg) were then divided

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by drainage areas (ha) to determine the yield (kg ha^{-1}). The relationships between yields for basins. The sample concentrations (mg L^{-1}) provided by WEAL were multiplied with USGS flow (l) data to calculate event loads (mg) and multiplied by 1,000 (kg). Event loads (kg) were then divided by drainage areas (ha) to determine the yield (kg ha^{-1}). The relationships between yields for basins during the calibration period were examined using linear regression and analysis of variance (ANOVA). Minimal detectable differences for basin pairs were determined using the method described by Kovner and Evans (1954). Data were tested to ensure it met required assumptions: normality of regression residuals (Anderson-Darling), autocorrelation (Durbin-Watson), and equal variance (Levene). Log, inverse, square root, and cubed root transformations were used to improve the distribution of the data sets. This study determined the strength of paired basin relationships for the following parameters: runoff, total solids (TS), total nitrogen (TN), total phosphorus (TP), and dissolved reactive phosphorus (DRP).

Basins 3, 5, 10, and 11 are single-use basins, meaning that only one crop type is grown in the basin at a time. During the WY 2003-04 calibration period, cropland in basins 3 and 5 was chisel-plowed in the fall and finished in the spring prior to corn planting in late April. Field average soil test phosphorus levels ranged from 88 to 130 ppm. A light application (17 Mg ha^{-1}) of solid beef and dairy manure was applied to all of basin 3 and portions of basin 5 in the fall of 2002. In the fall and winter of 2003 of solid dairy manure (6.3 Mg ha^{-1}) and liquid dairy manure (218 L ha^{-1}) were applied to all of the cropland in basin 3 and portions of basin 5. Basin 5 also received a solid manure application of 58 Mg ha^{-1}. During the WY 2007-08 calibration period, cropland was transitioned to alfalfa production and no manure applications were made.

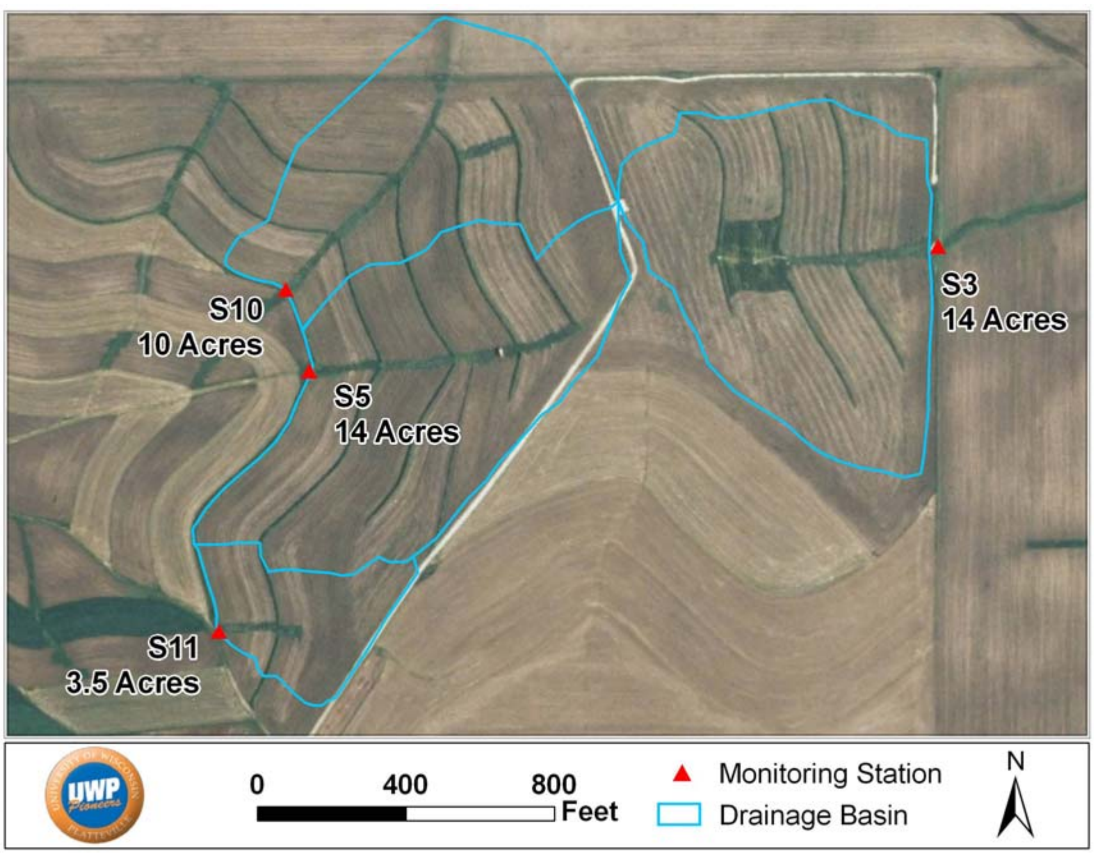

Figure 1. Monitored basins at UWP Pioneer Farm.

Results and Discussion

During the calibration period for basins 3 and 5, 9 runoff events were monitored in WY 2003 and 19 were monitored in WY 2004. The calibration period for basins S5, S10, and S11 included 11 events in WY 2007 and 27 events in WY 2008. The figures below plot total phosphorus yield for sequential runoff events from paired basins 5-10 and 5-11. The events in the shaded areas are snowmelt driven runoff events, non-shaded areas are rain driven runoff events. Figure 2 indicates a close relationship between paired basins 5 and 10 during both snowmelt and rainfall events. In contrast, basins 5 and 11 plotted in Figure 3 do not react as predictably, especially during snowmelt events. One reason for the potential weak pairing of basins 5 and 11 may be due to the slightly northern aspect of basin 11. Due to the slight northern aspect, snowmelt and snow accumulation may occur differently in this basin than it does in basins 5 or 10.

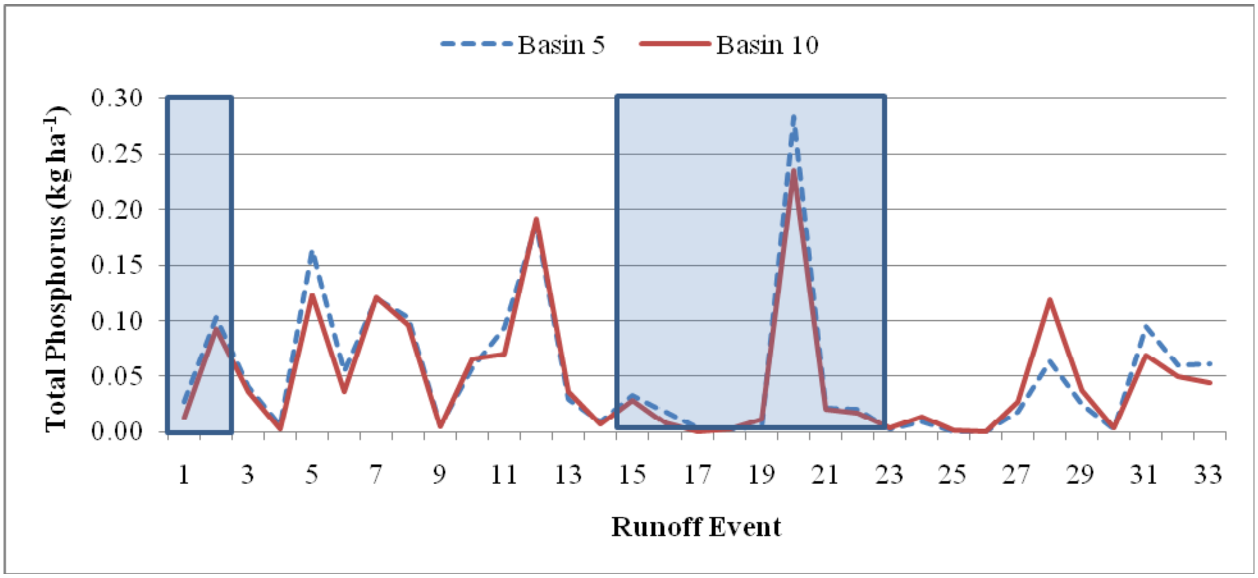

Figure 2. Total phosphorus yield event series for basins 3 and 5.

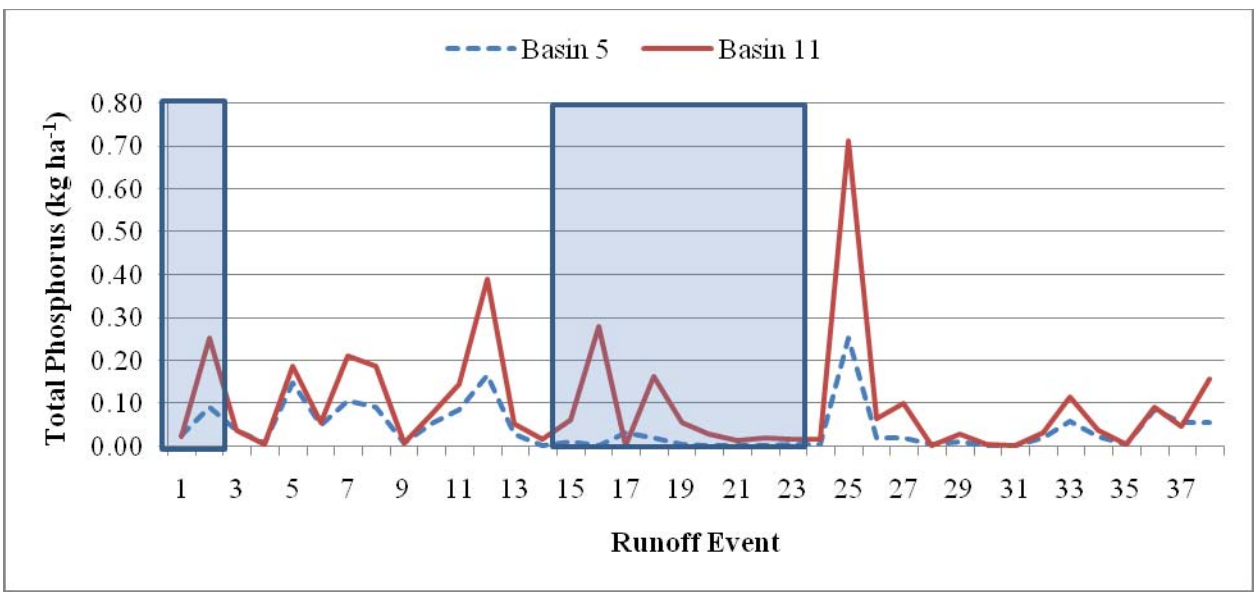

Figure 3. Total phosphorus yield event series for basins 5 and 11.

Given the calibration data that were collected, there are four possible pairs of basins: 5-3, 5-10, 5-11, and 10-11. Analysis of the calibration yield data indicates that regression equations for all parameters in all pairs were significant at the 0.05 level. However, the strength of the pairs was variable. Table 2 lists the smallest detectable differences by parameter for basin pairs. The basins that have the strongest relationship (i.e. smallest detectable difference) are 5 and 10. For this pair, an eight percent difference in the mean DRP yield would be statistically significant. In comparison, a 44% or greater change in mean DRP yield would be required in order to be detected as significant for the 10 and 11 paired basins. One possible reason for the apparent weakness in the 5-11 and 10-11 pairs may be due to the slight northern aspect of basin 11. This difference in aspect may be resulting in changes to snowmelt characteristics, which may affect hydrology. Also, the aspect may result in greater snow accumulation in this basin.

Table 2. Paired basins smallest detectable difference (expressed as a percentage of the mean).

	Basin 5					Basin 10				
Basin	Runoff	TS	TN	TP	DRP	Runoff	TS	TN	TP	DRP
			%					%		
3	20	40	34	31	34	------------------ No Data --------------				
10	14	27	21	12	8	------------------ No Data --------------				
11	46	46	63	68	42	48	43	60	49	44

Summary

Analyses of data collected from basins 3, 5, 10, and 11 at UWP Pioneer Farm indicate that the basins will be useful for evaluating the effect alternative agricultural practices and/or systems have on water quality and quantity. However, the strength of relationship between pairs of basins is not consistent. For example, basins 5 and 10 have the strongest relationship and can detect the smallest response due to the treatment- a 13% change in total phosphorus would be significant. Basins 3 and 5 also paired well, minimal detectable differences were 20 to 40% for sediments and nutrients. In contrast, the weakest pair of basins is 5 and 11 where a 68% or greater change in total phosphorus would be required in order to be statistically significant. The reason for the weak pairing with basin 11 may be due to the slight northern aspect of the basin. This may result in changes in snowmelt that alter the hydrology. Or, it may be influencing the amount of snow that accumulates in this basin.

References

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