Assessment of concentrated flow through riparian buffers

M.G. Dosskey, M.J. Helmers, D.E. Eisenhauer, T.G. Franti, and K.D. Hoagland

ABSTRACT: Concentrated flow of surface runoff from agricultural fields may limit the capability of riparian buffers to remove pollutants. This study was conducted on four farms in southeastern Nebraska to develop a method for assessing the extent of concentrated flow in riparian buffers and for evaluating the impact that it has on sediment-trapping efficiency. Field methods consisted of mapping field runoff areas and their pathways to and through riparian buffers to streams. Mathematical relationships were developed from a model (VFSMOD) that estimates sediment-trapping efficiency from the ratio of buffer area to field runoff area. Among the farms surveyed, riparian buffers averaged 9 to 35 m wide, and gross buffer area ranged from 1.5 to 7.2 ha, but the effective buffer area that actually contacts runoff water was only 0.2 to 1.3 ha. Patterns of topography and microrelief in fields and riparian zones prevented uniform distribution of field runoff across entire buffer areas. Using the mathematical relationships, it is estimated that riparian buffers at each of the four farms could potentially remove 99%, 67%, 59%, and 41% of sediment from field runoff if the runoff is uniformly distributed over the entire gross buffer area. However, because of non-uniform distribution, it is estimated that only 43%, 15%, 23%, and 34%, respectively, would actually be removed. The results indicate that concentrated flow through riparian buffers can be substantial and may greatly limit filtering effectiveness in this region.

Keywords: Concentrated flow, nonpoint source pollution, riparian buffers, sediment, surface runoff, vegetative filter strips

Riparian buffers are an accepted management practice for reducing runoff of pollutants from agricultural fields to streams. Riparian buffers are strips of perennial vegetation between fields and streams that intercept field runoff and trap pollutants before they can enter streams.

Maximum pollutant trapping efficiency is expected when field runoff is uniformly dispersed across the entire buffer area. Dillaha et al. (1986, 1989) observed that surface runoff commonly concentrated in fields and flowed through only parts of buffer strips. They reasoned that such buffers were rendered less effective because these portions became inundated during larger runoff events, and relatively little sediment appeared to accumulate in them. Similar observations have been reported by Fabis et al. (1993). Field and plot studies generally confirm that buffers are less efficient for sediment, nitrogen, and phosphorus retention when concentrated flow occurs (Daniels and Gilliam 1996; Dickey and Vanderholm 1981; Dillaha et al. 1988, 1989).

Little research information is available on patterns of concentrated flow to and through buffers, especially in field-scale settings. This may be partly because of a lack of quantitative methods that enable evaluation of field runoff patterns and their impact on buffer effectiveness. The objectives of this study were (i) to develop a method for evaluating concentrated flow patterns in riparian buffers and for estimating the likely impact on sediment-trapping efficiency, and (ii) to use this method to assess the extent of concentrated flow and its impact on the sediment-trapping efficiency of riparian buffers on four farms in southeastern Nebraska. Our hypothesis was that concentration of runoff flow is common and substantially reduces the sediment trapping efficiency of riparian buffers in this region.

Methods and Materials

Approach. Field methods were developed to visually assess concentrated flow patterns. They consisted of estimating sizes of field areas that contribute runoff, of the corresponding area of riparian buffer for each field runoff area (gross buffer area), and the portion of each riparian buffer that actually contacts field runoff (effective buffer area). The relationship among these three measurements is depicted in Figure 1. Concentrated flow is indicated where there is a substantial difference between gross and effective buffer area. Regression equations were developed from a model that enabled estimates of sediment-trapping efficiency from field determinations of the ratio of buffer area to field runoff area. An impact of concentrated flow is indicated where sediment-trapping efficiency based on effective buffer area is substantially less than that based on gross buffer area. These methods were used to assess existing riparian buffers on four farms in southeastern Nebraska.

Farm descriptions. The four study farms represented the range of farm landscapes typical of southeastern Nebraska, from rolling hills to loess plains (Table 1). Field areas produce primarily corn, grain sorghum, and soybeans. One farm is furrow-irrigated, while the other three are dryland. Among these farms, we identified 107 field runoff areas having a total drainage area of 156.3 ha (386.2 ac) and a total length of field margin adjacent to riparian buffers of 6,756 m (7391 yd). Slopes generally range from about 1% to 4%, with occasional portions of fields up to 9%. Riparian buffers range in distance from field margin to stream bank from 5 to 61 m and are typically vegetated with mixtures of trees and grass. On one farm (Hamilton), the riparian vegetation is entirely grasses, and the buffer areas are used as equipment turn lanes. None of the riparian buffer areas on these farms was intentionally designed for filtering runoff. The streams range from ephemeral to

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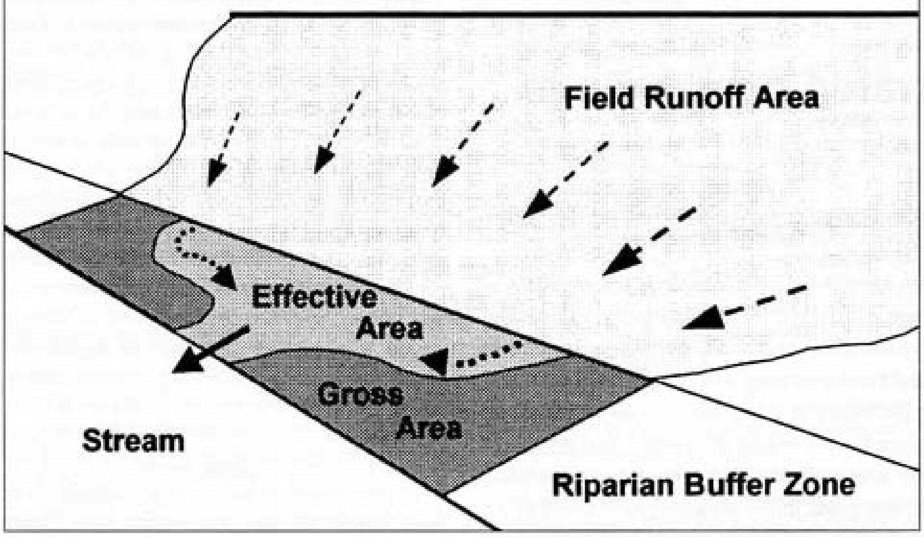
Figure 1

Schematic diagram depicting the general relationship between field runoff area, gross riparian buffer area, and effective riparian buffer area. Gross buffer area is the area that field runoff would contact if flow were dispersed across the entire buffer area to the stream. Effective buffer area is the actual pathway that field runoff travels to the stream.



third-order perennial and include both channelized and relatively unmodified reaches.

Field methods. Field runoff areas were delineated by walking the field margins adjacent to riparian buffer areas. Boundaries were identified for each area of crop field that drained to a common segment of riparian buffer. This method is similar to the watershed faceting procedure described by Bren (1998). Interpretations were based on topography, microrelief, and patterns of erosion and deposition of soil and crop debris. Interpretations were easier to make early in the growing season, when visibility of the land surface was not obscured by herbaceous ground cover. Attention was also given to crop-row direction, berms, terraces, and other land-shaping features that can influence runoff flow direction (Souchere et al. 1998). On topography with low slope, a surveying rod and level were used in conjunction with visual observations to help indicate direction of runoff flow. A U.S. Geologic Survey (USGS) 7.5-minute topographic map with a 10 ft contour interval provided a scaled base map with reference features for each farm. Runoff area boundaries were marked on enlarged copies of the USGS maps. The lengths of field margins adjacent to the riparian buffers and the sizes of each field runoff area were measured using a planimeter on boundaries recorded on the base map. In this study, we did not consider those fields that were adjacent to riparian buffers but drained into ditches, grass waterways, underground outlets, or other improvements that bypassed riparian buffers.

Gross buffer area corresponding to each field runoff area was estimated by the length of field margin adjacent to the buffer times the average distance from that field margin to the stream bank. Along sinuous streams, several pacing measurements were used to compute an average distance to the stream bank. Gross buffer area represents that area that runoff from the field would contact if there were uniformly dispersed flow across the entire field margin through the buffer to the stream.

Effective buffer-area estimation was more subjective and required careful interpretations of the actual flow path of runoff from the field area, across the field margin, and into and across the buffer area to the stream. Boundary identification was more difficult in heavy vegetation on flatter landscapes (<2% slope). At the Hamilton farm, runoff patterns in a few areas were checked during an irrigation runoff event. Boundaries of the effective buffer area probably vary with the volume or rate of field runoff. We attempted to make estimates that corresponded to larger runoff events. Estimates were based on visual observations of microrelief, sediment and debris deposition and orientation, and erosion patterns on the ground surface. While these methods yield less precise elevation data than micro-topographic surveys, they more clearly indicate location and continuity of actual flow pathways and can be conducted more easily over the large areas that we surveyed. The discrete point sampling of micro-topographic surveys can miss small ridges, berms, and furrows that influence runoff flow paths (Helmers et al. 2001, Souchere et al. 1998). Despite uncertainties, we believe that our visual methods provided adequate clues that, when considered together, were clear enough to enable reasonable interpretations of runoff flow boundaries.

Effective buffer areas were often irregular in shape. To convert irregular boundaries into an estimate of effective buffer area, the effective flow path was divided into a sequence of rectangular segments, with each segment representing a relatively narrow range of path width perpendicular to the direction of runoff flow. Up to three segments were described for each buffer area. The area of each rectangular approximation was computed and the segments summed to yield the effective area of the buffer. The relative density of vegetative ground cover in each segment was also noted, as well as surface features that appeared to influence flow direction, such as general topography, berms, and sediment accumulations.

Sediment-trapping relationships. We hypothesize that the sediment-trapping efficiency of a buffer decreases as input load per unit of effective buffer area increases. This relationship has received little attention. Low input loads to buffer areas that infiltrate most of the runoff yield very high sediment-trapping efficiency (e.g., Barfield et al. 1998), while very high input loads that submerge and inundate herbaceous buffer vegetation reduce sediment trapping efficiency (Ree 1949, Wilson 1967). Where input load varied between moderate levels, one study reported no significant impact (Lee et al. 2000).

Overcash et al. (1981), Mander et al. (1997), and Bren (1998, 2000) have proposed that buffer design be based on a ratio of upslope contributing area to effective buffer area, rather than on buffer dimensions alone. Mander et al. (1997) reported a trend between this ratio and N and P trapping among published literature values that included both surface runoff and groundwater observations. Overcash et al. (1981) found a strong relationship between this ratio and N, P, and sediment trapping from surface runoff among published literature values and modeled relationships. This source-sink relationship is similar to our hypothesis when input load is closely related to size of the

Table 1. Landscape characteristics of four case study farms in southeastern Nebraska.

Landscape	Characteristic	Rogers	Burr	ARDC	Hamilton
General	County	Lancaster	Otoe	Saunders	Hamilton
	Topographic region	rolling loess hills	rolling loess hills	loess plains	loess plains
	Farming system	dryland grains	dryland grains	dryland grains	furrow irrigated grains
Field runoff areas	Total area of fields draining through riparian buffer (ha)	15.1	10.7	21.0	109.5
	Number of areas identified	14	20	13	60
	Average size and range (ha)	1.1 (0.2-4.8)	0.5 (0.1-1.6)	1.6 (0.2-4.7)	1.8 (0.3-5.9)
	Average slope and range (area-weighted mean, %)	2.0 (1-5)	3.8 (1-9)	2.3 (1-4)	2.0 (1-6)
Riparian buffer areas	Total length of field margin adjacent to riparian buffers (m)	2069	1446	1516	1725
	Vegetation	trees & grass	trees & grass	trees & grass	grass
	Average distance from field margin to stream bank and range (m)	35 (18-61)	12 (5-40)	10 (7-15)	9 (9)
Stream	Stream size	2nd and 3rd order perennial	2nd order perennial	ephemeral	ephemeral
	Proportion of total length of riparian field margin that is adjacent to channelized stream (%)	23	0	100	100

contributing area. Accordingly, sediment-trapping efficiency may be quantitatively estimated from the ratio of field contributing area to effective buffer area. In further analyses, it was more convenient to evaluate the inverse of this ratio, i.e., buffer area per unit field area. This ratio is called the buffer-area ratio in this paper.

To study the relationship between the buffer-area ratio and sediment-trapping efficiency, the model VFSMOD (Muñoz-Carpena and Parsons 2000) was applied to our field site conditions. The VFSMOD model is a field-scale, mechanistic, single-event model that is based on the hydraulics of flow and of sediment transport and deposition (Muñoz-Carpena et al. 1993, 1999). The sediment deposition component is based on the University of Kentucky sediment-filtration model (Barfield et al. 1979; Hayes et al. 1979, 1984; Tollner et al. 1976, 1977). The model assumes that field runoff flow contacts the entire buffer area (i.e.., effective buffer area). Good agreement between modeled and

Table 2. Field and precipitation event conditions used in VFSMOD simulations for developing relationships between sediment-trapping efficiency and the ratio of effective buffer area to field runoff area for four case study farms in southeastern Nebraska.

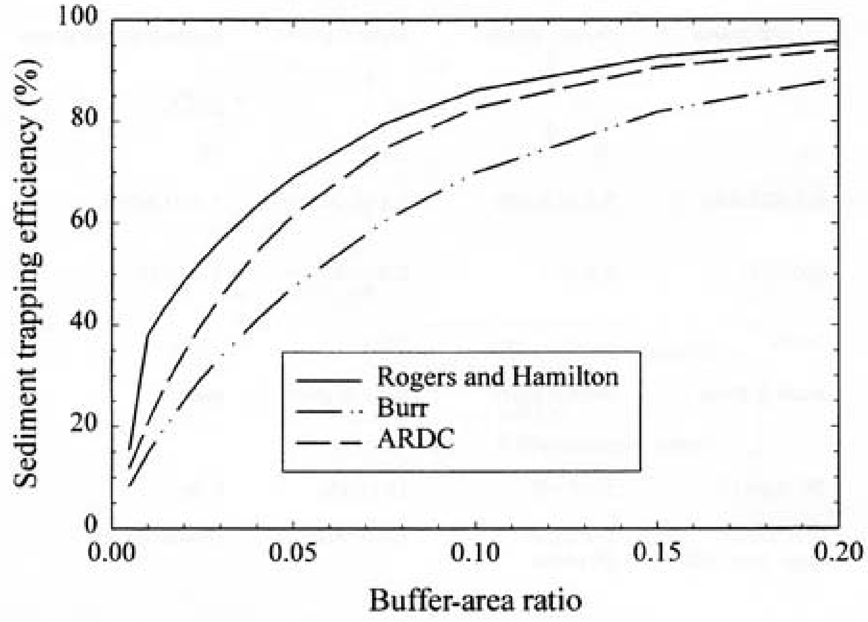
Condition	Rogers	Burr	ARDC	Hamilton
Land slope (%)	2.0	3.8	2.3	2.0
Soil texture[*]	Silt loam	Silty clay loam	Silty clay loam	Silt loam
Precipitation event:				
Amount (mm)	63.5	63.5	63.5	63.5
Duration (hr)	1	1	1	1
Return frequency (yr)	10	10	10	10
Slope length (m)	350	74	138	350
Curve Number[†]	90	90	90	90
Practice factor (P-factor)	1	1	1	1
Cover and management factor (C-factor)	0.5	0.5	0.5	0.5

[*] **Soil hydraulic parameters were obtained from handbook values (Rawls et al., 1993) corresponding to each soil texture class.**

[†] **Based on antecedent moisture condition III.**

Figure 2

Relationships between sediment-trapping efficiency and buffer-area ratio developed using VFSMOD for four farms in southeastern Nebraska. Buffer-area ratio = (effective buffer area / field runoff area).



observed trapping efficiencies have been determined for conditions in North Carolina (Muñoz-Carpena et al. 1999), Mississippi (Hayes and Hairston 1983), and Ontario, Canada (Abu-Zreig et al. 2001).

The key inputs to the model describe land, weather, and farming conditions at the four study farms (Table 2). The 10-year return period storm was chosen as suggested by Larsen et al. (1997) for designing erosion control and buffer practices. Precipitation amount and duration for this general area was derived from Hershfield (1961). The county soil survey was used to identify the soils at each farm. Soil hydraulic parameters were obtained from handbook values (Rawls et al. 1993) for the dominant soil textural class at each farm. For model simulations, buffer-area ratio was varied by changing the flow length of the buffer. Model simulations were run for 12 values of buffer-area ratio distributed between 0.01 and 0.20. The resulting relationship between sediment trapping efficiency and buffer-area ratio for each farm is shown in Figure 2. Obviously, the model is sensitive to input parameters, especially slope and soil texture, which also influence the magnitude of water and sediment loads transported from field areas to buffers.

To check the realism of the simulation results, they were compared to observations from field studies. Sixteen published reports were found that contain data on sediment retention by buffers where both field source and effective buffer areas were known (Table 3). Most of these studies were plot studies designed to evaluate a relationship to flow distance across a buffer. For our analysis, we converted field and buffer dimensions in each study to an area basis (rather than distance) and computed the buffer-area ratio corresponding to each measurement of sediment-trapping efficiency. Results from individual studies that compared different buffer-area ratios were consistent with our hypothesis. A scatterplot of all experimental data superimposed on our simulation results is shown in Figure 3. Variation in the scatterplot is at least partly because of the wide range of site conditions among these studies that influenced sediment trapping, such as buffer slope, soil texture, antecedent soil wetness, and storm intensity.

Another limitation of the published reports is that they tend to address relatively large values of buffer area to field area ratio. Only five of the sixteen studies addressed sites that had buffer-area ratios of less than 0.12, and only one study was below 0.03. In general, many existing buffers that we observed in the field (discussed in the next section) have lower buffer-area ratios, particularly the effective buffer areas.

Results and Discussion

Assessments of riparian fields and buffers on the four study farms were conducted in May through August 1997. The Rogers farm was assessed first, followed by ARDC, Hamilton, and Burr. The Rogers and ARDC farms were assessed while crop and herbaceous buffer vegetation were relatively low. The furrow irrigation system at the Hamilton farm, combined with check observations during an irrigation period, made this site relatively easy to assess, despite more advanced development of the corn crop and buffer grasses. The Burr farm was more difficult and time-consuming to assess because the crops and riparian vegetation had become well-developed and tended to obscure the more subtle evidences of runoff pathways. Consequently, area estimates for the Burr farm may be less accurate than for the other three farms.

A total of 107 field runoff areas were identified that drained through riparian buffers (Table 1). They ranged in size from 0.1 to 5.9 ha, with slopes ranging from 1% to 9%. More than half of these field runoff areas were located on the furrow-irrigated Hamilton farm.

Comparison of total gross buffer area with total effective buffer area on each farm indicates that concentrated flow through riparian buffers was common and substantial (Table 4). Effective buffer area averaged 6%, 12%, 40%, and 81% of the gross buffer area on the Rogers, Burr, ARDC, and Hamilton farms, respectively. On three of the four study farms, field runoff contacted a minor fraction of the gross area of riparian buffer.

Concentrated flow may greatly limit the sediment-trapping capability of riparian buffer areas on these study farms (Table 4). Sediment-trapping efficiency for riparian buffers on each farm was estimated for each field runoff area using the mathematical relationships illustrated in Figure 2, and then the field area-weighted average value was computed for each farm. Among the four farms, buffer-area ratios averaged 0.02 to 0.48, based on gross buffer area, and 0.01 to 0.03, based on effective buffer area. Based on gross buffer area, sediment-retention efficiency was estimated to be 99%, 67%, 59%, and 41% for Rogers, Burr, ARDC, and Hamilton, respectively. However, based on effective buffer area, estimates of sediment trapping efficiency were generally much lower, at 43%, 15%, 23%, and 34%, respectively. Large differences between estimated sediment-trapping

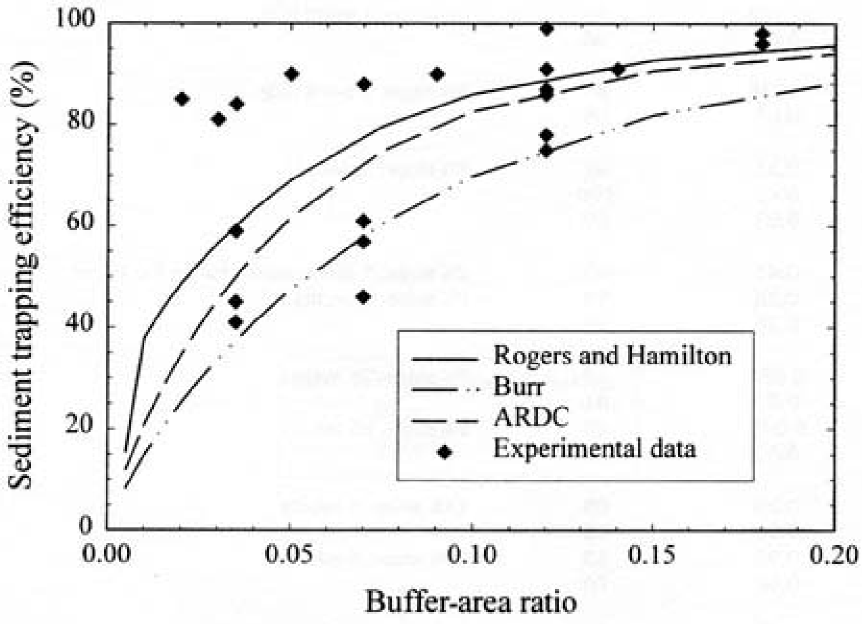
Table 3. Experimental studies that quantify sediment-trapping efficiency of buffers (sediment mass retained as a percentage of input load; %SR) and having a known ratio of effective buffer area to contributing field runoff area. All of these studies were conducted on grass plots, below cultivated erosion areas, under natural or simulated rainfall events, and where runoff was distributed fairly uniformly over the buffer plot area.

Reference	Location	Area Ratio	%SR	Comments
Arora et al. 1993	Iowa	0.035	41	3% slope, 1 event (E1)
		0.07	46	
Arora et al. 1996	Iowa	0.035	84	3% slope, 1 event (E6)
		0.07	88	
Barfield et al. 1998	Kentucky	0.21	97	9% slope, 2 events
		0.42	100	
		0.63	99	
Coyne et al. 1995	Kentucky	0.41	99	9% slope, 1 event, no rainfall on the buffer
Coyne et al. 1998	Kentucky	0.18	98	9% slope, 2 events
		0.25	96	
Daniels and Gilliam 1996[*]	N. Carolina	0.035	59	5% slope, 26 events
		0.07	61	
		0.035	45	2% slope, 35 events
		0.07	57	
Dillaha et al. 1989	Virginia	0.25	86	11% slope, 6 events
		0.50	98	
		0.25	53	16% slope, 6 events
		0.50	70	
Hall et al. 1983	Pennsylvania	0.27	76	14% slope, 1 growing season
Lee et al. 2000	Iowa	0.32	70	8% field slope, 5% buffer slope, 2 events, grass vegetation for 0.32 ratio and trees and grass vegetation for 0.74 ratio.
		0.74	92	
Magette et al. 1989	Maryland	0.21	70	5-10% slope, 3 events
		0.42	86	
Muñoz-Carpena et al. 1999[*]	N. Carolina	0.12	86	5-7% slope, 5 events for 0.12 ratio, 2 events for 0.23 ratio
		0.23	93	
Patty et al. 1997	Brittany, France	0.12	99	7% field slope, level buffer, 5 events
		0.24	99	
		0.36	100	
		0.12	87	10% field slope, level buffer, 3 events
		0.24	100	
		0.36	100	
		0.12	91	15% field slope, level buffer, 8 events
		0.24	97	
		0.36	98	
Parsons et al. 1990	N Carolina	0.12	75	2.5-4% slope, 1 event
		0.23	85	
Parsons et al. 1994[*]	N Carolina	0.12	78	1.9% field slope, 1% buffer slope, 8 events
		0.23	81	
Sheridan et al. 1999[*]	Georgia	0.03	81	3.5% slope, 103 events
Tingle et al. 1998	Mississippi	0.02	85	3% slope, 6 events at 2 and 84 days after tillage
		0.05	90	
		0.09	90	
		0.14	91	
		0.18	96	

[*] **Only the grass buffer data from these studies, that also included forested buffers, are reported here. Data for forested buffers were not used because: (i) effective buffer area could not be reliably calculated, or (ii) slopes were very steep.**

Figure 3

Published data relating sediment-trapping efficiency to buffer-area ratio superimposed over modeled relationships using VFSMOD for four farms in southeastern Nebraska. Buffer-area ratio = (effective buffer area / field runoff area).



efficiency based on gross area compared with the corresponding effective area suggest that concentrated flow may substantially limit sediment trapping by riparian buffers on three of the four farms that we assessed.

Concentrated flow on these farms occurred mostly before entry into riparian buffers (Table 5). For each farm, comparison was made between total length of field margin adjacent to riparian buffers, and widths of effective buffer area (perpendicular to runoff flow) near the field margin and near the stream. These dimensions correspond to widths of the potential flow path into buffers, actual flow path into buffers, and exit from buffers into streams. Entry and exit dimensions were obtained from estimates made for effective pathway segments closest to the field margin and closest to the stream, respectively. By this comparison, entry of runoff into buffers occurred along 8%, 11%, 28%, and 99% of the length of riparian field margin at Rogers, Burr, ARDC, and Hamilton, respectively. At Rogers and Burr, runoff flowed into topographic swales within fields, which was promoted by crop-row orientation parallel to the riparian zone that diverted water laterally across slopes into the swales. In contrast, the furrow system at Hamilton was oriented perpendicular to the stream, which directed runoff across almost the entire field margin into the buffer. At Rogers and ARDC, tillage and sediment accumulation formed berms at field margins 2 to 10 cm in height that appeared to force shallow runoff to run parallel along field margins before entering buffers at low points. Dillaha et al. (1986, 1989) described similar features on hilly landscapes in Virginia.

Further narrowing of the runoff flow paths through buffers was also apparent at the study farms (Table 5). In 71%, 40%, 38%, and 27% of the riparian buffer areas at Rogers, Burr, ARDC, and Hamilton, respectively, runoff exited the buffer through sparsely vegetated gullies. One apparent cause of this flow concentration was the spoils from channelization activities that have been deposited within the buffer zone. These spoils have created high areas (up to 30 cm) and have diverted runoff flow to remaining low areas and breakthrough points. In some locations, gullies were experiencing headcutting from the stream into buffers.

Implications for buffer design and management. Sediment-trapping efficiency of riparian buffers based on gross buffer area may greatly overestimate actual performance. The need to improve the sediment-trapping

Table 4. Total riparian buffer area (gross and effective), total field area draining directly through riparian buffer, average buffer to field area ratio, and estimated average sediment-trapping efficiency for riparian buffers on four farms in southeastern Nebraska.

	Rogers	Burr	ARDC	Hamilton
Total Riparian Buffer Area (ha)				
Gross Area	7.2	1.7	1.5	1.6
Effective Area	0.4	0.2	0.6	1.3
Effective Area as % of Gross Area	6	12	40	81
Total Area of Field Draining Through Riparian Buffer (ha)	15.1	10.7	21.0	109.5
Average Buffer Area : Field Area Ratio (ha/ha)*				
Based on Gross Area	0.48	0.16	0.07	0.02
Based on Effective Area	0.03	0.02	0.03	0.01
Average Sediment Trapping Efficiency (%)†				
Based on Gross Area	99	67	59	41
Based on Effective Area	43	15	23	34

*** Field runoff area-weighted mean.**

† Sediment Trapping Efficiency = [(input load - output load) / input load] x 100%; estimated by computing the value for each individual field runoff area using the relationships in Figure 2, and then, computing the field-weighted mean value for each farm.

Table 5. Riparian buffer width* on four case study farms in southeastern Nebraska.

	Rogers	Burr	ARDC	Hamilton
Number of field runoff areas	14	20	13	60
Total length of field margin adjacent to riparian buffers† (m)	2069	1446	1516	1725
Total width* of effective buffer near the field margin (m)	169	155	428	1708
Total width* of effective buffer near the stream (m)	53	92	392	727
Number of runoff areas where effective buffer nearest the stream consisted of a gully	10	8	5	16

*** "Width" refers to the path dimension perpendicular to runoff flow direction. Effective buffer areas were described as a sequence of up to three segments, each having a relatively narrow range of width. Width near the field margin and near the stream are represented by width of segments closest to field margin and stream, respectively.**

† Equivalent to total width of gross buffer area.

efficiency of existing buffers will depend on effective buffer area and whether it is performing at a desired efficiency level. If improvement is needed, additional information gathered by this method can be used to guide management decisions. At Hamilton, for example, substantial improvement of sediment-trapping efficiency is possible mainly by adding more buffer area, because most of the existing buffer area already contacts field runoff. In contrast, sediment trapping at Rogers, Burr, and ARDC could be improved by factors of 2 to 4 by improving the distribution of runoff to, and through, existing buffer areas. Adding more buffer area could also improve sediment trapping, but this option may not represent an efficient use of the land.

Several practices could be employed to improve distribution of field runoff across existing buffer areas. In the buffer zone, sediment accumulations, spoils from channelization, and tillage berms could be removed to assure that the buffer is lower than the field margin, and especially low areas that concentrate flow could be filled. Within the field, orientation of crop row direction could be adjusted so that it would discourage, or at least not contribute to, flow into swales before reaching the field margins. On relatively hilly topography, this could be accomplished by locating the riparian field margin closely on the contour, rather than a constant distance from the stream. Uphill-downhill farming is not recommended because it would increase erosion rates and counteract improvement in trapping efficiency of the buffer resulting from improved runoff distribution. At field margins, level spreaders (Franklin et al. 1992, Verchot et al. 1997) may be used to disperse concentrated runoff over a larger area of buffer.

In-field conservation practices that reduce total sediment load to buffers can also improve trapping efficiency of the buffers. This benefit occurs so long as other runoff characteristics, such as size distribution of sediment particles, remain relatively unaltered. Sediment loads can be reduced by implementing appropriate tillage, land-shaping, and in-field buffer practices.

Summary and Conclusions

A method was developed that enabled assessment of the extent of concentrated flow of surface runoff through riparian buffers and its probable impact on sediment trapping. The method combines field observations of runoff pathways and modeled estimates of relationships between pathway dimensions and sediment trapping efficiency. This method was used to assess existing riparian buffers on four farms in southeastern Nebraska. While the method was suitable for producing general descriptions of runoff patterns and estimates of the effects of concentrated flow on buffer effectiveness at our study sites, caution is necessary to prevent overly precise interpretations of the resulting data.

Information about the four farms that was obtained using this method included:

1. Concentrated flow of field runoff through existing riparian buffers was common and substantial on three of the four farms we studied. Effective buffer area averaged 6%, 12%, 40% and 81% of the gross buffer area on these four farms.

2. On farms where concentrated flow was substantial, estimated sediment-trapping efficiency was greatly limited. Sediment-trapping efficiency estimated from the ratio of gross buffer area to field runoff area was 99%, 67%, 59%, and 41% on the four study farms, but averaged 43%, 15%, 23%, and 34%, respectively, when based on the ratio of effective buffer area to field runoff area.

3. Most flow concentration occurred within fields, where runoff tended to flow into topographic swales before entry into buffers. Row direction parallel to buffer zones and short berms at field margins appeared to promote flow into the field swales.

4. Better runoff distribution through existing buffer areas would probably greatly improve sediment retention on three of the four farms that we examined. On the fourth farm, where the incidence of concentrated flow was not as great, substantial improvement in sediment trapping is likely to come mainly by adding new buffer area.

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