KANSAS FOREST SERVICE
KANSAS STATE UNIVERSITY

Planning Stream Buffers

Stream buffers are areas of perennial vegetation adjacent to streams, which are managed primarily for environmental benefits. Set aside for conservation, stream buffers in agricultural land are most often present as naturally generated forests on flood-prone or steep land and as planted grass strips on farmable land.

Buffer Benefits

Filtering runoff

A properly functioning stream buffer can improve water quality by intercepting agricultural runoff before it enters a stream. A study of three buffer types (grass, shrub, and fallow) in Geary County, Kansas, showed efficient capture and sequestration of sediment, phosphorus, and nitrogen.

Pollutant delivery to the stream was reduced to roughly half the levels measured in the untreated runoff (Barden, 1995). This filtration comes by way of infiltration. The buffers' surface roughness and soil porosity cause overland flow to slow, seep into the ground, become a subsurface flow, and gradually seep into the stream as return flow.

This residence time provides a steadier streamflow and allows soil and plant processes to capture and neutralize a portion of the pollutants.

Stabilizing streambanks

Stream buffers can affect the process of channel change by adding strength and surface protection to streambanks. In most cases, the stabilization effect is incremental, not total. Soil coverage by roots and foliage along a bank face reduces the rate of surface erosion. Soil reinforcement by roots deep within a bank reduces the size and occurrence of slumps and slides when high banks become saturated.

Example: Republican River, north central Kansas, 1993 high flow.

> During a period of high in-channel flows, but no prolonged overbank flooding, banks with many trees eroded 30 feet, banks with few trees (presumably a grass/tree mix) eroded 19 feet, banks with grass eroded 35 feet, and banks with row crops eroded 75 feet (Geyer, 2003). Sandy banks eroded at 10 times the rate of silty banks.

The presence of trees in stream buffers becomes a decisive factor for bank stability when other, more pervasive factors drive a stream toward a tipping point of rapid change. In disturbed watersheds, a large flood can bring a stream to this threshold.

Not to be confused with in-channel flows, a flood flow moves over the top of the floodplain in a more-or-less straight down-valley direction, crossing over the meandering stream channel at sharp angles along the way. Where trees are not present to obstruct the current, the flood flow can be highly erosive to the stream channel and adjacent fields.

Example: Kansas River, northeast Kansas, 1993 flood flow.

> During a period of prolonged overbank flooding, banks with trees experienced sediment accumulation, banks with grass eroded 80 feet, and banks with row crops eroded 150 feet. (Neppl, 1996). Sandy banks eroded at three times the rate of silty banks.

Quantifying the effects of various streambank vegetation types under normal flow conditions requires long-term field measurement. Geomorphic stream assessments account for more than a dozen factors that directly influence stream behavior (Rosgen, 1996), and form the basis for detailed studies of cause-and-effect relationships between streams and their vegetation

Example: Black Vermillion River and tributaries, northeast Kansas, 2007 – 2010 range of normal flows.

> During a range of normal in-channel flows, banks with trees eroded at half the rate of banks without trees (Keane

2012). Study banks were categorized using a comprehensive bank erosion hazard index and near-bank stress index to isolate the effects of bank vegetation. The streams' entrenched channel form and cohesive bank soils are representative of a large and important watershed region.

Buffer Size

Stream buffers are usually located on land likely to be affected by frequent flooding and/or channel migration. The amount of land that would benefit from management as a buffer varies significantly among streams of different sizes and conditions. For consistent reference among all stream sizes, buffer corridor width can be expressed in terms of the streams' active channel width (ACW).

For meandering streams, a five-ACW corridor provides the narrowest width within which long-term geomorphic processes of channel change may occur without significantly infringing upon adjacent actively managed areas such as cropland, building sites, and transportation infrastructure (Rosgen, 2019).

For steep, nonmeandering headwater streams, a three-ACW corridor likely provides sufficient space for many of the streams' natural processes to occur within.

The active channel width for a given site can be estimated with regional curve equations. These equations predict the stream's stable-form dimensions as related to the drainage area, stream type, and hydro-physiographic province (Emmert, 2001).

Since many streams are yet to recover from the destabilizing effects of historic and current land use and development, direct measurement of project streams for ACW determinations can provide an inconsistent reference for restoration planning. Figure 1 shows a typical progression of stream channel change following disturbance. Many Kansas streams are in stages 3 and 4 as labeled at the bottom of the figure. Notice the significant difference in channel width for the same stream over time.

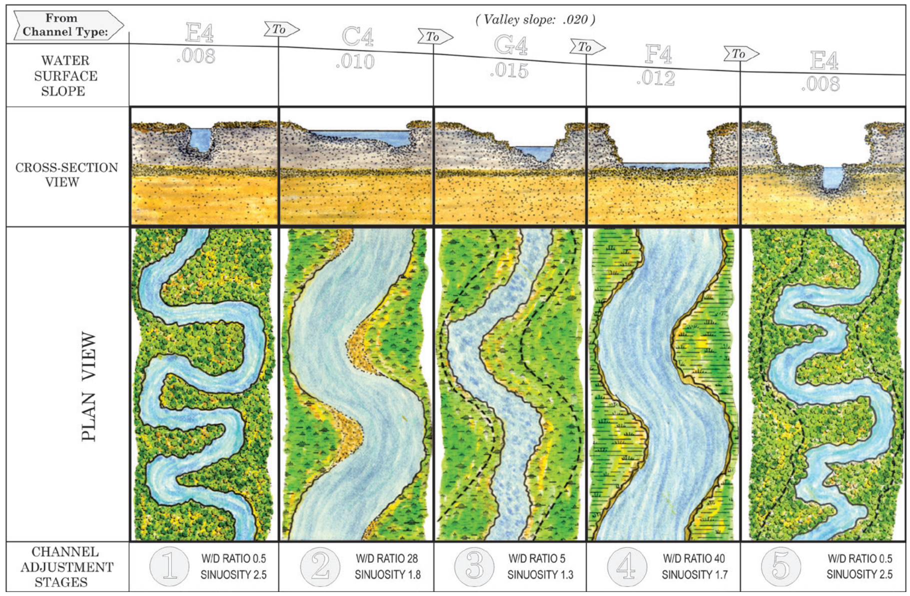

Figure 1. A common channel evolution sequence in Kansas. From Figure 6-5 in Applied River Morphology, 1996 textbook.

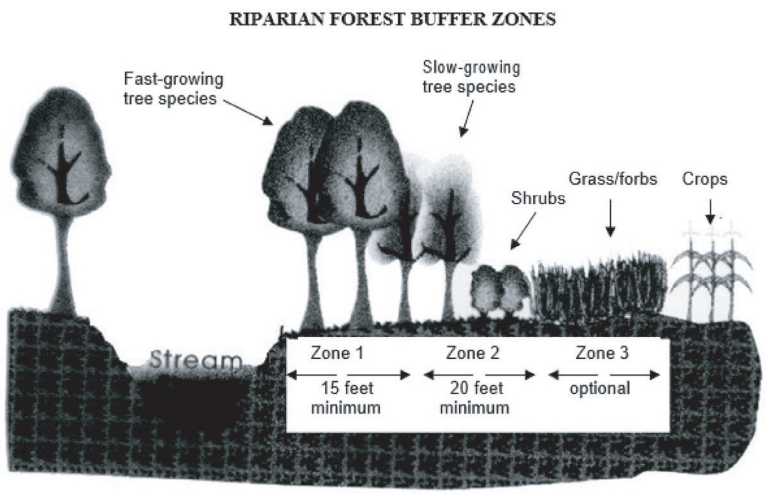

Figure 2. USDA forest buffer concept. From NRCS, 2018.

Buffer Design

Many considerations are pertinent to stream buffer planning. The design should incorporate landowner goals, for example: a specific type of wildlife habitat creation, restoration of the local native plant community, native fruit and nut production for human consumption, timber production, or hay production.

If specific landowner goals are unclear, the design should focus on soil and water conservation goals

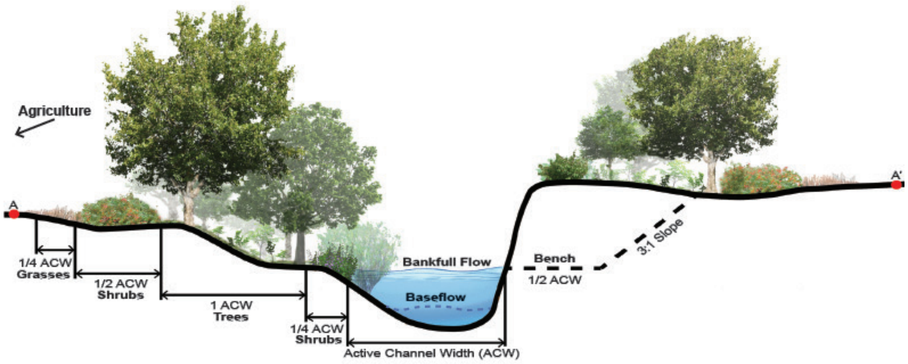

Figure 3. Revised forest buffer concept for incised Kansas streams. From Tindle 2019.

to maximize the long-term public benefits of the project.

A standard agroforestry riparian buffer promoted by USDA, shown in Figure 2, has received widespread application as a template for buffer structure. A slight modification of this concept, shown in Figure 3, may be more fitting to Kansas streams that are still recovering from post-settlement incision. The dashed line shows how high banks may be reshaped to restore a more stable stream geometry.

Kansas-specific Considerations

Forest buffers are a useful and legitimate feature in many of our landscapes, but in some places, their establishment may be counterproductive with other conservation goals.

Example: Pasture management

Riparian tree cover in cattle pasture has been correlated with greater amounts of bare ground and easily erodible sediment near streams as compared to grass-dominated riparian areas (Grudzinski, 2014). When livestock are expected to have access to the buffer, it may not be advisable to plant tree and shrub species that will create a shade canopy and encourage livestock to loaf around the stream. Livestock exclusion fencing is rarely adopted to preclude this behavior due to high installation expense, high likelihood of flood damage, and reduced access for invasive plant control. Possible alternatives: 1) Native grass/forb mix with or without shrubs. 2) Installation of off-stream livestock water and shade.

Example: Landscape architecture

The stable width of streams has been correlated with vegetative cover: Small streams with wooded riparian zones tend to be wider than small streams with herbaceous riparian zones (Anderson 2004). In consideration of natural plant community distributions and reservoir sedimentation issues in Kansas, it may not be advisable to plant trees in the near-stream zone of small, historically prairie streams where large woody debris is likely to contribute to channel blockages, bank scour, flooding, and the formation of bypass channels. Possible alternative: 1) Native grass/forb mix with or without shrubs. 2) Periodic clearing of large woody debris from the stream.

Buffer designs ought to differ according to site-specific conditions. Local plant communities, stream evolutionary processes, and land management practices dominate the long-term outcomes of buffer projects, so their designs should anticipate and work with these conditions from the outset. Linking buffer structure to stream size may be the simplest way to complement the common trends of stream corridor processes, land-use, and conservation needs in Kansas.

- Large streams:
  - Dense forest
- Medium-sized streams:
  - Dense forest
  - Woodland (native grasses/forbs with many trees)
- Small streams:
  - Woodland (native grasses/forbs with many trees)
  - Savanna (native grasses/forbs with scattered trees)
  - Shrubland (native grasses/forbs with shrub patches)
  - Prairie (native grasses/forbs alone)

References

Anderson, R., Bledsoe, B., and Hession, C. "Width of Streams and Rivers in Response to Vegetation, Bank Material, and Other Factors." Journal of the American Water Resources Association / 40.5 (2004): 1159-172. Web.

Barden, Charles J., Mankin, Kyle R., Ngandu, Daniel, and Geyer, Wayne A. "Assessing the Effectiveness of Various Riparian Buffer Vegetation Types." Kansas Agricultural Experiment Station Research Reports 12 (1995): Kansas Agricultural Experiment Station Research Reports, 1995-01-01 (12). Web.

Emmert, B.E., and Hase, K. Geomorphic assessment and classification of Kansas riparian systems. EPA No. CD997520-01 (2001)

Geyer, W. A., Neppl T., and Brooks K. "Streambank Stability of Two Kansas River Systems during the 1993 Flood in Kansas, USA." Transactions of the Kansas Academy of Science 106.1/2 (2003): 48-53. Web.

Grudzinski, Bartosz Piotr, and Kansas State University, Degree Granting Institution. Influence of Watershed Grazing Management on Stream Geomorphology in Grassland Headwater Streams. (2014). Web.

Keane, Tim D. and Sass, Christopher K. "Application of Rosgen's BANCS Model for NE Kansas and the Development of Predictive Streambank Erosion Curves." Journal of the American Water Resources Association 48.4 (2012): 774-87. Web.

Natural Resource Conservation Service, Kansas. Construction Specifications Riparian Forest Buffer (391). (2018): Web.

Neppl, Thomas G. "Influence of riparian vegetation on the Kansas River flood of 1993: an assessment of streambank erosion, deposition, and channel migration." Unpublished Thesis. (1996)

Rosgen, Dave. "Applied River Morphology." Wildland Hydrology. (1996)

Rosgen, Dave. "A Geomorphological Approach to Restoration of Incised Rivers." Proceedings of the Conference on Management of Landscapes Disturbed by Channel Incision. (1997)

Rosgen, Dave. Personal Communication. (2019)

Tindle, Jarran. Unpublished Riparian Forest Buffer Illustrations. Kansas Forest Service. (2019)

This publication is made available in cooperation with the USDA Forest Service.

Jarran Tindle
Kansas Forest Service
2610 Claflin Road
Manhattan, KS 66502
(785) 532-3300
www.kansasforests.org

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

MF3562 December 2021

K-State Research and Extension is an equal opportunity provider and employer. Issued in furtherance of Cooperative Extension Work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Director of K-State Research and Extension, Kansas State University, County Extension Councils, Extension Districts.