Twin Lakes Watershed Riparian Forest Assessment

Level Creek and Haun Creek Huc-12s

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Executive Summary

The Kansas Forest Service's Natural Resource Conservation Service's Regional Conservation Partnership Program (KFS-NRCS RCPP) assessment project involved using Geographical Information Systems (GIS), remote sensing, and in-field forest inventory to determine the location, extent, functional condition, and species composition of riparian forests and understory vegetation within the two Hydrologic Unit Code 12 (HUC-12s) of the Twin Lakes watershed in Morris County, Ks. In addition to the in-field forest inventory, in-field stream visual assessment protocol (SVAP-2), bank erosion hazard index (BEHI), and near-bank stress (NBS) measurements were completed in each of the two HUC-12 watersheds.

Once riparian forest location and extent were determined through GIS, forest functioning condition classes were assigned by calculating the percentage of forest canopy coverage within the riparian area. Based on these calculations, forests were placed into one of three functioning condition classes: *Forest in need of conservation* (forests that had adequate canopy coverage to protect streambanks), *Forest in need of management* (forests that exhibited less-than-ideal canopy coverage), and *Forest in need of establishment* (areas lacking forest canopy cover/bare streambank sites).

Forest data, forest regeneration data, ground cover vegetation, and visual observations were also recorded or made at field plots within each HUC-12. In addition, coefficient of conservatism (CoC) values were assigned to tree, sapling, seedling, and ground-cover vegetation. Mean C values provide a snapshot evaluation of the disturbance level and native biodiversity of the riparian forests to identify potential ecological and forest management resource concerns.

According to the GIS assessment, a majority of the 2 Active Channel Width (ACW) riparian area was determined to be forest in need of establishment (37.2 percent within Level Creek and 28.5 percent within Haun Creek) and forest in need of management (34.4 percent within Level Creek and 26.7 percent within Haun Creek). However, results of field inventories indicated that remote assessment overestimated the riparian area classified as forest in need of conservation, so much of that area should likely be reclassified as forest in need of management.

Riparian inventories and analysis of tree, sapling, seedling, and understory vegetation in the field indicated a relatively low number of species encountered per transect. These results are indicative of a low quality, disturbed riparian zone in both measurement areas.

Tree Value Groups 2 and 3 were found to dominate all watershed riparian zones, Value Group 2 was especially dominated by common hackberry. Common hackberry and other Value Group 2 and 3 trees also dominated regeneration subplots. Commonly observed threats to healthy, sustainable riparian woodlands included livestock use and lack of active forest management. BEHI scores indicated "very high" potential for streambank erosion in both of the HUC-12s.

Introduction

Forests that border waterways are known as riparian forests. Riparian, from the Latin word *riparius,* "frequenting riverbanks" or "the bank of a river" is where land meets water. Riparian areas in Kansas have many different compositions — from native tallgrass prairie lining the headwater streams of the Flint Hills to big-timber floodplain forests along rivers such as the Republican, Big Blue, Kansas, Missouri, Marais des Cygnes, Marmaton, and Neosho. Riparian areas and the forests they support provide benefits to both landowners and the environment, including valuable ecosystem goods and services.

Certain riparian areas, with rich soil and abundant water, are prime sites for timber production in Kansas. Properly functioning riparian forests provide watershed landowners and residents with a wide variety of sustainable income sources (e.g., quality timber, fuelwood, nuts, and berries) and aesthetics. With timber, food, and water all in one location, riparian areas also can provide landowners with excellent wildlife habitat — leading to outstanding hunting, fishing, and other recreational opportunities. Healthy riparian areas also buffer waterways by absorbing pollutants flowing off the landscape, leading to improved water quality. Forested riparian areas also help to stabilize streambanks, which can prevent large quantities of soil (and soil-associated pollutants, such as phosphorus) from entering streams. In Kansas, streambank stabilization may be the most important role for riparian forests in terms of water quality.

Research along the Kansas River following the flood of 1993 suggests riparian forests outperform other landcover types (e.g., grass, row crop) in stabilizing streambanks and reducing downstream sediment delivery (Geyer, et al., 2003). By protecting streambanks, forests also reduce the loading of sediment-associated nutrients to waterways. Because of their correlation to reduced sediment and nutrient loading, as well as their ability to provide other ecological goods and services such as stream shading and cooling, increased soil infiltration, filtration of pollutants from surface runoff, carbon sequestration, and wildlife habitat, properly functioning riparian forests are a critical component of the Twin Lakes watershed, Council Grove Reservoir, and Council Grove City Lake, as well as the greater Neosho River basin.

The goal of this project was to determine the location, extent, functioning condition, and species composition of riparian forests and understory vegetation within the two HUC-12 sections of the larger Twin Lakes watershed in Morris County, Kansas (Figure 1). Secondary goals of this project include gathering baseline riparian forest and understory vegetation information for the watershed and the region. Information gathered in this study will help Kansas Forest Service, Natural Resource Conservation Service (NRCS), Kansas Alliance for Wetlands and Streams (KAWS), and other conservation partners answer the following critical questions:

- Where are our riparian forests located?
- In what condition are they and their understory vegetation?
- How many acres exist?
- What tree species and understory vegetation are present?

Information gained from this project will help the Kansas Forest Service foresters and their partners determine where to work in order to achieve the biggest water quality benefits.

GIS Methodology

This project focused on assessing riparian forests within the Twin Lakes based on:

- **A two active channel width (2ACW) distance from the top of the streambank**, based on "Stream Visual Assessment Protocol v.2" (SVAP2, NRCS 2009) and the "Riparian Area Management: Process for Assessing Proper Functioning Condition" guidance (PFC, USDI-BLM 1998).
- **One square mile of drainage area to define where intermittent and perennial streams begin,** based on flow accumulation derived from 2 meter LiDAR digital elevation model (DEM) for Morris County (Kansas Data Access Center: *www.kansasgis.org*).
- **Consideration of Soils indexed to NRCS Conservation Tree and Shrub Groups (CTSG) 1, 2 and 3** based on the Soil Survey Geographic Database (SSURGO) for Kansas.
- **Estimated historical Kansas forest maps,** derived from historical Public Land Survey System (PLSS) (approximately 1850-70s) (Kansas Biological Survey 2010).

Determining the Active Channel Width

Table 1 presents the regression formulas (Tetra Tech et al. 2005) used to determine the recommended 2ACW riparian buffer zone along all 1 square mile drainage area streams.

Defining Intermittent and Perennial Streams (Why was a one square mile drainage area used?)

One way to classify streams is based on the flow characteristics of the stream. There are generally three types: perennial, intermittent, and ephemeral. Perennial streams generally flow more than 90 percent of the time. Intermittent streams flow only during wet periods (usually 30 to 90 percent of the time), and they flow in well-defined channels. Ephemeral streams only flow during storms and may or may not have well-defined channels. The stream bed for an ephemeral stream is always above the water table, so the primary source of water is storm runoff. These streams only have a limited water supply for riparian forests.

Since this riparian inventory was primarily focused on the quantity and quality of riparian forest in the 2ACW riparian zone, which would support riparian trees, we used a one square mile drainage area as the minimum threshold for determining the watershed riparian zones (Figure 1).

Why were CTSG 1,2 and 3 soils used as an overlay?

CTSG Soil Groups 1, 2, and 3 represent productive, floodplain soils, which have the greatest potential for forest/tree growth and management in riparian areas. These soils, because of their proximity to waterways, represent the area where trees would be most effective for water quality enhancement. However, limitations observed in the SSURGO soil survey data for CTSG 1, 2, and 3 soils in the riparian area influenced the decision to include this layer as an overlap rather than a definitive intersecting factor. Figure 2 identifies where CTSG 1, 2, and 3 soils are located in the Level Creek and Haun Creek watersheds.

Why were estimated historical Kansas forest maps used as an overlay?

A common question asked is, "Where did woodlands and forests occur naturally in Kansas before settlement?" This question is difficult to answer since there are limited records and few photographs from the period of westward migration through the United States and the Kansas settlement. The historical PLSS maps and notes were used as an overlay to compare the extent of riparian forest occurring now to what was estimated from maps and notes recorded during the settlement of Kansas.

The riparian area (i.e., the overlap of 2ACW width and one square mile drainage streams and rivers overlaid with CTSG 1, 2, and 3 soils and estimated Kansas historical forests) for the two project watersheds can be viewed in Figure 2.

Determining Forest Extent and Cover

Riparian forest extent was determined using 2011 leaf-off LiDAR imagery through evaluation of first return (top of forest canopy) and bare earth (ground level of forest canopy) imagery based on reflectance of laser light sources as it occurred throughout the Level Creek and Haun Creek watersheds in 2011: [First return LiDAR] – [Bare earth LiDAR]. Trees were defined where the difference between first return and bare earth reflectance height equaled or exceeded 1 meter, then all tree polygons were clipped to the 2ACW riparian buffer extent. The riparian forest extent boundaries were then evaluated to determine vegetative cover reflectance using a Normalized Difference Vegetation Index (NDVI) classification. NDVI values were calculated for a focused area (2ACW riparian forest) and were intentionally constrained to evaluate the NDVI values for riparian forest only, so as not to confound classification of other

land uses (e.g., confusion of high NDVI value cropland with riparian forest).

NDVI was calculated for 2015 1-meter color-infrared National Agriculture Imagery Program (NAIP) imagery clipped to the 2ACW riparian area of Level Creek and Haun Creek watersheds as the ratio of: ([near-infrared band] – [visible red band]) ÷ ([near-infrared band] + [visible red band]). This value was converted to a number from 0 to 200 for visual display.

Assigning Riparian Forest Functioning Condition Class

Functioning condition class was determined by estimating the percentage of forest cover occurring within the riparian area using NDVI values. Based on NDVI values, riparian forest areas exhibiting approximately 5 to 70 percent cover were classified as *forest in need of management*, and those with 70 to 100 percent forest cover were classified as *forest in need of conservation*.

Riparian Forest Inventory Methodology

Sampling Design

Forest data were collected at 15 transect plots located within the study watersheds — five in Level Creek and 10 in Haun Creek watersheds (Figure 3 – maps at the end of document). Transect plots were divided into two quadrats in 1ACW zone and two quadrats in 1ACW to 2ACW zone (if transect extended beyond 1ACW) (Figure 4). Forest data were collected to verify the GIS assumptions, and to collect vital information on riparian forest composition and structure. A landowner list was assembled and permission was sought for access to potential riparian inventory sites. Based on landowner permission, the first 15 of 25 potential sites were selected for riparian inventory.

Plot Layout and Forest Data Collection

Fifteen rectangular riparian forest inventory plots (Figure 4) were randomly located within the 2ACW riparian area identified by GIS for both the Level Creek and Haun Creek watersheds to capture the range of riparian area conditions. In the field, the survey crew went to each plot location and established a transect perpendicular to the stream that extended up to 2ACW (Figure 4, Table 1). The width of the transect was 30 feet, resulting in an area of 30 feet multiplied by the length of the transect. Within this rectangular transect plot or belt, a number of tree measurements and observations were recorded, including forest canopy, diameter at breast height (DBH) of tree species, and tree height of dominant crown class by species. General notes were recorded for each tree as well, such as presence of degradation including obvious pests and disease.

Within transect plots, forest canopy cover was evaluated along the transect line (Figure 4). Canopy cover measurements were made along the transect line every 10 feet starting from the beginning of the transect and extending up to 2ACW, if the riparian forest extended that far. Canopy cover was estimated as a percentage for each 10-foot point and classified as either part of the 1ACW or 2ACW riparian zone.

Within transect plots, all trees greater than 5 inches DBH were classified as mature trees and measured. Thirty-foot wide forest inventory transect plots or belt transects were divided into four quadrats by length up to the end of the 2ACW riparian zone and all trees occurring within the transect plots were measured for DBH and recorded by quadrat location. Quadrats 1 and 2 (Q1 and Q2) were located within 1ACW nearest the stream while Quadrats 3 and 4 (Q3 and Q4) were located within the 1ACW to 2ACW riparian zone of the transect furthest from the stream, if the riparian forest extended into the 2ACW zone of the riparian area. Forest width from the top of the streambank and forest canopy coverage also were recorded at plot transects. The heights of the dominant overstory trees were recorded by

Figure 4. *Forest inventory plot layout, with Q1 through Q4 representing transect quadrats and R1 and R2 representing understory vegetation regeneration sub-plots. Not to scale.*

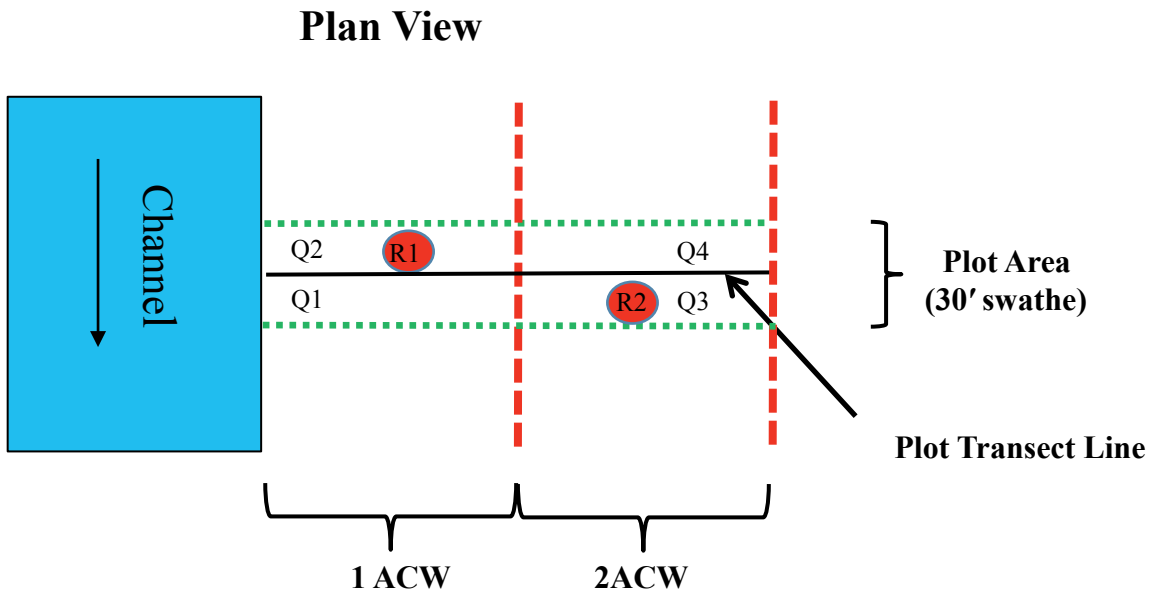

Table 1. *Riparian zone width estimates based on regression formulas for bankfull width (1ACW), bankfull depth, bankfull cross-sectional area, bankfull discharge, and drainage area by site number and watershed for Level Creek and Haun Creek watersheds. 1ACW refers to the extent from top of bankfull streambank to 1ACW riparian buffer and 2ACW refers to the riparian area extent from 1ACW to 2ACW of riparian buffer.*

Site	Drainage Area (mi^2)	Bankfull Width (1ACW) (ft)	Bankfull Depth (ft)	Bankfull Cross-sectional Area (ft^2)	Bankfull Discharge ($ft^3\ s^{-1}$)	2ACW (ft)
Level Creek						
3	11.7	50.3	2.2	110.7	2,035.5	100.6
4	2.6	28.7	1.4	40.2	137.6	57.4
17	13.7	53.4	2.4	128.2	500.3	106.8
19	5.4	37.7	1.8	67.9	242.7	75.4
25	2.0	26.0	1.3	33.8	112.2	52.0
Haun Creek	mi^2	ft	ft	ft^2	$ft^3\ s^{-1}$	ft
1	85.7	106.0	4.2	445.2	2,078.9	212.0
2	83.4	105.0	4.2	441.0	2,035.5	210.0
6	52.1	88.0	3.6	316.8	1,412.3	176.0
7	72.3	99.5	4.0	398.0	1,821.7	199.0
10	2.5	28.2	1.4	39.5	133.4	56.4
11	4.9	36.3	1.7	61.7	225.1	72.6
12	6.6	40.6	1.9	77.1	283.7	81.2
13	79.4	103.0	4.1	422.3	1,259.2	206.0
15	86.6	106.4	4.2	446.9	2,095.9	212.8
18	80.4	103.5	4.1	424.4	1,978.3	207.0

Regression Formula	Flint Hills Regional Curves (Tetra Tech et al. 2005)
Bankfull Width (BkfW or ACW) (ft)	$BkfW = 20.04 \times [\text{Drainage Area, } mi^2]^{0.3743}$
Bankfull Depth (BkfD) (ft)	$BkfD = 1.04 \times [\text{Drainage Area, } mi^2]^{0.3136}$
Bankfull Cross-sectional Area (BkfA) (ft^2)	BkfA = BkfW × BkfD
Bankfull Discharge (BkfQ)($ft^3\ s^{-1}$)	$BkfQ = 65.48 \times [\text{Drainage Area, } mi^2]^{0.7769}$

species within each quadrat and typically ranged from 30 to 70 feet.

Qualitative data also were recorded, such as evidence of livestock use and woodland management (i.e., marking, harvesting, or planting trees). If riparian inventory transects did not extend to 2ACW, the land use for the riparian area beyond where the riparian forest terminated was also visually classified as native grass, pasture, cropland, etc.

Seedling and sapling regeneration was recorded at 30 circular subplots within the 15 main transect plots located in the two study watersheds (maps at the end of document). Regeneration subplots (R1 and R2) had a radius of 5.3 feet (covering 1/500 acre), with at least one subplot located within Q1 or Q2, and at least one subplot located in Q3 or Q4 if the riparian forest extended into the 2ACW of the riparian area. Regeneration subplots (R1 and R2) were randomly located within the 1ACW riparian area (Q1 or Q2) and in the 2ACW riparian area (Q3 or Q4). If quadrats near-stream (Q1 or far stream (Q3 or Q4) were observed to be notably different, additional regeneration plots

Table 2. *Modified Daubenmire cover class scale used for the project.*

Cover Class	Trace	1	2	3	4	5	6	7	8	9	10
Range (%)	<1	1-4	5-15	16-25	26-39	40-60	61-74	75-84	85-95	96-99	100
Midpoint (%)	0.5	2.5	10.0	20.5	32.5	50.0	67.5	79.5	90.0	97.5	100

were evaluated in those quadrats, with locations within quadrats randomly determined.

Saplings were recorded in the plots if they were more than one inch but less than five inches in DBH. Seedlings were classified as any small specimens of tree species present up to 4.5 feet tall and having a DBH of less than one inch.

Ground cover vegetation was also measured within the regeneration subplots and included any plant species having a height of less than 4.5 feet. At each subplot, percent cover of each species rooted in or extending into the plot was estimated using a modified Daubenmire cover class approach per Tiner (1999) as shown in Table 2.

General notes regarding high water marks, flood debris, presence of levees and other potential influences on distribution of trees, saplings, seedlings and understory plants were also documented.

Calculations

The collected forest data was used to calculate the following, which provide a good estimation of forest structure and composition for the two watersheds:

a. Basal area per acre (BAA)
b. Trees per acre (TA)
c. Regeneration (seedlings and saplings) per acre (RA)
d. Quadratic mean diameter (QMD)

Species BA is a key measure of dominance, and is defined as the cross-sectional area at breast height and is computed through the formula by Avery and Burkhart (1994):

$$BA\ (ft^2) = \frac{\pi dbh^2}{4(144)} = 0.005454 \times DBH^2$$

where *BA* is the basal area of the tree, *DBH* is the diameter at breast height, and π is the mathematical constant 3.14159.

Categorization of tree species according to timber value

An important consideration was the tree species composition from a commercial viewpoint for the watersheds. In consultation with Kansas Forest Service forester David Bruton, the species found in the assessed watersheds were categorized into three groups, based on current timber market value. Group 1 (high dollar value) was composed of oak species and walnut. Group 2 (moderate dollar value) was composed of ash, black cherry, cottonwood, hackberry, hickory, basswood, and silver maple. Group 3 (low dollar value) was composed of all other species.

Stream Visual Assessment Protocol-2 (SVAP2), Bank Erosion Hazard Index (BEHI) and Near-bank Stress (NBS) Assessments

SVAP2 is a national protocol that provides an initial evaluation of the overall condition of wadeable streams, their riparian zones, and in-stream habitats. The SVAP2 is a preliminary qualitative assessment tool to evaluate features that affect overall stream conditions for wadeable streams at the property level and to identify resource concerns for NRCS programmatic support. The tool assesses visually apparent physical, chemical, and biological features within a specified reach of a stream corridor. Because of its qualitative nature, the protocol may not detect all causes of resource concerns, especially if such causes are a result of land use actions in other parts of the watershed. It does provide a means to assess site conditions of properties in the context of the larger watershed. A synthesis of information gathered during the preliminary assessment and field assessment portions of the protocol can be used to provide general guidance to landowners on how watershed features and practices they employ are reflected in the quality of their stream ecosystems and to highlight on-site resource concerns (NRCS 2009). SVAP2 is used by NRCS to evaluate resource concerns associated with water quality and can be used to score and rank sites for practice implementation to address the resource concerns. We performed SVAP2 assessments on two representative sites in the Level Creek and Haun Creek watersheds (one per watershed) according to methods outlined in NRCS guidance (NRCS 2009).

The BEHI assessment evaluates the susceptibility of a streambank to erosion by scoring multiple variables, which integrate combined streambank erosional processes and risks into an overall BEHI rating. We performed BEHI assessments on two study banks at representative sites (same as for SVAP2 and NBS) in the Level Creek and Haun Creek watersheds by taking measurements of the following variables:

- ratio of study bank to bankfull height;
- ratio of root depth to study bank height;
- root density for study bank;
- bank angle;
- percent surface protection;
- evaluation of bank materials and identification of stratified layers in the study bank and layers materials.

GIS Results

2ACW Riparian Zone and Streams

The total watershed areas for the Level Creek and Haun Creek HUC-12 watersheds were 28,234.4 and 28,081.2 acres, respectively (Table 3). The area identified as the 2ACW riparian zone in Level Creek watershed was 981.1 acres compared to 1170.8 acres for Haun Creek.

In the Level Creek watershed, second-order streams had the highest stream miles (18.5 miles) relative to third-order streams (10.1 miles), first-order streams (7.8 miles) and fourth-order streams (4.3 miles); all stream miles totaled 40.6 miles within the watershed. In the Haun Creek watershed, second-order streams had the highest stream miles (16.5 miles) followed by third-order streams (11.0 miles), fourth-order streams (8.6 miles) and first-order streams (3.9 miles), totaling 40.0 stream miles. Haun Creek had the highest miles of fourth-order streams overall: 8.6 miles compared to 4.3 miles for Level Creek. The Neosho River was the fourth-order stream in both watersheds (Table 3). Note that some first-order streams, likely ephemeral streams for the most part, were not captured in the 1.0-mile drainage threshold used in this analysis (i.e., some small primary headwater streams on a U.S. Geological Survey were not included).

Historical maps of riparian forest indicated that 4.0 percent of 2ACW riparian zone in Level Creek was likely riparian forest at the time the PLSS surveys during settlement in the 1850s to 1870s and 43.1 percent of the 2ACW riparian zone of Haun Creek was riparian forest (Table 2, Figure 2). Most of the historical riparian forest identified in both watersheds was along the Neosho River, and some of it was located along some second- and third-order tributaries (i.e., Crooked Creek and Haun Creek) to the Neosho River. Several of the riparian inventory sites in the Haun Creek watershed indicated the presence of historical riparian forest; however, obvious disturbance of the historical forest was observed at all sites, with few remaining old-growth trees present. This is also reflected in CoC and mean C values for the riparian inventory sites as described later in this report.

Table 3. *Descriptive comparisons of watershed area, 2ACW riparian zone, stream order, CTSG soil groups, and historical forest within the watershed riparian zones for Level Creek and Haun Creek watersheds.*

Watershed, Stream and Riparian Description	Level Creek	Haun Creek
Watershed Area	**Acres**	**Acres**
Total	28,234.4	28,081.2
2ACW Riparian Zone	**Acres**	**Acres**
Total	981.14	1,170.83
Stream Order	**Miles**	**Miles**
1	7.75	3.93
2	18.47	16.45
3	10.07	11.01
4	4.32	8.64
Total	40.61	40.03
CTSG Soils (2ACW)	**Acres**	**Acres**
1	4.19	0
4c	112.21	2.97
6	69.8	72.79
Not rated	794.94	1,095.07
Total	981.14	1,170.83
CTSG Soils 1, 2 and 3 % of Total (2ACW)	**%**	**%**
Total	0.43	0.00
Historical Forest (2ACW)	**Acres**	**Acres**
Total	39.15	504.23
% of 2ACW Riparian Zone	**%**	**%**
Total	3.99	43.07

Riparian Forest Functioning Condition Classes

Haun Creek watershed had the larger riparian area (1,170.8 acres), followed by Level Creek (981.1 acres) (Table 4). Within the Level Creek watershed, the majority of the riparian area acreage was determined to be of the following functioning condition classes: 37.2 percent *forest in need of establishment*, 34.4 percent *forest in need of management,* 21.5 percent *forest in need of conservation* and the remainder in other classes totaling less than 5 percent of the riparian area (Table 4, Figure 5). Within the Haun Creek watershed, the majority of the riparian area acreage was determined to be of the following functioning condition classes: 38.3 percent *forest in need of conservation*, 28.5 percent *forest in need of*

Table 4. *Forest functioning condition class by watershed riparian area in Level Creek and Haun Creek watersheds.*

Level Creek HUC-12 Watershed			Haun Creek HUC-12 Watershed		
Riparian Class	**Acres**	**%**	**Riparian Class**	**Acres**	**%**
Channel or Low Veg	27.50	2.80	Channel or Low Veg	39.44	3.37
Conservation	211.03	21.51	Conservation	448.83	38.33
Developed	12.23	1.25	Developed	7.33	0.63
Establishment	365.08	37.21	Establishment	333.37	28.47
Likely Wetland	0.00	0.00	Likely Wetland	0.25	0.02
Management	337.27	34.37	Management	323.70	27.65
Pond	19.96	2.03	Pond	0.00	0.00
Potential Wetland	0.00	0.00	Potential Wetland	3.43	0.29
Water	8.08	0.82	Water	14.49	1.24
Total	981.14	100.00	Total	1170.83	100.00

establishment, 27.7 percent *forest in need of management,* and the remainder in other classes totaling less than 6 percent of the riparian area (Table 4, Figure 6). Total acres of actual woodland identified within Level Creek and Haun Creek riparian areas were determined to be 548.3 and 772.5 acres, respectively.

Riparian Forest Inventory Results

Of the 15 transect plots (Figure 3), only six had riparian zones extending beyond 1ACW (three sites each in Level Creek and in Haun Creek) and only three of those had riparian zones extending to a full 2ACW riparian zone (two sites in Level Creek and one site in Haun Creek). Therefore, evaluation of the 1ACW to 2ACW riparian zone could only be completed at six transect plot locations and only at three sites for the entirety of the 2ACW riparian zone. Additionally, five of the riparian zones for the transect plot locations did not cover a full 1ACW extent in the study watersheds (two sites in Level Creek and three sites in Haun Creek watersheds).

Trees per Acre (TA) and Basal Area per Acre (BAA)

For TA (all species combined), the 1ACW to 2ACW (2ACW) riparian zone of Level Creek had the higher TA value of 183.0 ± 60.4 trees acre^{-1}. Average TA (all species combined) varied within and among watershed riparian zones ranging from 133.6 ± 34.0 trees acre^{-1} in 1 ACW of Level Creek to 183.0 ± 60.4 trees acre^{-1} in the 2ACW of Level Creek (Table 5, Figure 7). The 1ACW and 2ACW riparian zones of Haun Creek had TA values (all species combined) of 177.0 ± 43.0 and 149.2 ± 85.7, respectively.

Of the riparian zones in the two study watersheds, the 1ACW riparian zone of Haun Creek was found to have the highest BAA (all species combined), totaling 146.2 ± 25.9 ft^2. The lowest BAA (all species combined) was found in the 2ACW riparian zone of Level Creek (101.5 ± 19.2 ft^2). No significant differences were found when comparing average BAA (all species combined) among the 1ACW and 2ACW riparian zones in Level Creek and Haun Creek watersheds, although a statistical analysis was not performed. Small sample sizes and large standard errors contributed to no substantial differences in average BAA values.

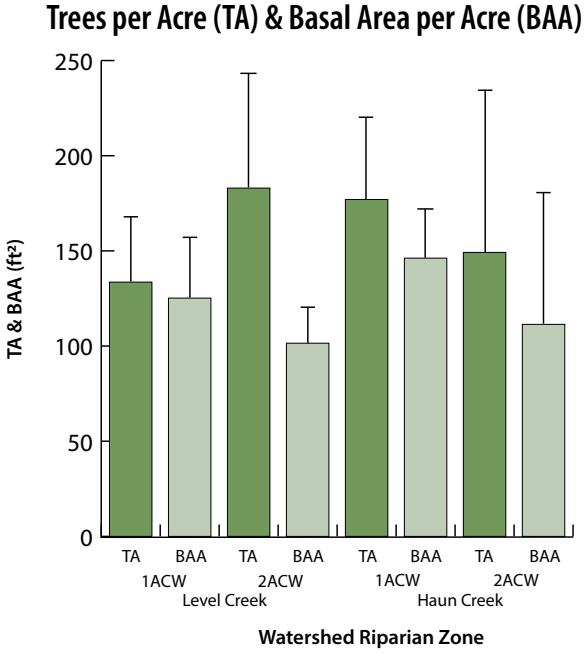

Figure 7. *Total BAA and TA (all species combined) by watershed and riparian zone (i.e., stream bank at 1ACW and 2ACW where it existed). Error bars are one standard error for the transect plots evaluated for all of the sites in each watershed riparian zone.*

Table 5. *Watershed TA (#), BAA (ft²) and QMD (inches) breakdown, by species and riparian zone. Top 3 species per category displayed in red text.*

TA,BAA and QMD	1ACW Level Creek			2ACW Level Creek			1ACW Haun Creek			2ACW Haun Creek		
By Species	TA (#)	BAA (ft2)	QMD (in)	TA (#)	BAA (ft2)	QMD (in)	TA (#)	BAA (ft2)	QMD (in)	TA (#)	BAA (ft2)	QMD (in)
Black Walnut	8.9	6.2	11.3	12.2	11.4	13.1	8.0	19.0	21.0	0.0	0.0	0.0
American Elm	17.8	9.1	9.7	0.0	0.0	0.0	13.9	7.2	9.7	29.8	6.7	6.4
Sycamore	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.7	5.8	0.0	0.0	0.0
Silver Maple	0.0	0.0	0.0	0.0	0.0	0.0	4.0	3.6	12.9	0.0	0.0	0.0
Green Ash	0.0	0.0	0.0	24.4	20.3	12.4	21.9	10.1	9.2	9.9	43.7	28.4
Bur Oak	0.0	0.0	0.0	0.0	0.0	0.0	8.0	6.7	12.4	0.0	0.0	0.0
Kentucky Coffee	0.0	0.0	0.0	0.0	0.0	0.0	23.9	7.4	7.9	59.7	33.0	10.1
Osage Orange	8.9	7.0	12.0	0.0	0.0	0.0	9.9	4.4	9.0	0.0	0.0	0.0
Honey Locust	17.8	3.8	6.3	48.8	22.3	9.1	17.9	7.5	9.3	0.0	0.0	0.0
Basswood	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.3	14.7	0.0	0.0	0.0
Plains Cottonwood	0.0	0.0	0.0	0.0	0.0	0.0	6.0	13.8	20.6	0.0	0.0	0.0
Chinkapin Oak	0.0	0.0	0.0	0.0	0.0	0.0	2.0	11.7	32.9	0.0	0.0	0.0
Boxelder	8.9	14.0	17.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Common Hackberry	71.3	85.0	14.8	97.6	47.5	9.4	55.7	51.7	13.3	49.7	27.9	10.2
Total	133.6	125.2	71.0	183.0	101.5	44.1	177.0	146.2	178.6	149.2	111.4	55.0

TA values in Level Creek watershed were found to be dominated by common hackberry (*Celtis occidentalis*, 71.3), American elm (*Ulmus americana*, 17.8), and honey locust (*Gleditsia triacanthos,* 17.8) in the 1ACW riparian zone and common hackberry (97.6), honey locust (48.8), and green ash (*Fraxinus pennsylvanica*, 24.4) in the 2ACW riparian zone (Table 5). Haun Creek was dominated by common hackberry (55.7), Kentucky coffeetree (*Gymnocladus dioica*, 23.9), and green ash (21.9) in the 1ACW riparian zone and Kentucky coffeetree (59.7), common hackberry (49.7), and American elm (29.8) in the 2ACW riparian zone (Table 5).

The top three BAA species in the 1ACW riparian zone of Level Creek were common hackberry (85.0 ft²), boxelder (*Acer negundo*,14.0 ft²), and American elm (9.2 ft²) (Figure 8).

Within the 2ACW riparian zone of Level Creek, the top three species in terms of BAA were common hackberry, honey locust, and green ash (Figure 8).

Within the 1ACW riparian zone of Haun Creek, the top three species in terms of BAA were common hackberry, black walnut (*Juglans nigra*), and plains cottonwood (*Populus deltoides*), (Figure 9).

For the 2ACW riparian zone of Haun Creek, the top three species in terms of BAA were green ash (43.8 ft²), Kentucky coffeetree (33.0 ft²) and common hackberry (27.9 ft²) (Figure 9).

Black walnut, bur oak, and chinkapin oak represent the top commercially valuable timber species present in these watersheds. For the Level Creek 1ACW riparian zone, black walnut represented 6.7 percent of the TA (Table 5). There were also no oak species represented in the 2ACW riparian zone of Level Creek, but black walnut was present (Table 5).

Within the stream bank to 1ACW riparian zone (1ACW) in Haun Creek, black walnut represented 4.5 percent of the TA, bur oak represented 4.5 percent of the TA, and chinkapin oak represented 1.1 percent of the TA, (Table 5). Within the 2ACW riparian zone in Haun Creek, there were no black walnut or oak species represented.

Categorization of tree species according to timber value

The species found in the assessed watersheds were categorized into three groups based on the timber market value. Group 1 (high dollar value) was composed of black walnut and oak species (bur oak and chinkapin oak in these study watersheds). Group 2 (moderate dollar value) was composed of green ash, plains cottonwood, common hackberry, American basswood, black cherry, bitternut hickory, other ash species, and silver maple. Group 3 (low dollar value) was composed of all other species.

Within all watersheds, BAA and TA were dominated by Value Groups 2 and 3 (Figures 10-11), except

for where Value Group 1 exceeded Value Group 3 for TA in the 1ACW zone of Haun Creek.

Regeneration per Acre (RA) and Mean C for Tree Saplings and Seedlings

Results of evaluating tree sapling and seedling regeneration are presented in Table 6 and Figure 12. The 1ACW riparian zone of Haun Creek exhibited the highest total RA (saplings and seedlings per acre) with a mean value of 4716.7 while the 2ACW riparian zone of Haun Creek exhibited the lowest RA mean value of 1645.4. The 1ACW and 2ACW riparian zones of Level Creek exhibited 2550.3 and 3291.6 RA, respectively.

Within all watershed riparian zones, regeneration was dominated by a single species (common hackberry), which made up 64.5 percent and 90.0 percent of the total RA for 1ACW and 2ACW riparian zones of Level Creek and 52.9 percent and 60.0 percent of the RA for the 1ACW and 2ACW riparian zones of Haun Creek. The 1ACW riparian of Haun Creek exhibited the greatest diversity for RA with 14 tree species represented but two were non-native species, while the other riparian zones only had from three (all native species) to six species (four native and two non-native species) for RA. Tree species of higher commercial value (e.g., oak species, black walnut) represented no more than 3.2 percent of the total regeneration present within any of the watershed riparian zones. In regeneration plots, seedlings were far more prevalent than saplings, with seedlings out-representing saplings by a ratio of nearly 14:1.

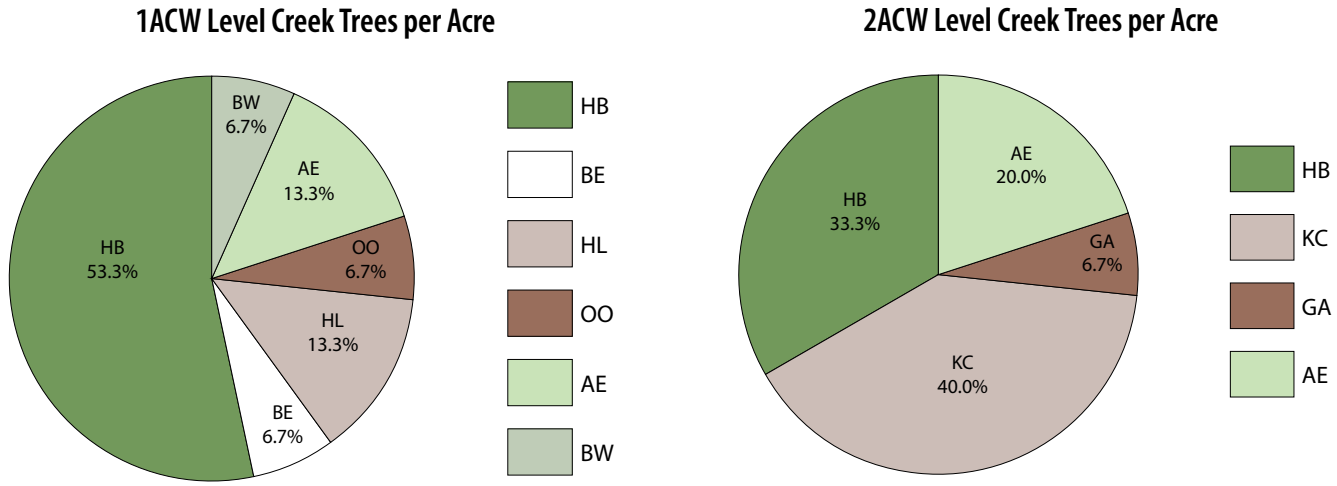

Figure 8. *Level Creek BAA composition by species for 1ACW and 2ACW riparian zones. BW= black walnut, AE= American elm, GA= green ash, OO= Osage orange, HL= honey locust, BE= boxelder, HB= common hackberry.*

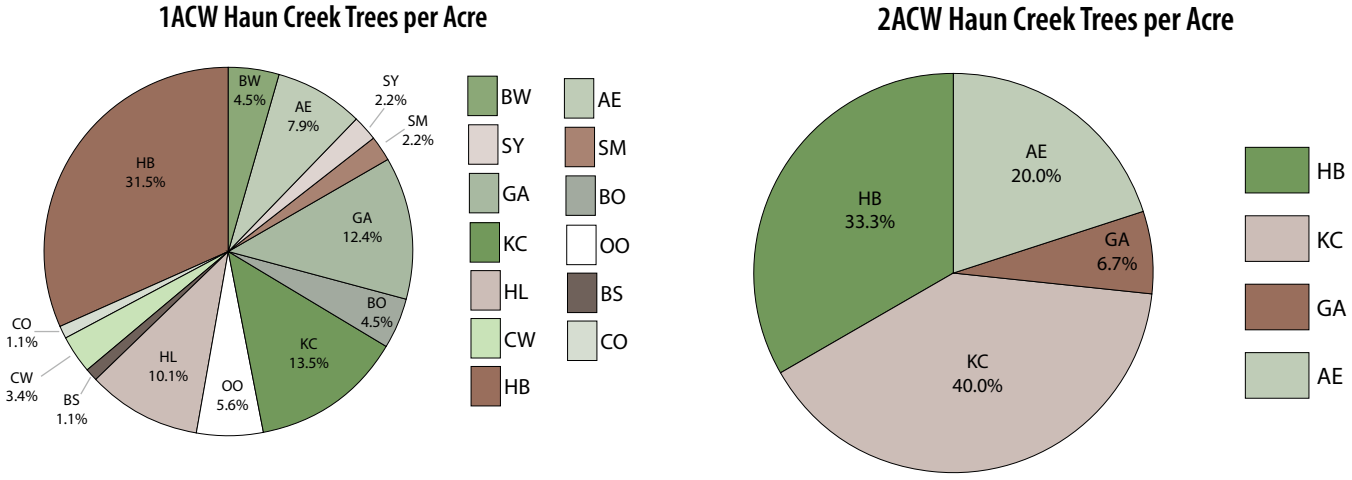

Figure 9. *Haun Creek BAA composition by species for 1ACW and 2ACW riparian zones. BW= black walnut, AE= American elm, SY= sycamore, SM= silver maple, GA= green ash, BO= bur oak, KC= Kentucky coffeetree, OO= Osage orange, HL= honey locust, BS= basswood, CW= plains cottonwood, CO= chinkapin oak, HB= common hackberry.*

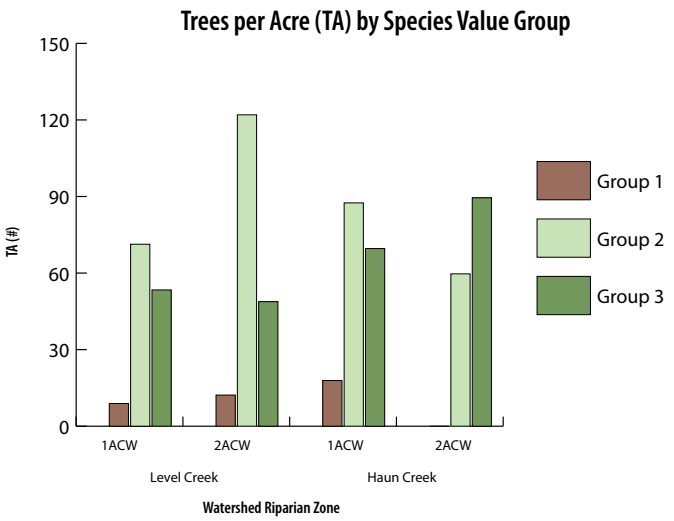

Figure 10. *Trees per Acre (TA) by Species Value Group and Watershed Riparian Zone.*

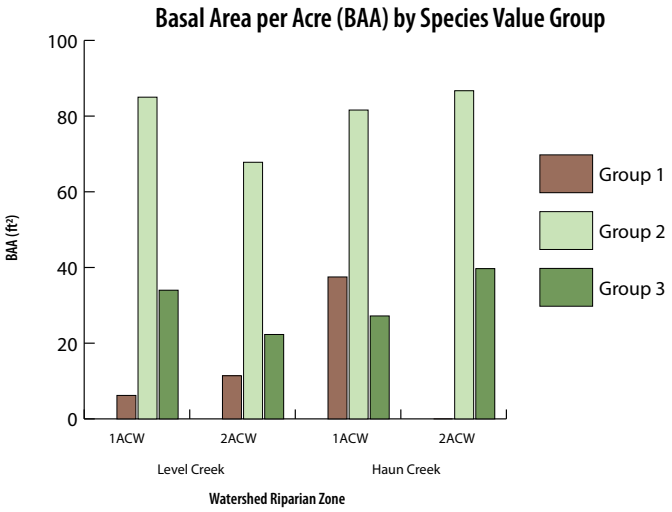

Figure 11. *Basal Area per Acre (BAA) by Species Value Group and Watershed Riparian Zone.*

Table 6. *Total regeneration per acre, mean C and number of native and non-native tree saplings and seedlings for regeneration plots by tree species and watershed riparian zone. The highest regeneration value by species is indicated in red.*

Tree Sapling/ Seedling Regeneration Plots			Level Creek		Haun Creek	
			1ACW	2ACW	1ACW	2ACW
Tree Scientific Name	Tree Common Name	CoC Value	# Acre^{-1}	# Acre^{-1}	# Acre^{-1}	# Acre^{-1}
Acer negundo	Boxelder	1	0.0	0.0	27.4	0.0
Acer saccharinum	Silver Maple	2	0.0	0.0	27.4	0.0
Aesculus glabra	Western Buckeye	5	0.0	0.0	54.8	0.0
Carya cordiformis	Bitternut Hickory	4	0.0	0.0	27.4	0.0
Celtis occidentalis	Common Hackberry	1	1,645.4	2,961.6	2,495.5	987.2
Cornus drummondii	Roughleaf Dogwood	1	0.0	0.0	767.8	164.5
Fraxinus pennsylvanica	Green Ash	0	246.8	0.0	54.8	0.0
Gleditsia triacanthos	Honey Locust	0	164.5	164.5	137.1	164.5
Gymnocladus dioica	Kentucky Coffeetree	4	0.0	0.0	54.8	164.5
Juglans nigra	Black Walnut	3	82.3	0.0	27.4	0.0
Maclura pomifera	Osage Orange	*	0.0	0.0	82.3	164.5
Morus alba	White Mulberry	*	164.5	0.0	54.8	0.0
Quercus species	Oak Species	NA	0.0	0.0	27.4	0.0
Ulmus americana	American Elm	2	246.8	164.5	877.5	0.0
Total Regeneration per Acre	-	-	**2,550.3**	**3290.7**	**4716.7**	**1645.4**
Mean C	-	**2.1**	**1.2**	**1.0**	**2.1**	**1.2**
# of Native Species	-	**12**	**5**	**3**	**12**	**4**
# of Non-native species	-	**2**	**1**	**0**	**2**	**1**

Table 7. *Understory Vegetative Cover: % Cover Per 100*

			Level Creek		Haun Creek	
			1ACW	2ACW	1ACW	2ACW
Plant Scientific Name	**Common Name**	**CoC Value**	**% Per 100**	**% Per 100**	**% Per 100**	**% Per 100**
Acalypha virginica	Virginia copperleaf	0	0.06	-	-	0.11
Alliaria petiolata	Garlic mustard	*	-	-	0.10	-
Ambrosia trifida	Tall ragweed	0	0.18	9.77	1.42	12.88
Amorpha frutescens	False indigo	6	0.05	-	-	-
Artemisia filifolia	Narrow-leaved sage	3	1.11	-	-	-
Artemisia ludoviciana	Louisiana sagewort	2	-	-	-	0.11
Bidens polylepis	Coreopsis beggar-ticks	1	-	-	0.02	-
Boehmeria cylindrica	Small-spike false nettle	3	-	-	0.02	-
Bromus inermis	Smooth brome	*	-	31.37	9.81	24.48
Carex blanda	Woodland sedge	1	4.00	0.10	1.56	0.27
Carex sp	sedge species	NA	1.05	-	0.43	2.26
Chenopodium sp	a goosefoot	NA	0.18	0.49	1.85	0.10
Cirsium altissimum	Tall thistle	2	-	-	-	0.15
Conium maculatum	Poison hemlock	*	0.55	-	0.02	-
Desmodium glutimosum	Large-flower tick clover	3	-	-	0.12	-
Elymus virginicus	Virginia wild rye	2	12.92	12.37	21.14	18.60
Erigeron strigosus	Daisy fleabane	4	-	-	0.12	-
Eupatorium rugosum	White snakeroot	3	1.11	0.12	5.22	2.36
Eupatorium serontinum	Fall joe-pye weed	2	-	-	0.59	-
Euphorbia dentata	Eastern toothed spurge	0	0.06	-	0.03	0.11
Fallopia scandens	Hedge cornbind	0	0.05	-	-	-
Festuca arundinacea	Tall mountain-fescue	*	1.11	-	-	-
Geum canadense	White avens	1	2.69	0.22	0.22	0.15
Helianthus tuberosus	Jerusalem artichoke	1	1.44	0.12	-	-
Laportea canadensis	Wood nettle	4	-	-	4.58	-
Leersia virginica	Rice cut grass	3	-	-	0.94	-
Kummerowia stipulacea	Korean low bush-clover	*	-	-	-	0.11
Muhlenbergia sp.	a Muhly grass	NA	2.32	22.40	5.54	7.35
Parthenocissus quinquefolia	Virginia creeper	1	-	-	0.37	-
Persicaria virginiana	Jump seed	2	-	0.59	0.04	-
Physalis pumila	Prairie ground-cherry	4	0.06	-	-	0.15
Phytolacca americana	Poke root	0	2.51	-	0.16	-
Poa pratensis	Kentucky bluegrass	*	2.29	-	0.31	-
Ribes missouriense	Wild gooseberry	3	-	-	0.15	-
Rumex crispus	Curly dock	*	-	0.49	0.09	0.10
Sanicula sp	a sanicle	2	0.47	0.10	-	-
Sida spinosa	Prickly sida	*	-	-	-	0.11
Smilax tamnoides	Bristly greenbrier	2	1.29	0.12	0.34	1.04

Table 7. *Continued*

			Level Creek		Haun Creek	
			1ACW	2ACW	1ACW	2ACW
Plant Scientific Name	**Common Name**	**CoC Value**	**% Per 100**	**% Per 100**	**% Per 100**	**% Per 100**
Solidago canadensis	Canadian goldenrod	2	-	-	0.41	-
Solidago gigantea	Fall goldenrod	3	0.32	-	0.47	-
Stellaria media	Chickweed	*	-	-	0.02	-
Symphoricarpos orbiculatus	Buckbrush	1	2.90	0.59	8.36	17.71
Symphiotrichum drummondii	Drummond's aster	2	-	-	0.10	-
Taraxacum officinale	Dandelion	*	0.05	-	-	-
Toxicodendron radicans	Poison ivy	0	6.55	4.01	0.59	2.26
Tridens flavus	Red top	1	2.29	-	-	2.26
Triosetum perfoliatum	Clasping horse gentian	4	-	-	0.02	-
Urtica dioica	Stinging nettles	1	4.45	-	0.29	-
Verbesina alternifolia	Wing-stem crownbeard	4	0.06	0.12	8.65	-
Vernonia baldwinii	Baldwin's ironweed	2	0.05	-	-	-
Viola sp	a violet species	NA	0.06	-	0.02	-
Vitis riparia	River bank grape	2	-	-	0.02	-
Tree Scientific Name	**Common Name**	**CoC Value**	**1ACW**	**2ACW**	**1ACW**	**2ACW**
Acer negundo	Boxelder	1	-	-	0.02	-
Acer saccharinum	Silver maple	2	-	-	0.02	-
Aesculus glabra	Western buckeye	5	-	-	0.09	-
Carya cordiformis	Bitternut hickory	4	-	-	0.02	-
Celtis occidentalis	Common hackberry	1	7.00	10.70	4.74	0.88
Cornus drummondii	Roughleaf dogwood	1	1.88	-	1.96	0.15
Fraxinus pennsylvanica	Green ash	0	1.23	-	0.09	-
Gleditsia triacanthos	Honey locust	0	0.06	-	0.02	0.11
Gymnocladus dioica	Kentucky coffeetree	4	-	-	0.03	-
Juglans nigra	Black walnut	3	0.06	-	-	-
Maclura pomifera	Osage orange	*	-	-	0.08	0.57
Morus alba	White mulberry	*	1.23	-	0.04	-
Quercus species	Oak species	NA	-	-	0.02	-
Ulmus americana	American elm	2	0.06	0.16	1.87	0.11
% Cover Per 100 Subtotal	-	-	**63.75**	**93.83**	**83.17**	**94.50**
Bare	-	-	**18.58**	**1.83**	**8.08**	**0.50**
Debris	-	-	**-**	**-**	**0.56**	**-**
Litter	-	-	**17.67**	**4.33**	**8.19**	**5.00**
% Cover Per 100 Total	-	-	**100.00**	**100.00**	**100.00**	**100.00**

Table 8. *Understory Vegetative Cover: % Absolute Cover.*

Plant Scientific Name	Common Name	CoC Value	Level Creek 1ACW Absolute %	Level Creek 2ACW Absolute %	Haun Creek 1ACW Absolute %	Haun Creek 2ACW Absolute %
Acalypha virginica	Virginia copperleaf	0	0.08	-	-	0.17
Alliaria petiolata	Garlic mustard	*	-	-	0.14	-
Ambrosia trifida	Tall ragweed	0	0.25	16.67	1.75	22.50
Amorpha frutescens	False indigo	6	0.08	-	-	-
Artemisia filifolia	Narrow-leaved sage	3	1.67	-	-	-
Artemisia ludoviciana	Louisiana sagewort	2	-	-	-	0.17
Bidens polylepis	Coreopsis beggar-ticks	1	-	-	0.03	-
Boehmeria cylindrica	Small-spike false nettle	3	-	-	0.03	-
Bromus inermis	Smooth brome	*	-	32.50	9.42	26.50
Carex blanda	Woodland sedge	1	6.00	0.17	2.61	0.33
Carex sp	sedge species	NA	1.67	-	0.72	3.33
Chenopodium sp	a goosefoot	NA	0.25	0.83	2.03	0.17
Cirsium altissimum	Tall thistle	2	-	-	-	0.17
Conium maculatum	Poison hemlock	*	0.83	-	0.03	-
Desmodium glutimosum	Large-flower tick clover	3	-	-	0.14	-
Elymus virginicus	Virginia wild rye	2	17.17	17.50	29.81	32.50
Erigeron strigosus	Daisy fleabane	4	-	-	0.14	-
Eupatorium rugosum	White snakeroot	3	1.67	0.17	7.97	3.50
Eupatorium serontinum	Fall joe-pye weed	2	-	-	0.72	-
Euphorbia dentata	Eastern toothed spurge	0	0.08	-	0.03	0.17
Fallopia scandens	Hedge cornbind	0	0.08	-	-	-
Festuca arundinacea	Tall mountain-fescue	*	1.67	-	-	-
Geum canadense	White avens	1	3.75	0.33	0.36	0.17
Helianthus tuberosus	Jerusalem artichoke	1	2.08	0.17	-	-
Laportea canadensis	Wood nettle	4	-	-	6.83	-
Leersia virginica	Rice cut grass	3	-	-	1.25	-
Kummerowia stipulacea	Korean low bush-clover	*	-	-	-	0.17
Muhlenbergia sp.	a Muhly grass	NA	3.50	33.33	8.22	10.83
Parthenocissus quinquefolia	Virginia creeper	1	-	-	0.69	-
Persicaria virginiana	Jump seed	2	-	0.83	0.06	-
Physalis pumila	Prairie ground-cherry	4	0.08	-	-	0.17
Phytolacca americana	Poke root	0	3.42	-	0.19	-
Poa pratensis	Kentucky bluegrass	*	3.42	-	0.56	-
Ribes missouriense	Wild gooseberry	3	-	-	0.19	-
Rumex crispus	Curly dock	*	-	0.83	0.11	0.17
Sanicula sp	a sanicle	2	0.42	0.17	-	-
Sida spinosa	Prickly sida	*	-	-	-	0.17
Smilax tamnoides	Bristly greenbrier	2	1.67	0.17	0.47	1.67
Solidago canadensis	Canadian goldenrod	2	-	-	0.58	-
Solidago gigantea	Fall goldenrod	3	0.42	-	0.56	-
Stellaria media	Chickweed	*	-	-	0.03	-

Table 8. *Continued*

Plant Scientific Name	Common Name	CoC Value	Level Creek 1ACW Absolute %	Level Creek 2ACW Absolute %	Haun Creek 1ACW Absolute %	Haun Creek 2ACW Absolute %
Symphoricarpos orbiculatus	Buckbrush	1	4.25	0.83	11.17	23.67
Symphiotrichum drummondii	Drummond's aster	2	-	-	0.14	-
Taraxacum officinale	Dandelion	*	0.08	-	-	-
Toxicodendron radicans	Poison ivy	0	6.92	6.83	1.00	3.33
Tridens flavus	Red top	1	3.42	-	-	3.33
Triosetum perfoliatum	Clasping horse gentian	4	-	-	0.03	-
Urtica dioica	Stinging nettles	1	7.08	-	0.58	-
Verbesina alternifolia	Wing-stem crownbeard	4	0.08	0.17	13.86	-
Vernonia baldwinii	Baldwin's ironweed	2	0.08	-	-	-
Viola sp	a violet species	NA	0.08	-	0.03	-
Vitis riparia	River bank grape	2	-	-	0.03	-
Tree Scientific Name	Common Name	CoC Value	1ACW	2ACW	1ACW	2ACW
Acer negundo	Boxelder	1	-	-	0.03	-
Acer saccharinum	Silver maple	2	-	-	0.03	-
Aesculus glabra	Western buckeye	5	-	-	0.14	-
Carya cordiformis	Bitternut hickory	4	-	-	0.03	-
Celtis occidentalis	Common hackberry	1	9.33	17.67	7.11	1.00
Cornus drummondii	Roughleaf dogwood	1	1.67	-	2.78	0.17
Tree Scientific Name	Common Name	CoC Value	1ACW	2ACW	1ACW	2ACW
Fraxinus pennsylvanica	Green ash	0	1.67	-	0.14	-
Gleditsia triacanthos	Honey locust	0	0.08	-	0.03	0.17
Gymnocladus dioica	Kentucky coffeetree	4	-	-	0.03	-
Juglans nigra	Black walnut	3	0.08	-	-	-
Maclura pomifera	Osage orange	*	-	-	0.17	0.83
Morus alba	White mulberry	*	1.67	-	0.06	-
Quercus species	Oak species	NA	-	-	0.03	-
Ulmus americana	American elm	2	0.08	0.17	2.83	0.17
% Absolute Cover Subtotal	-	-	**86.83**	**129.33**	**115.89**	**135.50**
Bare	-	-	**18.58**	**1.83**	**8.08**	**0.50**
Debris	-	-	**-**	**-**	**0.56**	**-**
Litter	-	-	**17.67**	**4.33**	**8.19**	**5.00**
% Absolute Cover Total	-	-	**123.08**	**135.50**	**132.72**	**141.00**

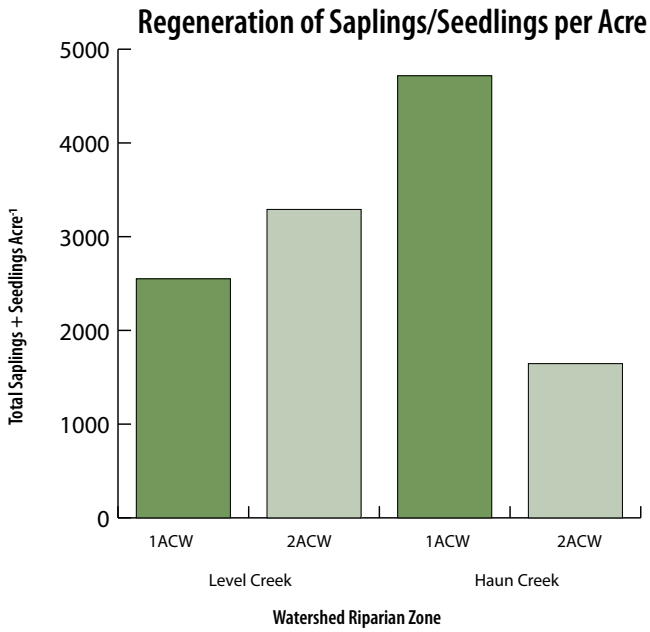

Figure 12. *Total regeneration per acre (tree saplings and seedlings) by watershed riparian zone.*

Ground Cover Percent Plant Cover and Mean C

Absolute percent cover is a measure of the ground cover occupied by herbaceous plants (forbs), shrubs, and tree seedlings relative to bare ground, litter and debris, and reflects understory vegetative canopy conditions, (Table 8). The highest percentage of vegetative absolute percent cover was exhibited in the 2ACW riparian zone of Haun Creek followed by 2ACW Level Creek. The 1ACW riparian zone of Level Creek exhibited the highest percentage of bare ground (18.6 percent) and litter (17.7 percent) relative to vegetative cover (Table 6).

The number of understory tree seedling and plant species sampled in the regeneration plots provides a measure of species richness of the understory and helps to better understand the vegetative diversity of the understory vegetation. The mean number of species comprising the understory regeneration plots ranged from a high value of 10.7 ± 3.2 species per transect location.

The total number of native understory tree seedling, shrub, grass, and forb species found in the ground cover within the riparian zones of each watershed was 42 for 1ACW Haun Creek, 32 for 1ACW Level Creek, 22 for 2ACW Haun Creek and 16 for 2ACW Level Creek (Table 9). Combined, the relatively low number of species encountered per transect and watershed riparian zone and low mean C values per watershed riparian zone are indicative of a low quality, disturbed riparian zone in both watersheds, which compares poorly with a higher quality and potentially more diverse natural riparian wooded area before settlement of the region, and consequently is an ecological resource concern.

Generally, GIS cover estimates overestimated riparian areas *in need of conservation* (set at 70 percent cover through previous riparian forest assessment procedures) in both the Level and Haun Creek watersheds. However, based on field observations, 70 percent cover did not equate to a high-quality *forest in need of conservation* as is alluded to in previous sections of this report (species number and mean C values). Based on observations in the field, the GIS cover estimate for *forests in need of conservation* may need to be adjusted to approximately 85 to 90 percent cover to distinguish potentially higher quality riparian forest from *forest in need of management*. Based on field observations, all transect plots within the wooded portion of the 1ACW and 2ACW riparian zones indicated riparian woods in need of management and perhaps some establishment of more diverse late seral stage tree and understory species. None of the sites were high quality or old growth riparian forests. Regardless of quality, all riparian forest in the 2ACW riparian zone should be conserved, but there are tremendous opportunities for riparian TSI and establishment to increase forest product and ecological value and diversity throughout the Level Creek and Haun Creek watersheds.

Therefore, we recommend GIS procedures for future assessments be adjusted to reflect new criteria for GIS estimations of the riparian areas in need of management and conservation categories as follows:

1. Establishment: greater than or equal to 5 to 20 percent riparian forest cover;
2. Management: greater than or equal to 20 to 85 percent riparian forest cover;
3. Conservation: greater than or equal to 85 percent riparian forest cover and confirmation in the field to evaluate floristic quality and potential

Table 9. *Understory Mean Species and Mean C.*

	Level Creek		Haun Creek	
	1ACW	2ACW	1ACW	2ACW
Mean # Species Per Transect	10.50	7.67	9.39	10.67
Mean # Species Standard Error	1.67	2.33	0.81	3.18
Mean C Per Watershed	1.57	1.57	2.00	1.28
Native Species Per Watershed	32	16	41	22
Non-native Species Per Watershed	5	2	9	5

Table 10. *Descriptive qualitative data within riparian zone of Level and Haun Creek watersheds.*

	% Land Use of 2ACW Riparian Zone				
Watershed	**Native Grass**	**Cropland**	**Pasture**	**Forest**	**Total**
Level Creek	6.2	44.16	0	49.63	100
Haun Creek	0	16.67	11.03	72.31	100
Watershed	**% Forest Management (# of transects)**		**% with Livestock Impacts (# of transects)**		
Level Creek	0 (0)		20 (1)		
Haun Creek	10 (1)		10 (1)		

Table 11. *SVAP2 scores and ratings for Level Creek and Haun Creek watershed sites.*

SVAP2 Scoring Category	Level Creek Watershed: Site 17	Haun Creek Watershed: Site 2
E1. Channel Condition	5.0	4.0
E2. Hydrologic Alteration	6.0	6.0
E3. Bank Condition	4.0	4.0
E4. Riparian Area Quantity	4.0	3.0
E5. Riparian Area Quality	4.0	3.0
E6. Canopy Cover	5.0	4.0
E7. Water Appearance	4.0	4.0
E8. Nutrient Enrichment	6.0	6.0
E9. Manure or Human Waste Presence	8.0	8.0
E10. Pools	6.0	7.0
E11. Barriers to Aquatic Species Movement	7.0	7.0
E12. Fish Habitat Complexity	5.0	5.0
E13. Aquatic Invertebrate Habitat	5.0	5.0
E14. Aquatic Invertebrate Community	3.0	3.0
E15. Riffle Embeddedness	6.0	5.0
Average Score	**5.2**	**4.9**
Average Score Adjective	**Fair**	**Poor**

improvements for forestry product enhancement and ecological diversity and health; may wish to cross-reference with Kansas Natural Heritage Inventory Program.

Qualitative data

Within transect plots, we classified the land use beyond the riparian forest zone present (up to the 2ACW extent) into three additional groups: native grass, cropland, and pasture. In Level Creek watershed, 72.3 percent of the 2ACW riparian zone was forest, while 16.7 percent was cropland and 11.0 percent was pasture (Table 10). In Haun Creek watershed, 49.6 percent of the land use within the 2ACW riparian zone was forest, 6.2 percent was native grass, and 44.2 percent was cropland, indicating a little less than half of the 2ACW riparian area is cropland and is not providing riparian functions due to its lack of riparian vegetation.

SVAP2, BEHI, and NBS Indices

SVAP2 assessments were conducted at one site in both Level Creek (Site 17) and Haun Creek (Site 2) watersheds (Table 11, Figure 13 – maps at the end of document). SVAP2 scores for Level Creek and Haun Creek sites were 5.2 (fair rating) and 4.9 (poor rating), respectively. Results of SVAP2 indicated the following resource concerns (scores equal to or less than 5) in Level Creek watershed at Site 17: channel condition (5), bank condition (4), riparian area quantity (4), riparian area quality (4), canopy cover (5), water appearance (4), fish habitat complexity (5), aquatic invertebrate habitat (5), and aquatic invertebrate community (3). For Haun

Table 12. *BEHI and NBS scores and ratings for Level Creek and Haun Creek watershed sites.*

Level Creek Watershed: Site 17			
BEHI Elements	**Value**	**Score**	**Rating**
Ratio of bank height to bankfull height (BH)	2.96	10	Extreme
Ratio of root depth to bank height (RDH)	72.97	2.95	Low
Root density (%) (RD)	10	8.5	Very High
Surface protection (%) (SP)	25	6.95	High
Bank angle (degrees) (BA)	65	4.95	Moderate
Material adjustment (MA)	0	0	Silt-Clay
Stratification adjustment (SA)	5	5	Present
Total BEHI Score		**38.35**	**Very High**
NBS Total Score (Method 2)		**2.85**	**Extreme**

Haun Creek Watershed: Site 2			
BEHI Elements	**Value**	**Score**	**Rating**
Ratio of bank height to bankfull height (BH)	2.9	10	Extreme
Ratio of root depth to bank height (RDH)	74.71	2.95	Low
Root density (%) (RD)	25	6.95	High
Surface protection (%) (SP)	35	4.95	Moderate
Bank angle (degrees) (BA)	75	4.95	Moderate
Material adjustment (MA)	0	0	Silt-Clay
Stratification adjustment (SA)	5	5	Present
BEHI Total Score		**34.8**	**Very High**
NBS Total Score (Method 2)		**0.62**	**Very Low**

Creek watershed at Site 2, resource concerns were similar and included the following: channel condition (4), bank condition (4), riparian area quantity (3), riparian area quality (3), canopy cover (4), water appearance (4), fish habitat complexity (5), aquatic invertebrate habitat (5), aquatic invertebrate community (3), and riffle embeddedness (5).

The BEHI assessments were conducted at Site 17 in Level Creek watershed and Site 2 in Haun Creek watershed (Table 12, Figure 13 – maps at the end of document). The total BEHI score for the study bank at Site 17 in Level Creek watershed was 38.4, indicating a "very high" rating for streambank erosion emanating from the streambank evaluated onsite (within land owner property boundaries). The "very high" rating for the study bank at Site 17 in Level Creek watershed was due mainly to its "extreme" score for ratio of bank height to bankfull height (RBH), "very high" score for low root density (RD), "high" score for surface protection, and presence of a stratified layer in the bank comprised of gravel. The total BEHI score for Haun Creek watershed at Site 2 was 34.8, which indicates a "very high" rating for streambank erosion for the representative study bank evaluated at the site (within land owner property boundaries). The "very high" rating for the study bank at Site 2 in Haun Creek was driven by its "extreme" score for RBH, "high" score for low RD, and presence of a stratified layer in the bank comprised of gravel and cobble.

The NBS assessment conducted at Site 17 in Level Creek watershed indicated both a "very high" BEHI rating and an "extreme" NBS rating due to a relatively high radius of curvature (97 degrees) relative to its bankfull width. It is likely a high-priority resource concern with respect to stream sedimentation within this watershed. Banks similar to it in the Level Creek watershed may also be a high-priority concern for streambank erosion and candidates for some natural channel design, streambank stabilization, and/or bank shaping practices, as well as complimentary riparian plantings and improvements.

The NBS assessment conducted at Site 2 in Haun Creek watershed indicated that, while the BEHI rating was "very high" for streambank erosion potential, the NBS stress on the study bank was "very low" due to

the low radius of curvature (approximately 40 degrees) relative to its bankfull width. In general, streambanks within the vicinity of Site 2 in Haun Creek watershed displaying a higher radius of curvature (more bank-directed water influences and disproportionate energy distribution into the near-bank region) but similar characteristics of the study bank variables as scored by BEHI likely represent greater resource concerns than the streambank studied at Site 2.

Resource Concerns and Management Recommendation Conclusions

Forest management, ecological, and economic resource concerns were identified within Level Creek and Haun Creek watersheds based on remote assessment and in-field riparian and stream assessments conducted at a random subset of representative sites for the two watersheds.

A majority of the 2ACW riparian area was determined to be forest in need of establishment (37.2 percent within Level Creek and 28.5 percent within Haun Creek) and forest in need of management (34.4 percent within Level Creek and 26.7 percent within Haun Creek) within watersheds, with forest in need of conservation comprising most of the remaining areas. However, results of riparian inventories in the field indicated that remote assessment overestimated the riparian area classified as forest in need of conservation. Much of that area should be reclassified as forest in need of management since it is not high-quality or old-growth woodland. However, these areas do provide utility from relatively dense forest structure for streambank stabilization and flood mitigation, especially where the stream channel is connected to the floodplain for less than five-year flood events and the riparian forest extends beyond 1ACW to the 2ACW riparian zone so they merit conservation as well.

Riparian inventories and analysis of tree, sapling, seedling, and understory vegetation in the field indicated a relatively low number of species encountered per transect and watershed riparian zone and low mean C values per watershed riparian zone. These results are indicative of a low quality, disturbed riparian zone in both watersheds, which compares poorly with a higher quality and more potentially diverse natural riparian wooded area before settlement of the region (vegetative potential). This reflects an ecological resource concern and an opportunity for management and establishment actions.

Total forest TA and BA as well as regeneration TA (all species combined) were found to provide utility for streambank stabilization in the watersheds where riparian buffer widths extended beyond 1ACW to 2ACW. However, a lack of presence and diversity of late-seral-stage trees in the riparian zone and dominance of the TA, BA, and regeneration by common hackberry represents a forest management and ecological concern. Additionally, much of the riparian forest and understory vegetation may not be connected to its stream channel at less than five-year flood return-intervals due to stream incision and entrenchment. Some functionality of the riparian vegetation present in Level Creek and Haun Creek may not be realized, indicating an ecological resource concern.

Tree Value Groups 2 and 3 were found to dominate BA and TA within all watershed riparian zones (especially Value Group 2 dominated by common hackberry), while Value Group 1 represented a relatively small proportion. Common hackberry and other Value Group 2 and 3 trees also dominated watershed RA, which suggests that the next generation of forest within project watersheds will be composed primarily of lower-value, less-desirable species. This is a forest management concern and an economic concern if desiring to promote riparian forestry.

The QMD for Value Group 1 (i.e., oak and walnut) suggests that, while the number of trees per acre is minimal, some of these trees are in the "zone of release," which suggests that crop-tree release and/or Forest Stand Improvement efforts within the near future would be of great benefit. These practices would reduce competition from less-desirable species, increase growth of desired species, and reduce the time needed for Value Group 1 trees to reach financial maturity (i.e., harvest time). In Haun Creek 1ACW riparian zone, black walnut and chinkapin oak indicated a larger QMD value suggesting some of the trees are reaching or have reached financial maturity; however, larger QMD coupled with low TA for these species is likely a forest management resource concern, especially with limited regeneration occurring in watershed riparian zones for these species.

Commonly observed threats to healthy/sustainable riparian woodlands included: some livestock use of riparian areas, lack of active forest management but considerable long-term disturbance of the riparian forest, non-native (invasive) species, less than adequate 2ACW riparian forest extent and disconnection of much of the riparian forest from bankfull discharges and five-year flood events.

SVAP2 scores for Level Creek and Haun Creek sites were fair to poor and indicated the following resource concerns (scores less than or equal to 5): channel condition, bank condition, riparian area quantity, riparian area quality, canopy cover, water appearance, fish habitat complexity, aquatic invertebrate habitat, aquatic invertebrate community, and riffle embeddedness.

BEHI scores indicated "very high" potential for streambank erosion for Level Creek and Haun Creek watersheds based on study sites. NBS scores indicated that the major resource concerns were likely for streambank types similar to those assessed along acutely bending stream meanders, especially those without adequate riparian forest vegetation, but also possibly along those with intact riparian forest. However, these findings were only based on one site per watershed so additional on-site investigation would be necessary to evaluate the range of streambank types and in-stream conditions occurring throughout the Level Creek and Haun Creek watersheds.

Combined, riparian inventories and stream assessments indicate both forest management and ecological resource concerns. Forest management recommendations include:

- Tree and shrub establishment in *forest in need of establishment* areas to extend riparian zones to 2ACW in Level Creek and Haun Creek watersheds. Tree and shrub establishment may also include understory vegetation establishment and management to include a diversity of native tree, grass, sedge, and herbaceous (forb) species. Design should enhance riparian forest quantity and quality.
- Timber stand improvement and tree-planting diversification to include a complex of late-seral-stage tree species intermixed with mid-seral stage companion/nursery tree species and understory diversification in *forest in need of management* and many *forest in need of conservation* areas. Design should enhance riparian forest cover, quantity, and quality.

Stream and watershed management recommendations:

- Natural channel design in up-stream reaches to arrest head-cutting and stabilize streambanks along acute meander bends using low-cost, natural materials and designs, such as cedar revetments, bank shaping, and head-cut hardening. Design should enhance fish and aquatic invertebrate habitat and community.
- Natural channel design, especially using lower-cost, natural materials or designs, in down-stream reaches to reconnect floodplains to riparian forest (e.g., streambank shaping, riparian planting, and low-cost-impermanent streambank stabilization) and arrest head-cut migration upstream. Design should enhance fish and aquatic invertebrate habitat and community.
- Restoration of floodplain oxbow wetlands as sediment and water storage, nutrient treatment, and habitat areas.
- Watershed management practices to restore per-settlement hydrograph, so stream channel can stabilize and heal from effects of incision and widening caused by land disturbance, land use change, and long-term management.
- Removal of in-stream impoundments to allow for aquatic organism passage for native aquatic species. While aquatic organism passage barriers were not identified at the SVAP2 sites, upstream and downstream barriers of the sites persist throughout the watershed (e.g. perched culverts, bridges, low-water crossings, impoundments).

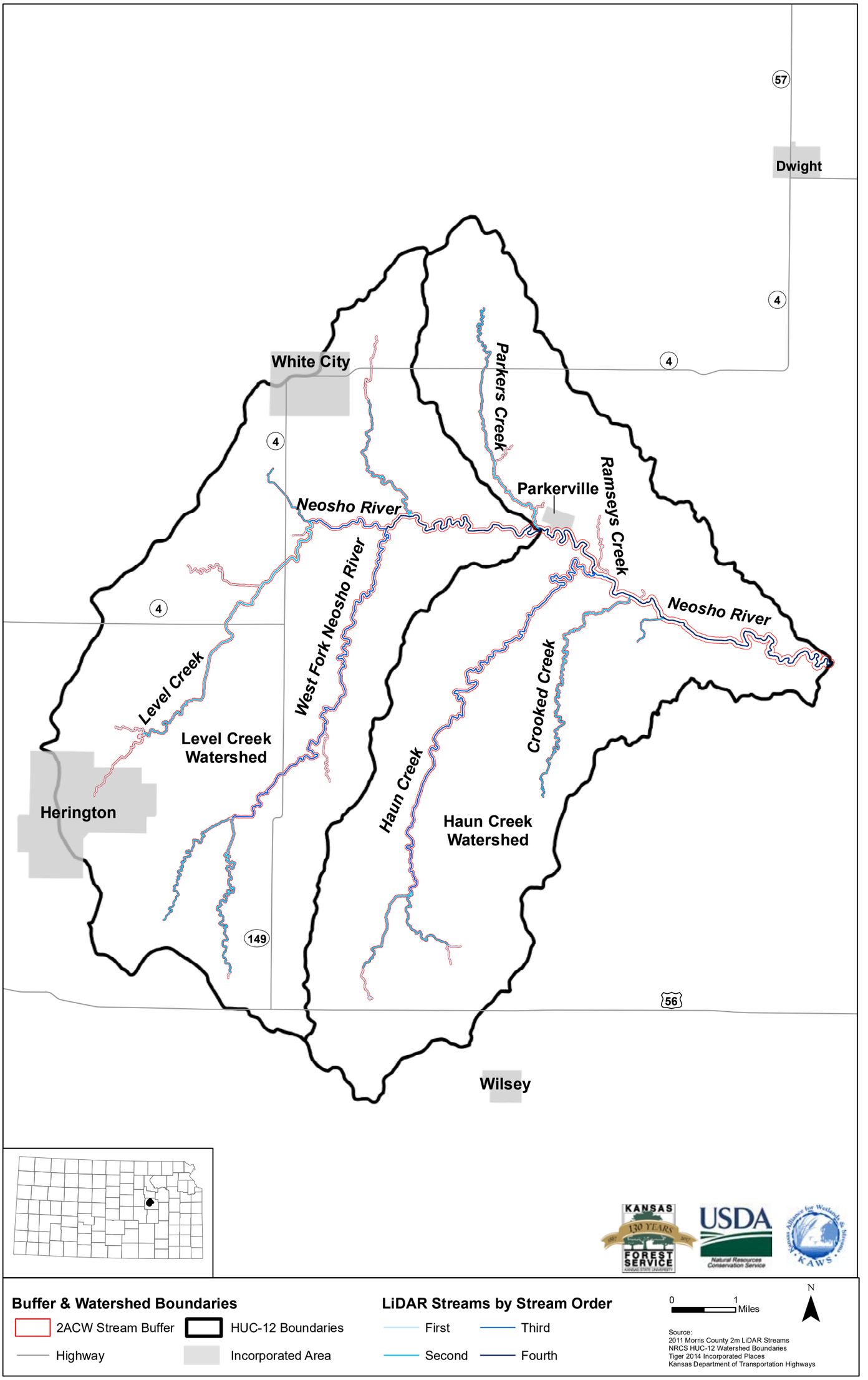

Figure 1. Location of Level Creek-Neosho River (Level Creek) and Haun Creek-Neosho River (Haun Creek) HUC-12 watersheds and riparian study areas in Morris County, Kansas. The two HUC-12 study areas are located within the Twin Lakes WRAPS and have been identified as priority watersheds for BMP implementation.

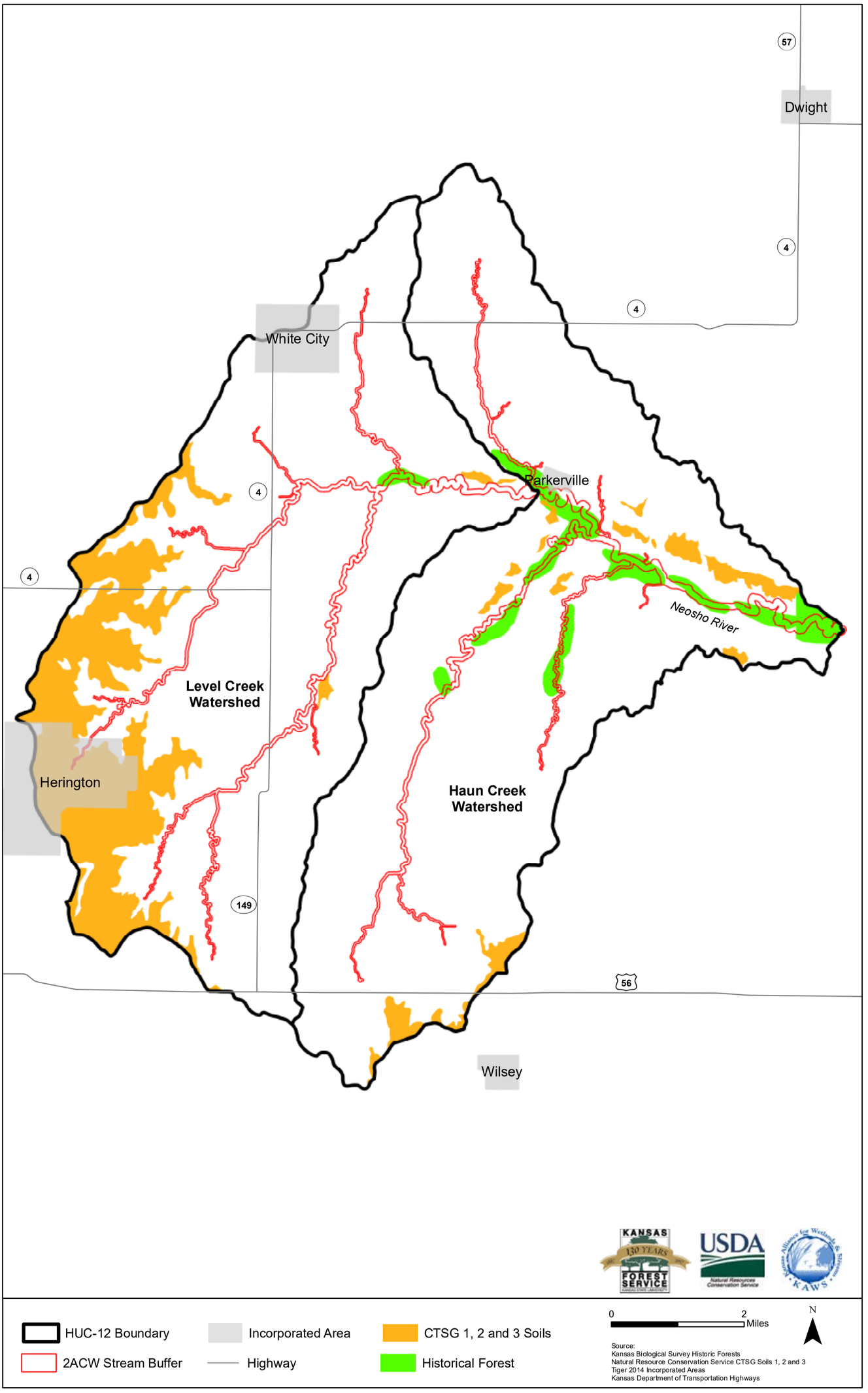

Figure 2. Extent of CTSG 1, 2, and 3 soils and historical forests in Level Creek and Haun Creek watersheds.

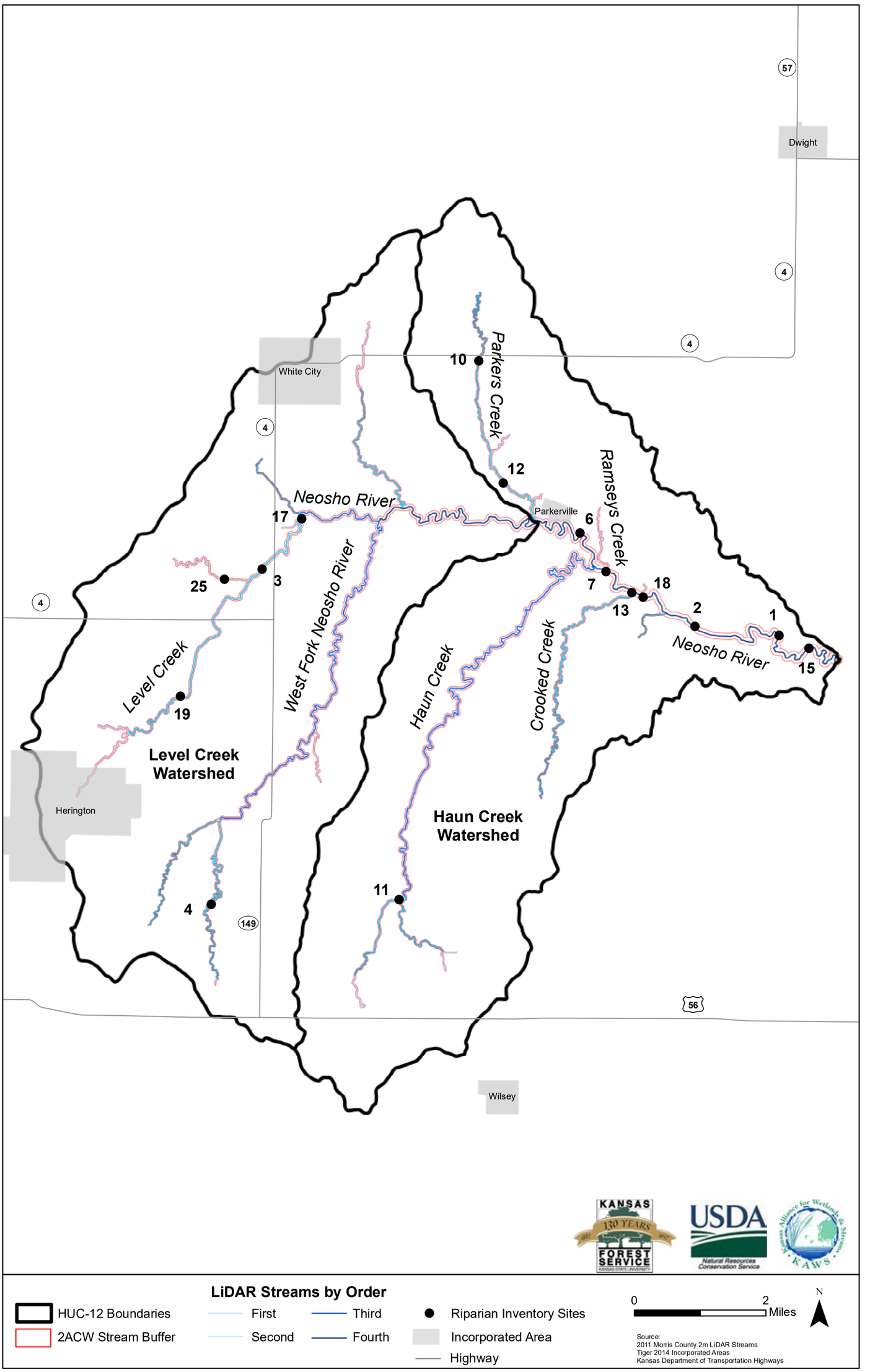

Figure 3. Location of riparian inventory sites in Level Creek and Haun Creek watersheds.

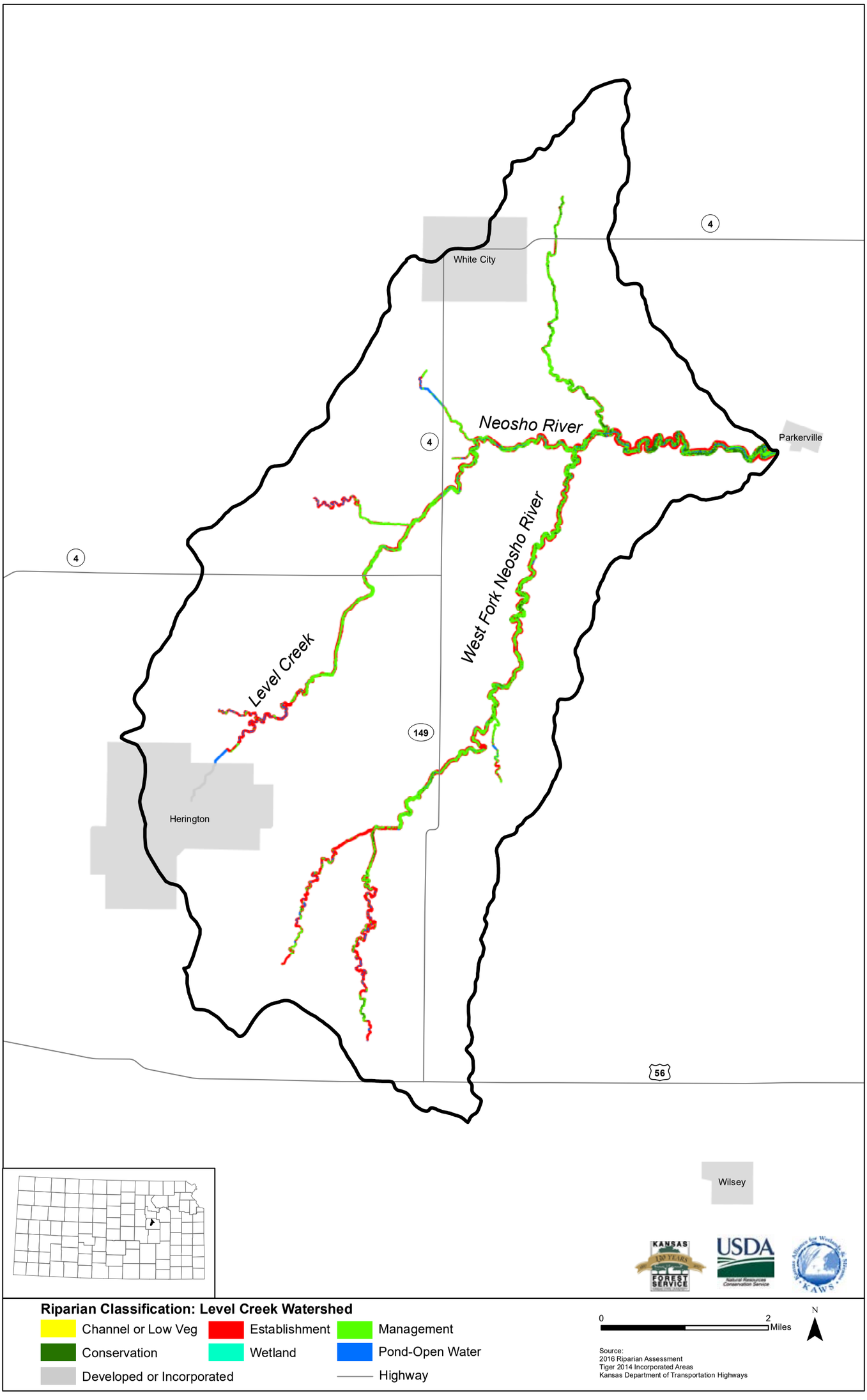

Figure 5. Riparian forest functioning condition classification of 2ACW riparian zone in Level Creek watershed, Morris County, Kansas.

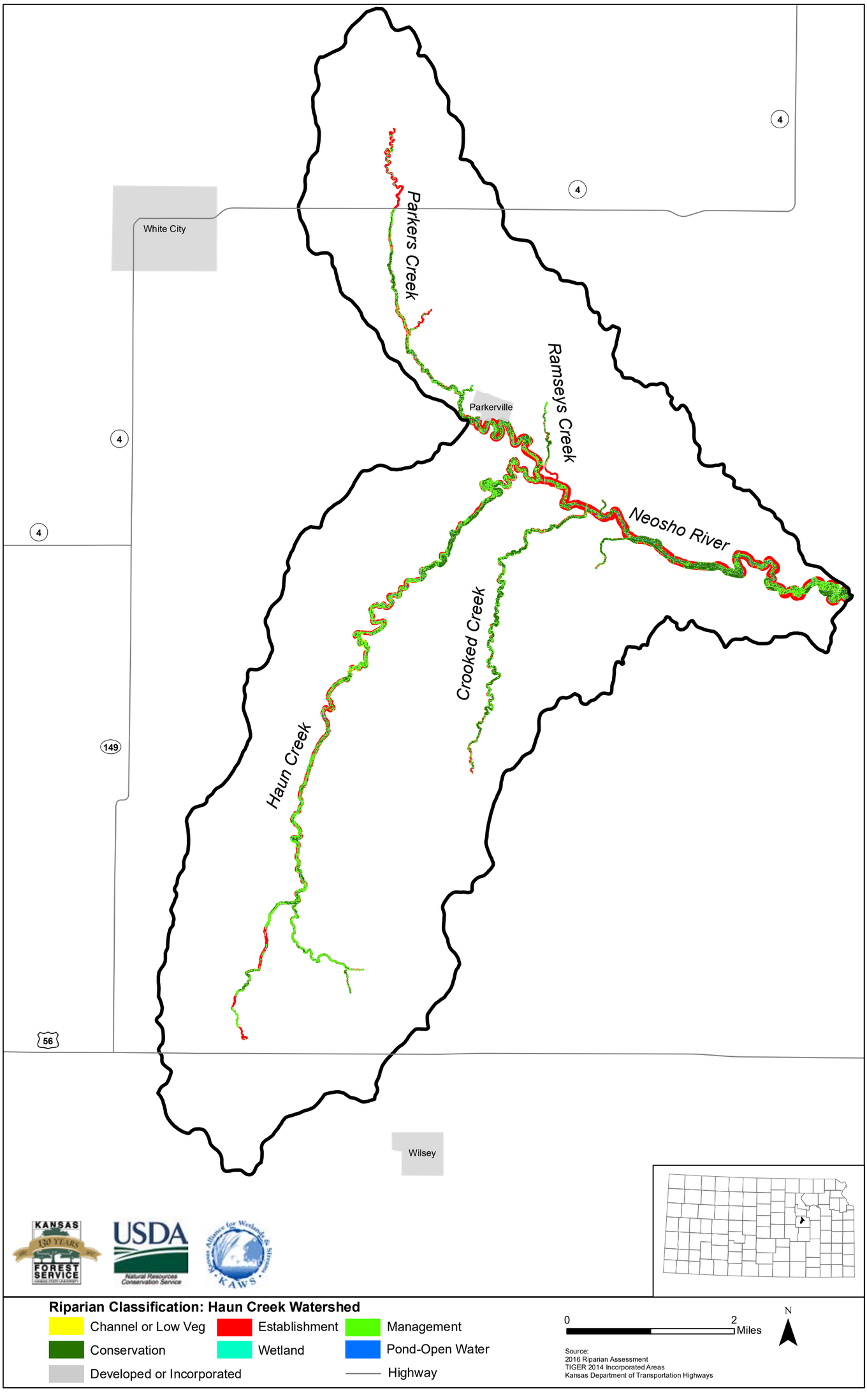

Figure 6. Riparian forest functioning condition classification of 2ACW riparian zone in Haun Creek watershed, Morris County, Kansas.

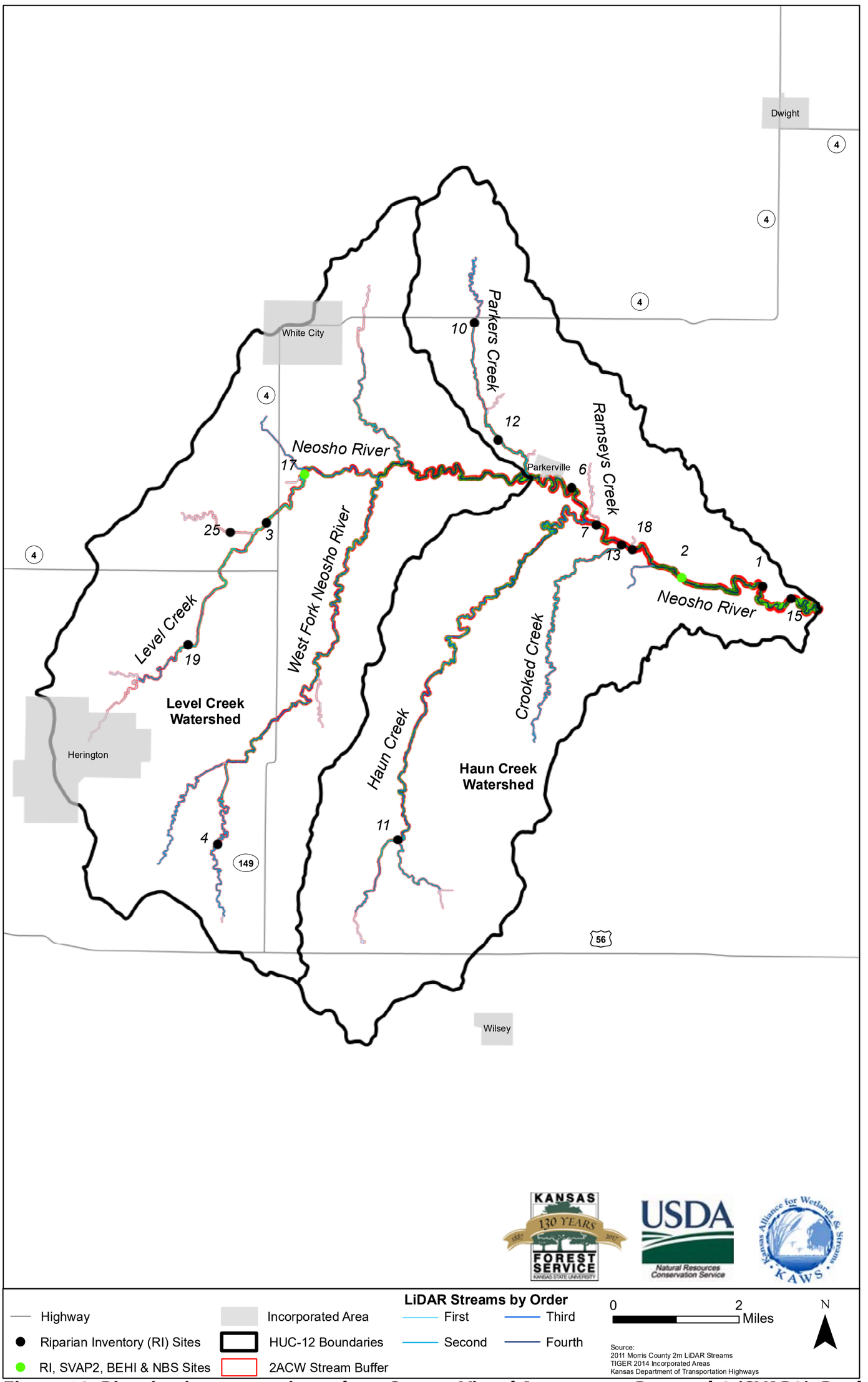

Figure 13. Riparian inventory sites where Stream Visual Assessment Protocol-2 (SVAP2), Bank Erosion Hazard Index (BEHI) and Near-bank Stress (NBS) assessments were also completed in Level Creek and Haun Creek Watersheds, Morris County, Kansas.

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