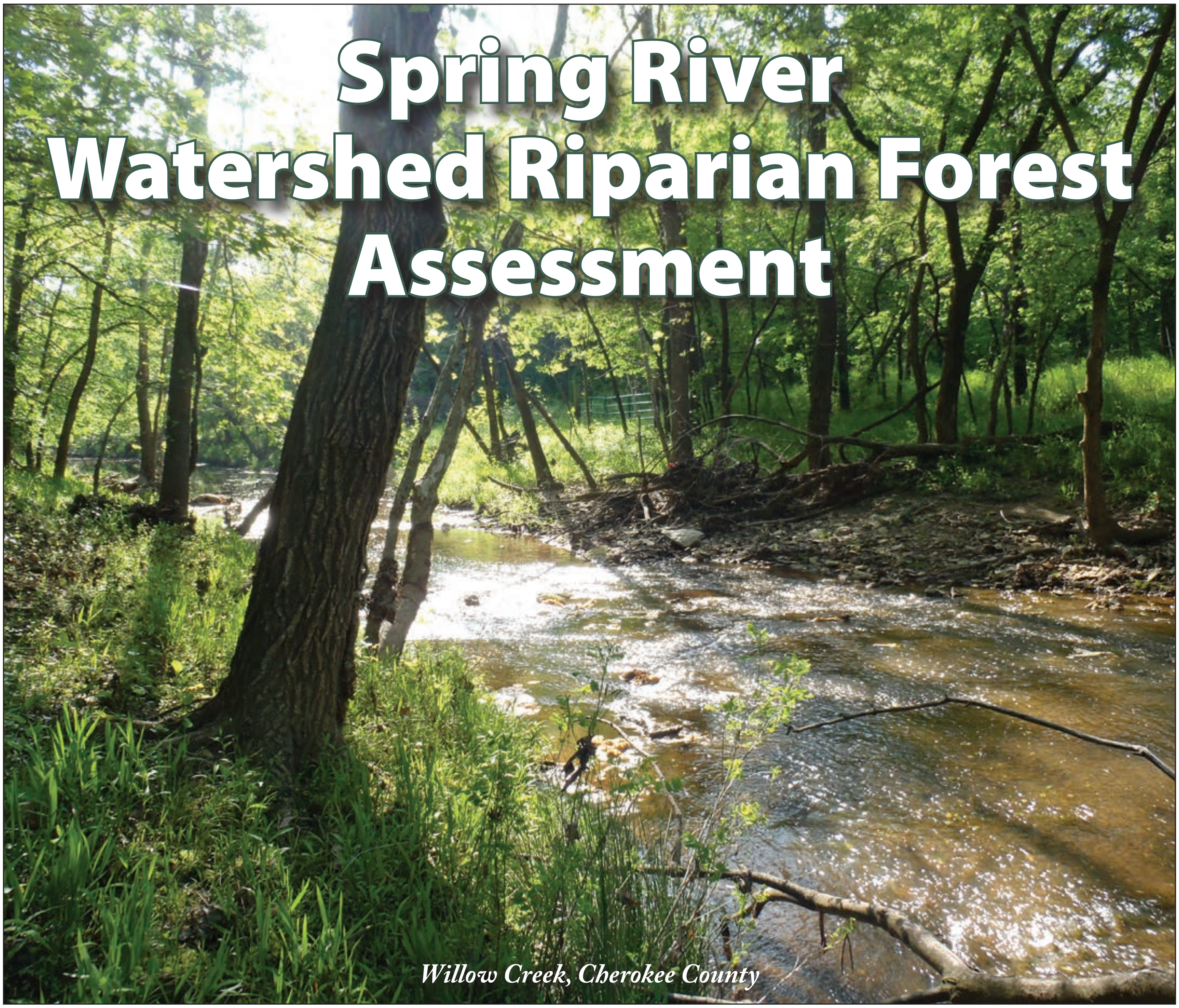
Spring River Watershed Riparian Forest Assessment



Willow Creek, Cherokee County

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Prepared for:
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Executive Summary

The Spring River Watershed Restoration and Protection Strategy group (WRAPS) identified the reduction of sediment and nutrient loads as a priority goal within their comprehensive, nine-element watershed plan (Gordon, 2011).

Streamside forests (also known as *riparian* forests) are an effective means of reducing sediment and nutrient loading to waterways, primarily through streambank stabilization (Geyer et al., 2003).

The current Kansas Forest Service project entailed using Geographical Information Systems (GIS), remote sensing, and in-field forest inventory to determine the location, extent, functioning condition, and species composition of riparian forests within three Hydrologic Unit Code 12 (HUC 12) sub-watersheds of the larger Spring River WRAPS watershed (11070207) in southeast Kansas. The three HUC 12 sub-watersheds assessed include: Willow Creek (1002) and Shoal Creek (0806) in Cherokee County, and Cow-Clear Creek (0401) in Crawford County.

Once the riparian forest location and extent were determined through GIS, forest functioning condition class was assigned by calculating the percentage of forest canopy coverage within the riparian area. Based on this calculation, forests were placed into 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 (e.g., tree species, diameter, height) and visual observations (e.g., invasive species presence, forest management evidence, degradation evidence) were also recorded at in-field plots within each watershed. In-field data and observations were used to validate GIS assumptions, as well as provide guidance for future direction of voluntary forestry programs (e.g., EQIP) and technical assistance aimed at achieving the greatest water quality impact for the Spring River watershed.

Forest in need of management was the dominant condition class within Shoal and Willow Creek watersheds, representing 86 and 61 percent of the total riparian area, respectively. *Forest in need of conservation* dominated the Cow-Clear riparian area (63%), represented a significant portion of the Willow Creek riparian area (39%), and was a relatively small component of the Shoal Creek riparian area (5%). The *forest in need of establishment class* represented a very small portion of the assessed riparian area in all watersheds, totaling 2, 9, and <1 percent of the riparian area within the Cow-Clear, Shoal, and Willow Creek watersheds, respectively.

In general, riparian forests within all three sub-watersheds exhibited a general lack of active forest management. This absence of management is evidenced by the current, mature forest species composition, which was found to be dominated by species of lower commercial value, such as hackberry (*Celtis occidentalis*), elm (*Ulmus spp.*), and ash (*Fraxinus spp.*). Regeneration (seedling/sapling) composition of all three watersheds was similarly found to be dominated by these lower-value species. In addition, two species *alone* (elm and hackberry) were found to make up 65, 31, and 52 percent of the total regeneration in the Cow-Clear, Shoal, and Willow Creek watersheds, respectively. Tree species of higher commercial value (e.g., walnut (*Juglans nigra*), oak (*Quercus spp.*)) represented no more than 15 percent of the total regeneration present within study watersheds, again indicating an absence of management.

At field plot locations, commonly observed threats to riparian forest health/sustainability included excessive livestock use, vine growth, and lack of active forest management.

Introduction

Forests that line Kansas waterways are known as *riparian* forests, and are vital for clean water. Riparian, simply put, is an area where land meets water — examples include riverbanks, lakeshores, and areas next to wetlands. Riparian comes from the Latin word *riparius*, meaning "frequenting riverbanks" or "the bank of a river." Riparian areas in Kansas have many different looks — from native tallgrass prairie lining the headwater streams of the Flint Hills, to big-timber floodplain forests along rivers such as the Republican, the Neosho, the Kansas, the Missouri, and of course, the Spring.

Riparian areas, and the forests they support, provide tremendous benefits to both landowners and the environment. From a forestry perspective, certain riparian areas (with their rich soil) are the prime sites for timber production in Kansas. Thus, properly functioning riparian forests provide watershed landowners and residents with a wide variety of sustainable income sources (e.g., quality timber, fuel wood, nut crops), 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. From a water quality perspective, healthy riparian areas buffer waterways by absorbing pollutants flowing off the landscape. Forested riparian areas also help 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 1993 flood suggests that riparian forests outperform other land cover types (i.e., 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 (i.e., phosphorus) to waterways. Because of their correlation to reduced sediment and nutrient loading, as well their ability to provide other ecological services such as stream shading/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 Spring River watershed.

The goal of this project was to determine the location, extent, functioning condition, and species composition of riparian forests within three HUC 12 sub-watersheds within the larger Spring River watershed: Willow Creek (1002) and Shoal Creek (0806) in Cherokee County, and Cow/Clear Creek (0401) in Crawford County (Figure 1). This information will be compiled into a GIS database that will be used by researchers, watershed stakeholders, and forestry professionals to allocate resources and guide forestry cost-share and technical-assistance programs, such as Environmental Quality Incentives Program (EQIP), and Continuous Conservation Reserve Program (CCRP), for water quality purposes. It also will help the Spring River WRAPS to achieve specific pollutant reduction goals (e.g., sediment, phosphorus), and get Best Management Practices (BMPs) implemented on the landscape — in the form of riparian forest buffers.

Secondary goals of this project include the gathering of baseline riparian forest information for the watershed and the region. Currently, detailed information on riparian forests in Kansas simply does not exist. Thus, information gathered in studies such as this will help the Kansas Forest Service answer the following critical questions: Where are our riparian forests located; what condition are they in; how many acres exist; and what tree species are present? Answers to these questions will help the Kansas Forest Service more effectively manage our state's riparian forest resources for water quality enhancement.

This study also sets the stage for WRAPS-funded Kansas Forest Service riparian forestry technical service over the next 3 years (FY14-16). Using information gained from this project, Kansas Forest Service foresters will know "where in the watershed do we need to work in order to get the biggest water quality bang-for-the-buck?"

GIS Methodology

Note: A detailed, technical GIS methodology can be found in Appendix A.

Determining the riparian area (i.e., where did we look?)

This project focused on assessing riparian forests within the Spring River watershed. Thus, the first step was to define the riparian area. For this project, the riparian area was defined as the intersection of:

- **A 2 active channel width (ACW) distance from the top streambank**, based on "Stream Visual Assessment Protocol v.2" (SVAP2, USDA-NRCS 2009) and the "Riparian Area Management: Process for Assessing Proper Functioning Condition" guidance (PFC, USDI-BLM 1998).

and

- **Soils indexed to NRCS Conservation Tree and Shrub Groups (CTSG) 1 and 2** based on the Soil Survey Geographic Database (SSURGO) for Kansas (USDA-NRCS 2009).

So, the riparian area (where we analyzed) can be defined as anywhere that the appropriate soils were found within a 2ACW buffer from the top streambank. An example of this overlap can be viewed in Figure 2.

Why was 2ACW used: Active channel width (ACW), also known as bankfull width, can be described as the width of the water in a stream channel at bankfull discharge. In unaltered/natural watersheds, bankfull discharge is defined as the volume of water flowing through a channel just before it spills into its floodplain. However, in post-settlement watersheds, where extensive land cover alterations have resulted in channel incision, the top streambanks do not define the bankfull width. Again, because of incision, most modern bankfull width measurements are taken between two points within the channel itself. Bankfull discharge is important, as it is the flow level where most of the channel-forming activity takes place. In Kansas, bankfull discharge typically occurs following a 1.2 to 1.7 year rainfall event. So, if you were a bird looking down over the Spring River soon after a 1.2 to 1.7 year rain event, the width of the water would be the ACW. The SVAP2 (a stream-assessment guide produced by the USDA) states that natural vegetation needs to extend at least 2ACW on each side of the stream for the riparian area to be properly functioning.

Why CTSG 1 and 2 soils were used: Groups 1 and 2 represent productive, floodplain soils. It is soils within CTSG 1 and 2 that represent the greatest potential for forest/tree growth and management. In addition, these soils, because of their proximity to waterways, represent the area where trees would be most effective for water quality enhancement.

The riparian area (i.e., the overlap of 2ACW width and CTSG 1 and 2 soils) for the three project watersheds can be viewed in Figures 3 and 4.

Determining forest cover

The percentage of forest cover within the riparian area was a critical factor in determining riparian forest functioning condition class. Forest cover was determined by using leaf-off LiDAR imagery (Figure 5).

Assigning riparian forest functioning condition class

Functioning condition class was determined by the percentage of forest cover found within the riparian area. Riparian areas exhibiting 0 to 5, 6 to 75, and 76 to 100 percent forest cover were classified as *forest in need of establishment*, *forest in need of management*, and *forest in need of conservation*, respectively. To aid with future WRAPS BMP promotion and implementation, classification was based on county landownership parcels.

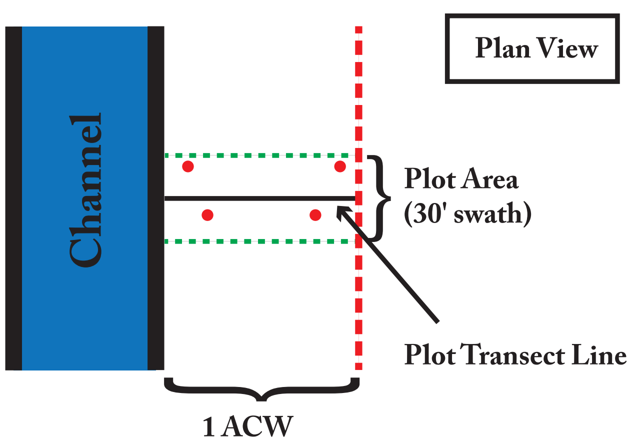

Figure 8. *Forest inventory plot layout, with red circles representing regeneration sub-plots. Not to scale.*

Forest Inventory Methodology

Sampling Design

Forest data was collected at 47 plots located within the study watersheds (Figures 6 and 7). Forest data was collected to verify the GIS assumptions and to collect vital information on riparian forest composition and structure.

To collect the data, a selected representative sample design was used. Plots were located in areas identified as *forest in need of conservation* by GIS. A landowner list was assembled and contacts were made to seek access permission. It was difficult to randomly distribute plots across the watersheds, as landowner permission was required for site access. In each watershed, a minimum of 15 field plots were striven for. In past assessments, 15 plots per watershed was the minimum needed to satisfy statistical requirements.

Plot layout and forest data collection

Rectangular plots were established with a long axis perpendicular to the stream of 50 feet or 1 ACW, whichever was greater, (Figure 8). The width of the plot was 30 feet, resulting in a plot area of at least 1,500 ft^2. Within this plot, a number of tree measurements and observations were recorded, including diameter at breast height (dbh), tree height, and tree crown class by species. Crown class is essentially a way to measure the "pecking order" of the forest. Amount of sunlight hitting the crown and tree height are the two factors that determine a tree's crown class. General notes were recorded for each tree as well, and included: disease presence, form, and degradation presence (e.g., vines, rot).

Within plots, all trees above 5 inches dbh were classified as mature trees and measured. Seedling and sapling regeneration was recorded from four circular sub-plots within the main plot. Regeneration plots had a radius of 5.3 feet (1/500 acre), with two plots located within the half of the plot nearest the stream, and two located in the half of the plot furthest from the stream. Regeneration plots were randomly stratified. Seedlings were classified as any small specimens of tree species present up to 4.5 feet tall and having a diameter of less than one inch. Saplings were recorded in the plots if they were more than 1 inch but less than 5 inches in dbh.

Stream ACW, forest width from the top of the streambank, and forest canopy coverage were recorded at plots as well. Qualitative data was also recorded, such as evidence of livestock use, evidence of woodland management (marking, harvesting, or planting trees), and dominant ground cover (grassy, broadleaved herbaceous, brushy, woody debris). The second ACW beyond the plots was also visually classified as forest, grass, or crop field.

Calculations

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

a. Basal area per acre (BA)
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 defined as the cross-sectional area at breast height and is computed through the formula by Avery and Burkhart (1994):

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

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

For each plot, the sum of the total BA per tree species was multiplied by the appropriate expansion factor (e.g., 29.04 for 1,500 ft^2 plots), to yield overall BA. The same expansion factors were also used to calculate estimates of TA. The expansion factor for RA was 1/500. QMD is defined as the diameter of the theoretical "tree" with the average BA for that particular species. In less technical terms, it provides the average diameter of each tree species recorded during the project.

Categorization of tree species according to timber value

It was important to consider the tree species composition from a commercial view point for the watersheds. Therefore, in consultation with Kansas Forest Service district 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 all oaks and walnut. Group 2 (moderate dollar value) was composed of ash, black cherry, cottonwood, hackberry, hickory, and silver maple. Group 3 (low dollar value) was composed of all other species.

GIS Results

Willow Creek watershed had the largest riparian area (639.8 acres), followed by Cow-Clear (574.7 acres), and finally Shoal Creek (433.8 acres). Within the Shoal and Willow watersheds, the majority of riparian area acreage was determined to be of the functioning condition class *forest in need of management* (Table 1), with that class representing 86 and 61 percent of the riparian area, respectively. *Forest in need of conservation* was dominant within Cow-Clear, representing 63 percent of the riparian area. Within Shoal and Willow, *forest in need of conservation* represented 5 and 39 percent of the total riparian area, respectively. *Forest in need of establishment* (i.e., non-forested riparian areas) represented 2, 9, and less than 1 percent of the total riparian area within Cow-Clear, Shoal, and Willow, respectively. A by-ownership parcel breakdown of watershed riparian areas by functioning condition class can be viewed in Figures 9 and 10. Total acres of actual woodland identified within Cow-Clear, Shoal and Willow riparian areas were determined to be 406, 118, and 396 acres, respectively.

Table 1. *Watershed riparian area breakdown by forest functioning condition class.*

Watershed	Condition Class	Acreage	% Total Acreage
Cow-Clear Creek	*Establishment*	10.6	2%
	Management	201.2	35%
	Conservation	362.9	63%
	Total	574.7	-
Shoal Creek	*Establishment*	38	9%
	Management	371.5	86%
	Conservation	24.3	5%
	Total	433.8	-
Willow Creek	*Establishment*	0.5	<1%
	Management	391.3	61%
	Conservation	248	39%
	Total	639.8	-

Riparian Forest Inventory Results

The Spring River watershed has a tree species diversity that is unmatched within Kansas. During the field inventory, foresters found several species that would not be found anywhere in Kansas outside of the extreme southeast counties, including flowering dogwood (*Cornus florida* L.), deciduous holly (*Ilex decidua* Walt.), and sassafras (*Sassafras albidum* Nutt.). Forest species diversity was relatively high compared to other areas of the state, with more than 25 tree species recorded within the 47 total field plots (Appendix B). It should be noted that all oak, hickory, ash, and elm species were lumped into the general categories of "oak," "hickory," "ash," and "elm," respectively. The category "other" included species that were found in low abundance (Appendix A).

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

Of the three study watersheds, Cow-Clear Creek was found to have the highest BA (all species combined), averaging 155.2 ft^2. Willow Creek ranked a close second, with 153.3 ft^2, while Shoal Creek was found to have the lowest, with 120.6 ft^2. This trend repeated itself for TA (all species combined), with Cow-Creek being the highest (215), followed by Willow (190), and Shoal (164) (Figure 11).

Within Cow-Clear, the top three species in terms of BA were hackberry (*Celtis occidentalis*), osage orange (*Maclura pomifera* (Raf.)), and ash (*Fraxinus americana and F. pennsylvanica*), with BA of 53.1, 43.3, and 16.8 ft^2, respectively (Figure 12). The top three BA species in Shoal Creek were ash (27.7 ft^2), elm (*Ulmus spp.*) (18.2 ft^2), and hackberry (17.8 ft^2) (Figure 13). Within Willow, the top 3 BA species were oak (*Quercus spp.*) (30.3 ft^2), other (27.4 ft^2), and hickory (*Carya spp.*) (22.8 ft^2) (Figure 14).

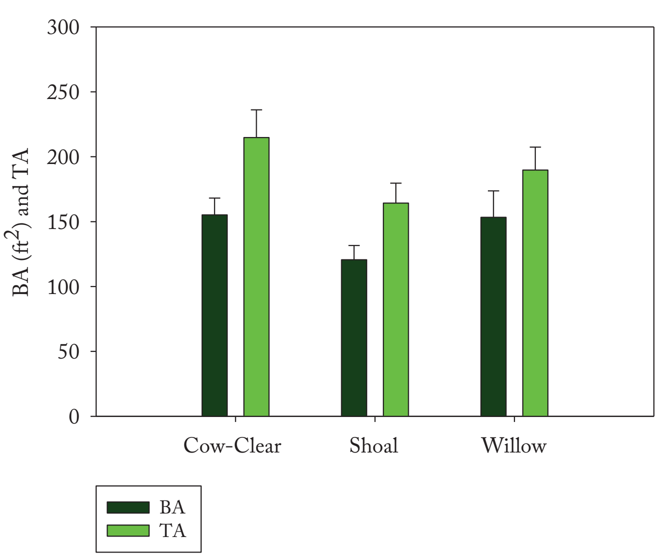

Figure 11. *Total BA and TA (all species combined) by watershed.*

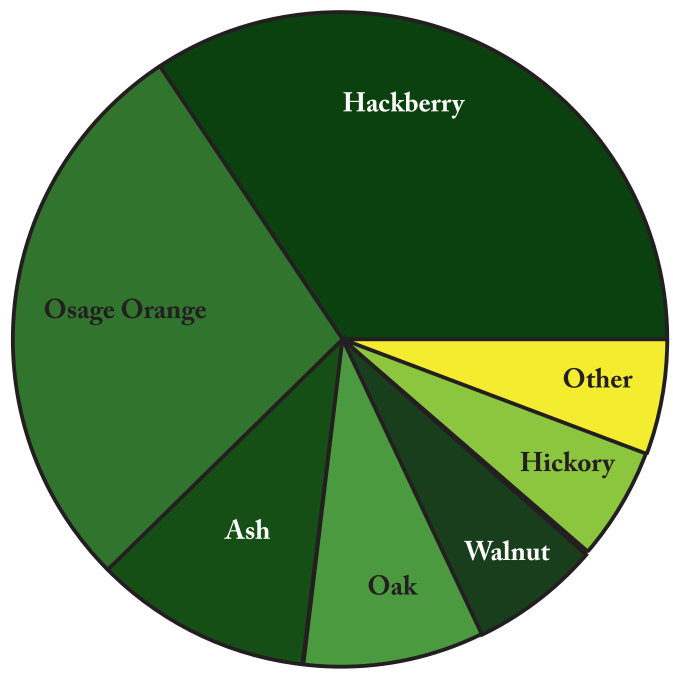

Figure 12. *Cow-Clear Creek BA composition by species*

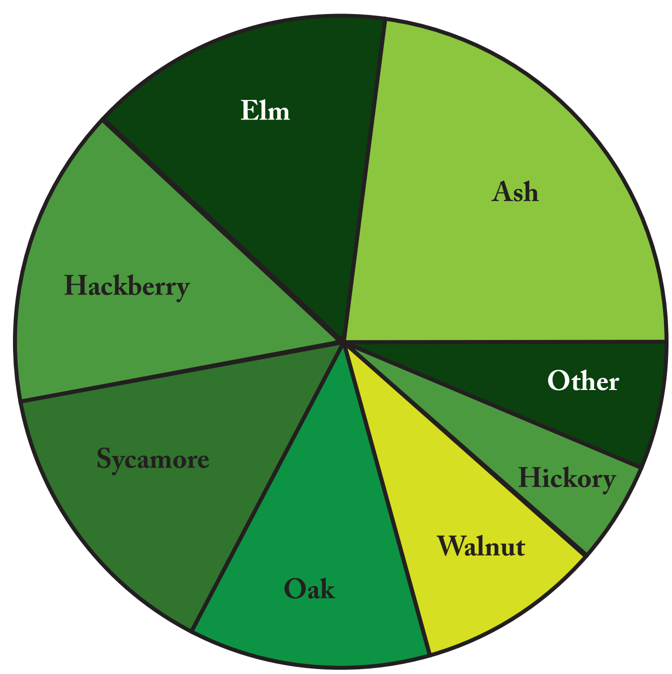

Figure 13. *Shoal Creek BA composition by species.*

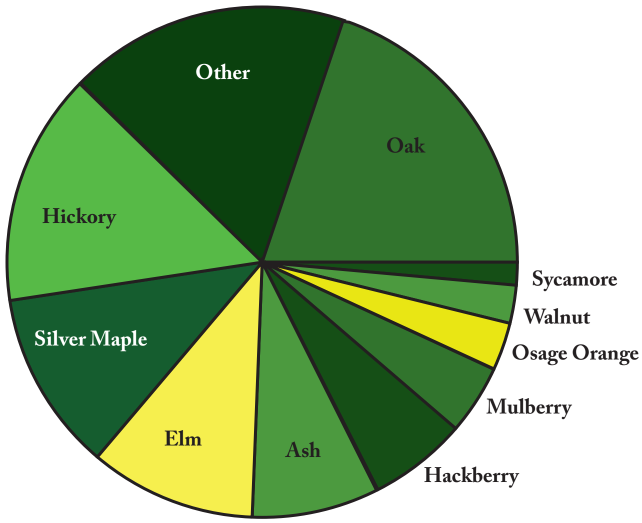

Figure 14. *Willow Creek BA composition by species.*

In terms of TA, Cow-Clear was dominated by osage orange (92), hackberry (52), and ash (17). Shoal was found to be dominated by ash (40), elm (40), and hackberry (30), while Willow was dominated by hickory (43), other (43), and elm (25) (Table 2).

Oak and black walnut represent the top commercially valuable timber species in Kansas, yet both represented a very small portion of the total BA and TA within project watersheds. Each individual species generally represented less than 15 percent of the total BA and TA within each watershed, with the exceptions of oak BA in Willow (20%).

Regeneration per Acre (RA)

Shoal Creek exhibited the highest total RA (seedlings and saplings) of the watersheds with an average of 3350. Cow-Clear and Willow exhibited 1476 and

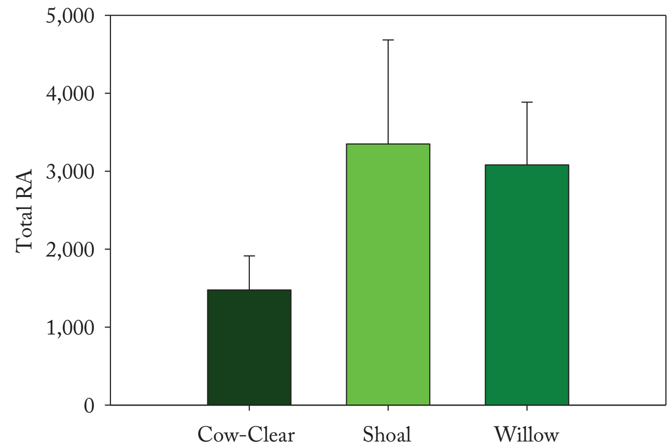

Figure 15. *Total RA (seedlings and saplings) by watershed.*

3080 RA, respectively (Figure 15). Within Cow-Clear and Willow, regeneration was dominated by two species *alone* (elm and hackberry), which made up 65 and 52 percent of the total RA. Shoal Creek exhibited slightly more diversity, as elm and hackberry only represented 31 percent of the total RA, with oak, hickory, and other making up the bulk of the remainder. Tree species of higher commercial value (e.g., oak, walnut) represented no more than 15 percent of the total regeneration present within study watersheds. In plots, seedlings were far more prevalent than saplings, with seedlings out-representing saplings by a ratio of nearly 14:1.

Quadratic Mean Diameter

Quadratic Mean Diameter (QMD) is the average diameter of each tree species recorded during the project. QMD can assist land managers in developing effective strategies for forest management, including the

Table 2. *Watershed TA breakdown, by species. Top three species per watershed displayed in red text.*

Cow – Clear		Shoal		Willow	
Species	*Average TA*	*Species*	*Average TA*	*Species*	*Average TA*
Ash	17	Ash	40	Ash	11
Elm	8	Elm	40	Elm	25
Hackberry	52	Hackberry	30	Hackberry	21
Hickory	12	Hickory	9	Hickory	43
Mulberry	3	Mulberry	0	Mulberry	6
Oak	13	Oak	11	Oak	17
Osage Orange	92	Osage Orange	0	Osage Orange	10
Silver Maple	0	Silver Maple	0	Silver Maple	8
Sycamore	1	Sycamore	11	Sycamore	2
Walnut	9	Walnut	11	Walnut	4
Other	6	Other	12	Other	43

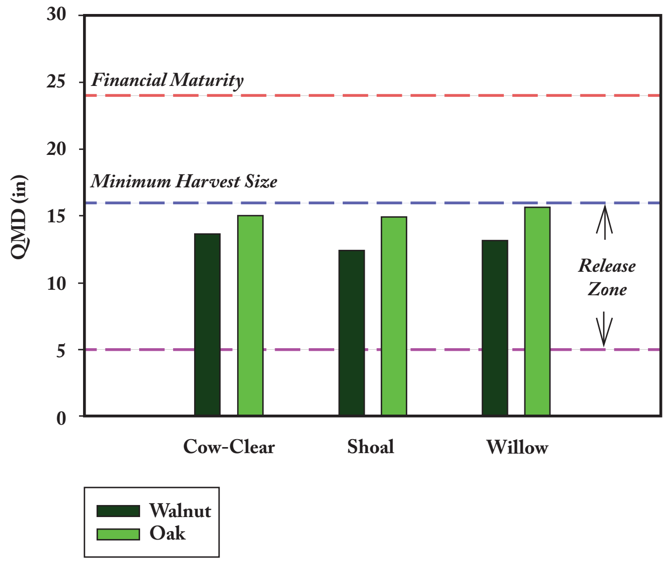

Figure 16. *Oak and walnut QMD by watershed.*

scheduling of Forest Stand Improvement (e.g., thinning) and timber harvest. As an example, consider the QMD of black walnut and oak within study watersheds. Black walnut QMD was found to be 13.6 inches, 12.3 inches, and 13.2 inches for Cow-Clear, Shoal, and Willow, respectively (Figure 16). Oak QMD was found to be 14.9 inches, 14.8 inches, and 15.6 inches for Cow-Clear, Shoal, and Willow, respectively. These numbers indicate that oak and walnut would greatly benefit from a release. Releases are commonly in the form of Forest Stand Improvement (FSI) practices, where adjacent, competing, less-desirable tree species are removed to enhance the growth of desired species.

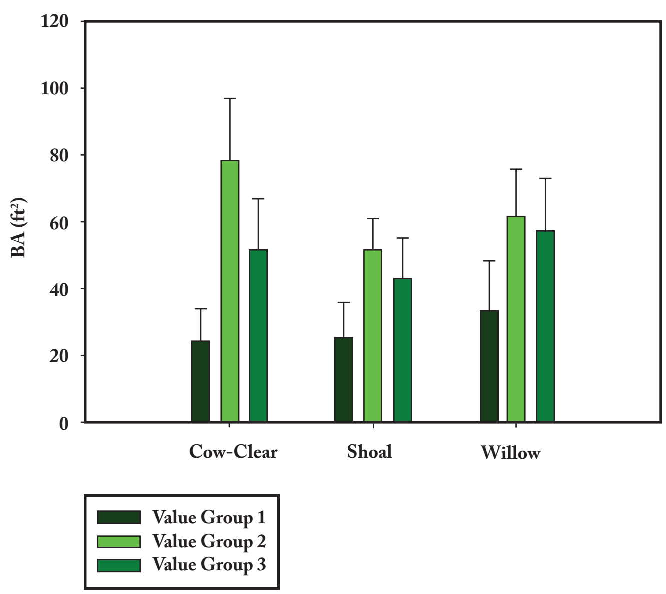

Figure 17. *Watershed BA by Species Value Group.*

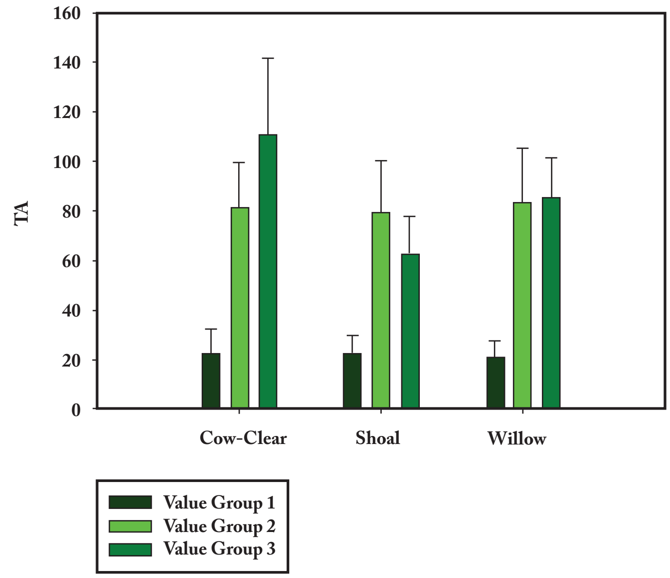

Figure 18. *Watershed TA by Species Value Group.*

Categorization of overstory 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 all oaks and walnut. Group 2 (moderate dollar value) was composed of ash, black cherry, cottonwood, hackberry, hickory, and silver maple. Group 3 (low dollar value) was composed of all other species.

Within all watersheds, BA and TA were dominated by Value Groups 2 and 3 (Figures 17 and 18). Species Value Group 2 represented the highest BA within all watersheds, representing 51, 43, and 41 percent of total BA in Cow-Clear, Shoal, and Willow Creek watersheds, respectively. Value group 1 BA was quite similar across watersheds, with Cow-Clear, Shoal, and Willow exhibiting 24.1, 25.5, and 33.9 ft^2 / acre, respectively. Cow-Clear exhibited the highest Value Group 2 BA (79 ft^2), while Shoal exhibited the lowest (51.7 ft^2). Value Group 3 BA was found to be fairly similar across watersheds as well, with Cow-Clear, Shoal, and Willow yielding 51.8, 43.3, and 57.2 ft^2 per acre, respectively. Value Group 1 represented the lowest percentage of total BA within Cow-Clear (15%). Within Shoal and Willow, Value Group 1 represented 21 and 22 percent of the total BA, respectively.

Value Group 1 TA was similar across watersheds, with Cow-Clear, Shoal, and Willow exhibiting 22.3, 22.2, and 21.2 TA, respectively. Value Group 2 TA was also similar across watersheds, with Cow-Clear, Shoal, and Willow exhibiting 82, 79, and 83 TA. A more noticeable TA difference across watersheds occurred for Value Group 3, where it was highest in Cow-Clear (110

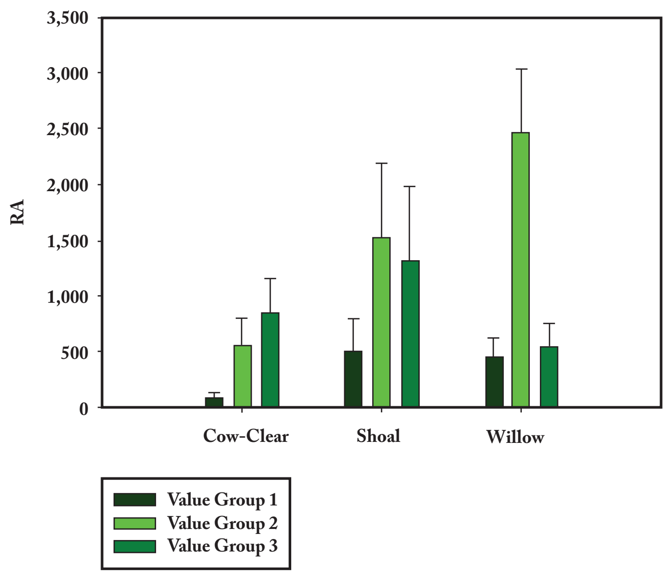

Figure 19. *Watershed RA by Species Value Group.*

TA), followed by Willow (85 TA), and finally Shoal (63 TA). Value Group 1 represented the lowest percentage of total TA in Cow-Clear (10%). Value Group 1 was also a relatively low component of total TA in Shoal (13.5%) and Willow (11.2%).

Categorization of regeneration species according to timber value

A high number of total RA (ranging 1476 to 3350) was recorded in all three watersheds, with species in Value Group 2 being the most common overall (Figure 19). Compared with BA and TA, Value Group RA varied relatively greatly across watersheds. Value Group 1 RA was found to be greatest in Shoal Creek (500), followed by Willow (458), and finally Cow-Clear (81). Value Group 1 represented the lowest percentage of total RA within Cow-Clear (5%), while that Group represented 15 percent of total RA within both remaining watersheds. Value Group 2 RA was highest in Willow (2467), followed by Shoal (1525), and finally Cow-Clear (559). Willow exhibited a relatively low Value Group 3 RA (545), with Cow-Clear (836), and Shoal (1325) being higher.

Qualitative data

Livestock use (e.g., manure, trails, visible livestock) was most prevalent within Cow-Clear plots, with 41 percent of all plots exhibiting some form of livestock evidence. Within Willow, livestock evidence was found within 13 percent of plots, while no evidence at all was observed within Shoal Creek plots (Table 3). Active Forest Management (e.g., marked trees, evidence of thinning/harvest) was present on 47 percent of all plots within both Willow and Shoal Creek watersheds. Management was least prevalent in Cow-Clear, with only 29 percent of all plots exhibiting some form of forest management. It is of note that a majority of the management observed within watersheds was estimated to be relatively old (older than 20 years), and of small scale (e.g., isolated fuel wood harvest).

While in plots, foresters classified the land use present beyond the first ACW into three groups: forest, grass, or row-crop. In both Shoal and Willow, 100 percent of land use beyond plots was forest. In Cow-Clear, 82 percent of second ACW land use was forest, while 12 percent was represented by row-crop, and 6 percent by grass (Table 3).

Abundant vine growth also represented a threat to forest health, and was observed frequently in all watersheds. While beneficial in smaller amounts (especially to wildlife), heavy growth of poison ivy (*Toxicodendron radicans*) and Japanese honeysuckle (*Lonicera japonica*) was observed inhibiting tree growth by girdling tree trunks and overtaking canopies. Heavy amounts of vines within the forest canopy reduce the amount of sunlight available to trees, and also add significant weight to tree canopies, leaving them more vulnerable to ice and wind damage.

Invasive species presence was recorded within plots. Garlic mustard (*Alliaria petiolata*) and multi-flora rose *(Rosa multifora*) were observed in all watersheds, but in relatively low abundance. The primary invasive species that threatened forest health was the aforementioned Japanese honeysuckle, which was observed extensively.

Table 3. *Qualitative Plot Data*

		% Plots with		% Plot Second ACW Land Use		
Watershed	**# Plots**	**Livestock**	**Management**	**Forest**	**Grass**	**Crop**
Cow-Clear	17	41	29	82	6	12
Shoal	15	0	47	100	0	0
Willow	15	13	47	100	0	0

Conclusions

A majority of the riparian area within watersheds was determined to be *forest in need of management* or *forest in need of conservation*, which suggests a good proportion of the riparian corridor is wooded, to some extent. Also encouraging is the fact that the acreage of *forest in need of establishment* was found to be relatively low within all watersheds.

The three project watersheds were found to have a high diversity of riparian tree species, with more than 25 species recorded within field inventory plots. Total forest BA and TA (all species combined) were found to be adequate for streambank stabilization and properly functioning riparian areas in all three watersheds. It should be noted that inventory plots were only performed within areas determined as *forest in need of conservation*.

Tree Value Groups 2 and 3 were found to dominate BA and TA within all watersheds, while Value Group 1 represented a relatively small proportion. Value Groups 2 and 3 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. In addition, two species *alone* (i.e., elm and hackberry) comprised a majority of the RA within Cow-Clear (65%) and Willow Creek (52%) watersheds, and 31 percent of the RA in Shoal Creek. It should be noted that no statistical significant differences ($p=0.05$) were detected between watersheds for total BA, TA, or RA.

The QMD for both species within Value Group 1 (i.e., oak and walnut) suggests that a majority 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). The ratio of BA to TA for Value Group 1 also suggests that there are a number of larger (greater than 20 inches dbh), over-mature oak and walnut trees in the woodlands of these watersheds.

Common observed threats to healthy/sustainable woodlands included: excessive livestock use, lack of active management, and vines. Livestock use was most prevalent in Cow-Clear, lesser so in Willow, and absent in Shoal Creek inventory plots. Excessive livestock use can be detrimental to forest regeneration, vegetative ground cover, and streambank condition. It is of note that Cow-Clear had both the highest incidence of riparian livestock use and the lowest overall RA. Cow-Clear also saw the least amount of forest management evidence, with evidence slightly higher within Shoal and Willow.

It should be noted that a vast majority of forest management efforts observed within field inventory plots were very old. In addition, many were of small scale (e.g., limited fuel wood harvest). Current forest management activities (e.g., recent harvest, thinning, tree marking) were rare.

Within all watersheds, the land cover beyond the first ACW from the top streambank was predominately forest.

Management Recommendations

Cow-Clear Creek watershed

Because the majority of the Cow-Clear riparian corridor was determined to be *forest in need of conservation* (63%), efforts to expand active forest management within the riparian area are encouraged. In conjunction with this, efforts to limit/restrict livestock access to riparian areas would help to enhance forest regeneration and nonwoody ground cover.

Management of existing riparian forests, through Forest Stand Improvement, would help to lessen the dominance of Value Group 2 and 3 trees species (especially osage orange and hackberry), and increase the abundance of Value Group 1 species (oak and walnut). Reducing competition around mid-size oaks and walnuts would act to spur growth and shorten the time until harvest. In addition, harvesting a select amount of larger oak and walnut (greater than 20 to 24 inches dbh) would help to create gaps in the canopy, which would promote sun-loving oak and walnut seedlings. Removal of vines present on crop trees would also help to increase growth and overall vigor.

It is worth mentioning that all riparian tree species are intrinsically valuable, and have a place in the riparian ecosystem. Great emphasis is placed on promoting hardwood species such as oak and walnut, however, because these species have been logged-out of many watersheds across Kansas. These past, nonsustainable harvests were commonly known as "high-grades". During "high-grades" every merchantable tree was cut out of the woods, leaving only the poor-form, low-vigor individuals to reproduce. Also, commercially valuable trees may help landowners view riparian areas as an asset/income source, thus reducing the chance that these areas are degraded or converted to another land use (e.g., row-crop). Increasing the abundance of oak, walnut, and hickory may lead to more wildlife-associated recreation in the future, such as hunting and wildlife watching.

Shoal Creek watershed

Because the riparian area within Shoal was found to be composed of 9 percent *forest in need of establishment*, and only 2 percent *forest in need of conservation*, a riparian forest buffer establishment initiative is recommended. During this initiative, planting buffers with a high percentage of Value Group 1 species is recommended. Innovative tactics will be needed to increase the adoption of riparian forest buffer among Shoal's landowners (and all Kansas landowners). For example, combining WRAPS BMP funds with traditional cost share funds (e.g., CCRP) to allow the landowner to hire a forestry contractor to plant and maintain (e.g., weed control) forest buffers for at least 3 years (3 years of maintenance is critical, and will substantially increase the chance that riparian tree plantings are successful). Because the majority (86%) of the riparian area within Shoal was found to be *forest in need of management*, efforts to increase buffer widths to at least 1 ACW (or 50 foot minimum) are recommended.

Also, as with Cow-Clear, management of existing forests is needed. Forest Stand Improvement efforts, for example, would help to reduce the abundance of Value Group 2 and 3 trees species (especially elm and hackberry), and increase the abundance of Value Group 1 species (oak and walnut). Again, similar to Cow-Clear, efforts to release mid-sized oak and walnut would increase their growth and vigor, thus lessening the time period until they reach harvestable size. Addressing vine growth should also be a priority. Restricting / limiting livestock access to riparian areas is not a high priority for this watershed, as no livestock evidence was present in any field inventory plots. This watershed held many extensive tracts of forest (all inventory plots had forest land cover in the area beyond the first ACW), thus, landowners within Shoal may be more open to comprehensive, sustainable forest management plans (i.e., Forest Stewardship Plans).

Willow Creek watershed

A vast majority of the riparian area with Willow was found to be either *forest in need of management* (61%), or *forest in need of conservation* (39%). Thus, an initiative to establish new forest buffers is not recommended. Instead, the primary focus should be on expanding existing buffer widths to at least 1 ACW (50 feet minimum), and promoting Forest Stand Improvement practices to protect existing riparian woodland. During FSI practices, reducing vine competition with trees should be a top priority. In addition, livestock exclusion efforts should be given a relatively low priority (only 14 percent of plots had livestock evidence).

The portion of the watershed present east of Spring River held extensive tracts of forest. Thus, similar to Shoal, landowners in this area may be more open to comprehensive, sustainable forest management plans (i.e., Forest Stewardship Plans).

A Note on Emerald Ash Borer

Emerald ash borer is an exotic invasive beetle from eastern Russia and northeastern Asia that likely was brought to the United States in infested packing material. It was first detected in Kansas in 2012, in Wyandotte County. This beetle threatens urban and riparian forests by killing North American ash species (*Fraxinus spp*.) and their cultivars. To date in the United States, more than 25 million ash trees have been destroyed because of emerald ash borer. Ash was found to be a component of riparian forests within all three watersheds (most abundant in Shoal). Thus, all watersheds are threatened to lose a portion of their riparian timber composition in the near future, which will have implications on streambank stability, stream temperature, and wildlife habitat. Landowners may wish to remove a greater percentage of ash during Forest Stand Improvement and harvesting efforts, and may wish to discontinue using ash in riparian tree planting projects.

More information on emerald ash borer can be found online at *www.kansasforests.org*.

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Appendix A: GIS Methodology

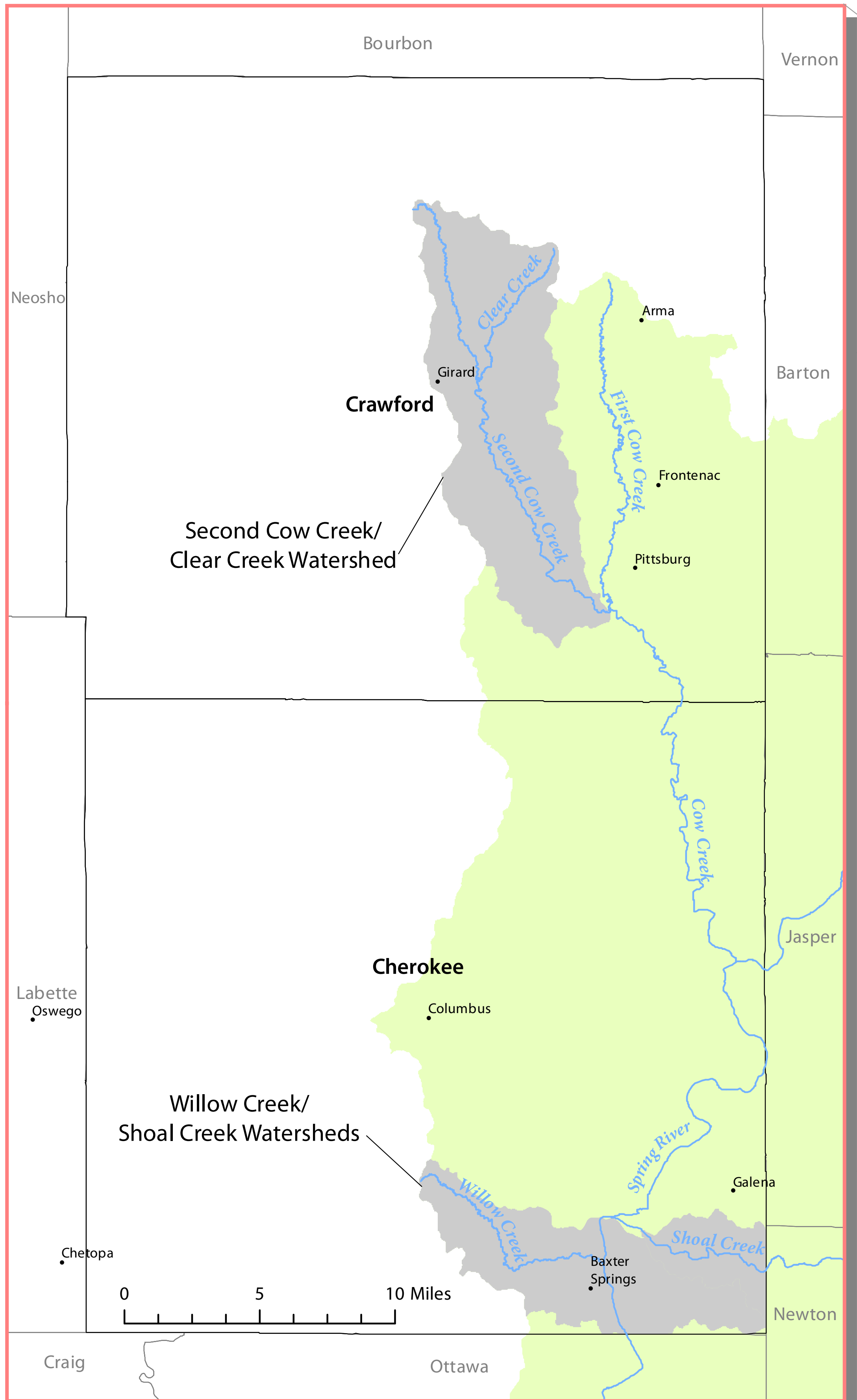
1. To get ACW:
   a. Create flow accumulation raster from LiDAR data using ArcGIS hydrology toolset
   b. Each cell value equals drainage area in m^2, need to convert to mi^2 — divide area in m^2 by 3.86102e-7 to calculate drainage area in mi^2.
   c. Select out flow accumulation cells > 1 mi^2 using extract by attributes tool
   d. Convert raster to point
   e. Add field "ACW" (active channel width) and calculate field based on SC regional curve:
   f. Multiply this by 1.33 to get bank width and add 2*ACW to 0.5*bank width to get buffer distance
   g. Buffer by the 2ACW field
   h. For Spring River and other streams with drainage areas beyond the HUC12 of interest, ACW needs to be measured by hand because of complexity of integrating upstream drainage area
   i. Merge and dissolve "custom" Spring River and flow accumulation-derived 2ACW buffers
2. To get woodland cover using leaf-off LiDAR data:
   a. Use ArcScan to buffer leaf-off LiDAR data to a distance of 20m for each pixel greater than 3.96m (13 feet) to create an overestimate of woodland cover (Dilate with value of 20). Convert to vector, select GRIDCODE = 1, and clip NAIP by this shape.
   b. Use "Extract by Attributes" tool to extract NAIP-derived NDVI values greater than 0.45, which seemed to be a breaking point where the NDVI pixels represented woodland cover
3. To get percent cover within 2ACW buffer width per parcel:
   a. Intersect parcels with 2ACW buffer
   b. Clip resulting layer by suitable soils (NRCS SSURGO Conservation Tree and Shrub suitability classes 1 and 2)
   c. Dissolve by parcel ID field
   d. Add a new field – "suitable acres," calculate geometry in acres
   e. Intersect this layer with the woodland cover layer created in step 2
   f. Add a new field – "wooded acres," calculate geometry in acres
   g. Add a new field – "percent cover," use field calculator to divide wooded acres field by suitable acres field, which yields percent cover
   h. Export the attribute table for this layer and join it to the original parcels layer using the parcel ID field as the join field
   i. Search for parcels that fulfil the soil suitability requirements, but that don't have any tree cover. Manually digitize these parcels and enter something like "0.01" to indicate absence of tree cover
   j. Symbolize the parcels by cover thresholds (0-5%, 6-75%, and 76-100% cover)

Appendix B: Tree Species List

Common Name	Scientific Name
Ash (includes Green, White)	*Fraxinus, spp.*
Black walnut	*Juglans nigra*
Elm (includes American, Red)	*Ulmus, spp.*
Hackberry	*Celtis occidentalis*
Hickory (includes Pecan, Bitternut, Shagbark)	*Carya, spp.*
Mulberry (includes Red, White)	*Morus, spp.*
Oak (includes Black, Bur, N. Red, Pin,White)	*Quercus, spp.*
Osage Orange	*Maclura pomifera*
Silver Maple	*Acer saccharinum*
American Sycamore	*Platanus occidentalis*
*Black Cherry	*Prunus serotina*
*Black Locust	*Robinia pseudoacacia*
*Boxelder	*Acer negundo*
*Buckeye (Western)	*Aesculus glabra*
*Buckthorn (Woolly)	*Bumelia lanuginosa*
*Catalpa	*Catalpa speciosa*
*Deciduous Holly	*Ilex decidua*
*Dogwood (Flowering)	*Cornus florida*
*Eastern Redcedar	*Juniperus Virginiana*
*Hawthorne (Cockspur)	*Crataegus crus-galli*
*Honey Locust	*Gleditsia triacanthos*
*Kentucky Coffeetree	*Gymnocladus dioica*
*Paw Paw	*Asimina triloba*
*Persimmon	*Diospyros virginiana*
*Redbud	*Cercis canadensis*

*Grouped as “Other”

Spring River Riparian Forest Assessment Study Area



Sources:
USGS National Hydrography Dataset
U.S. Census Bureau

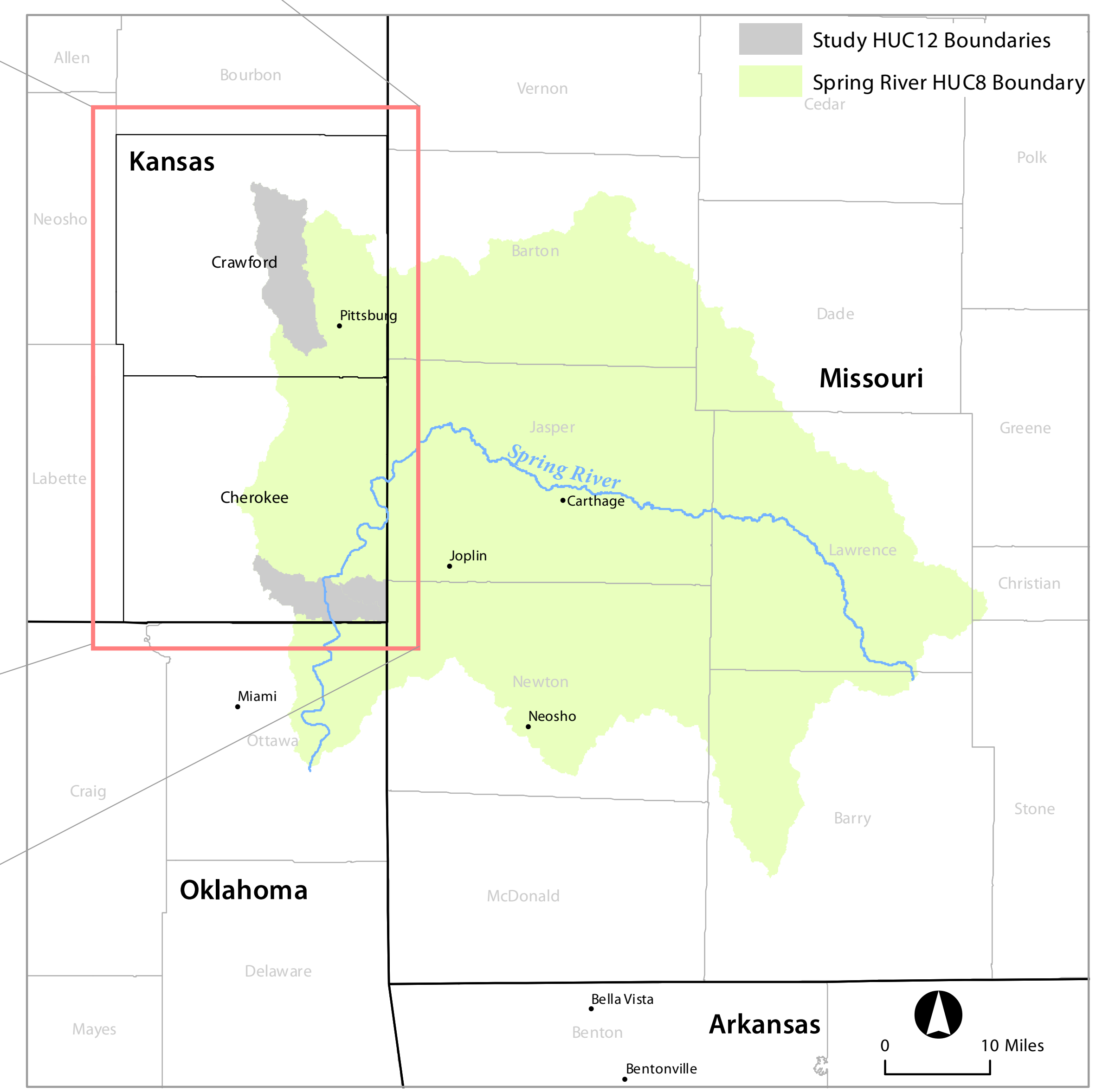


Figure 1. Spring River Riparian Forest Assessment Study Area

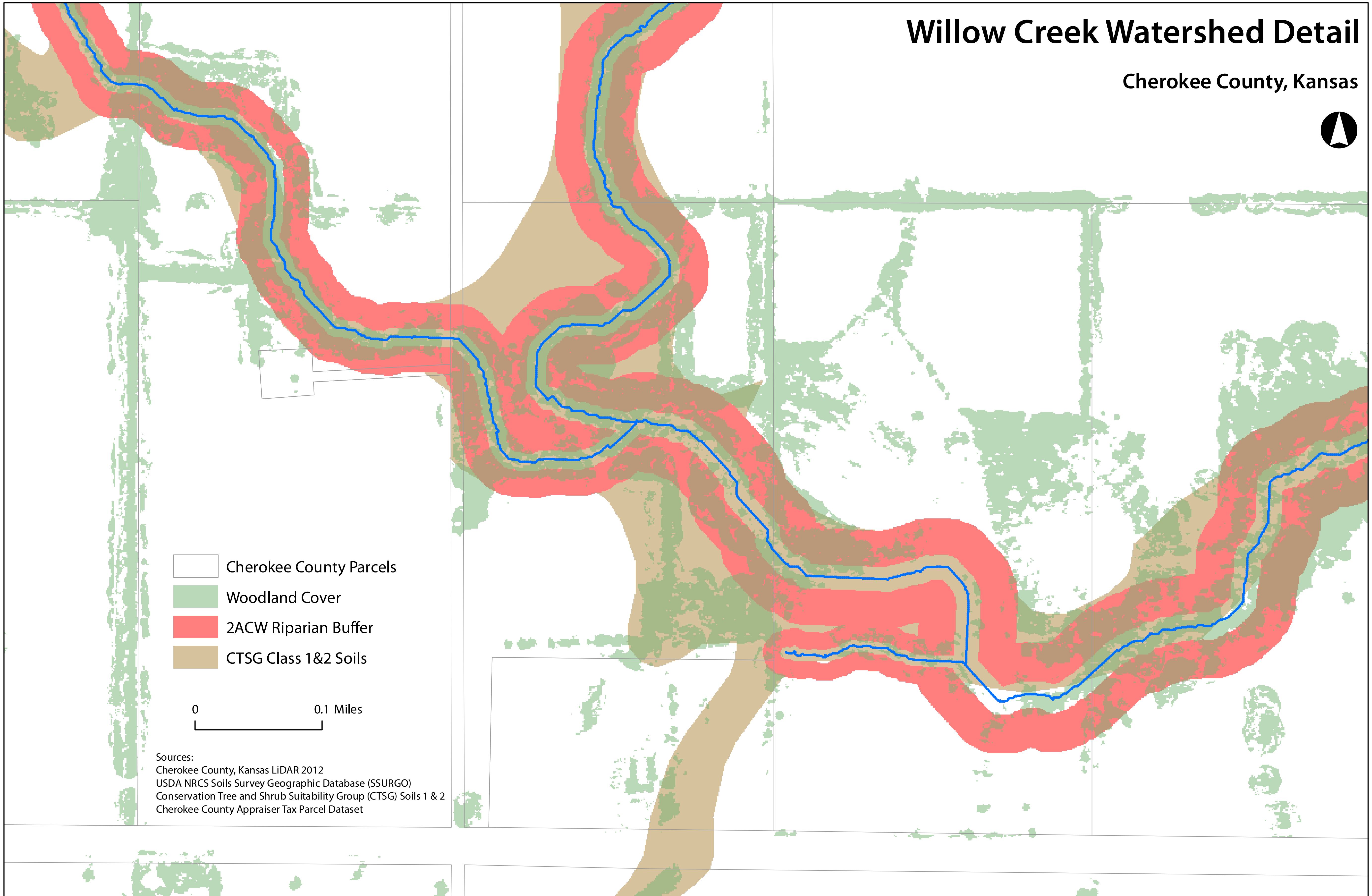
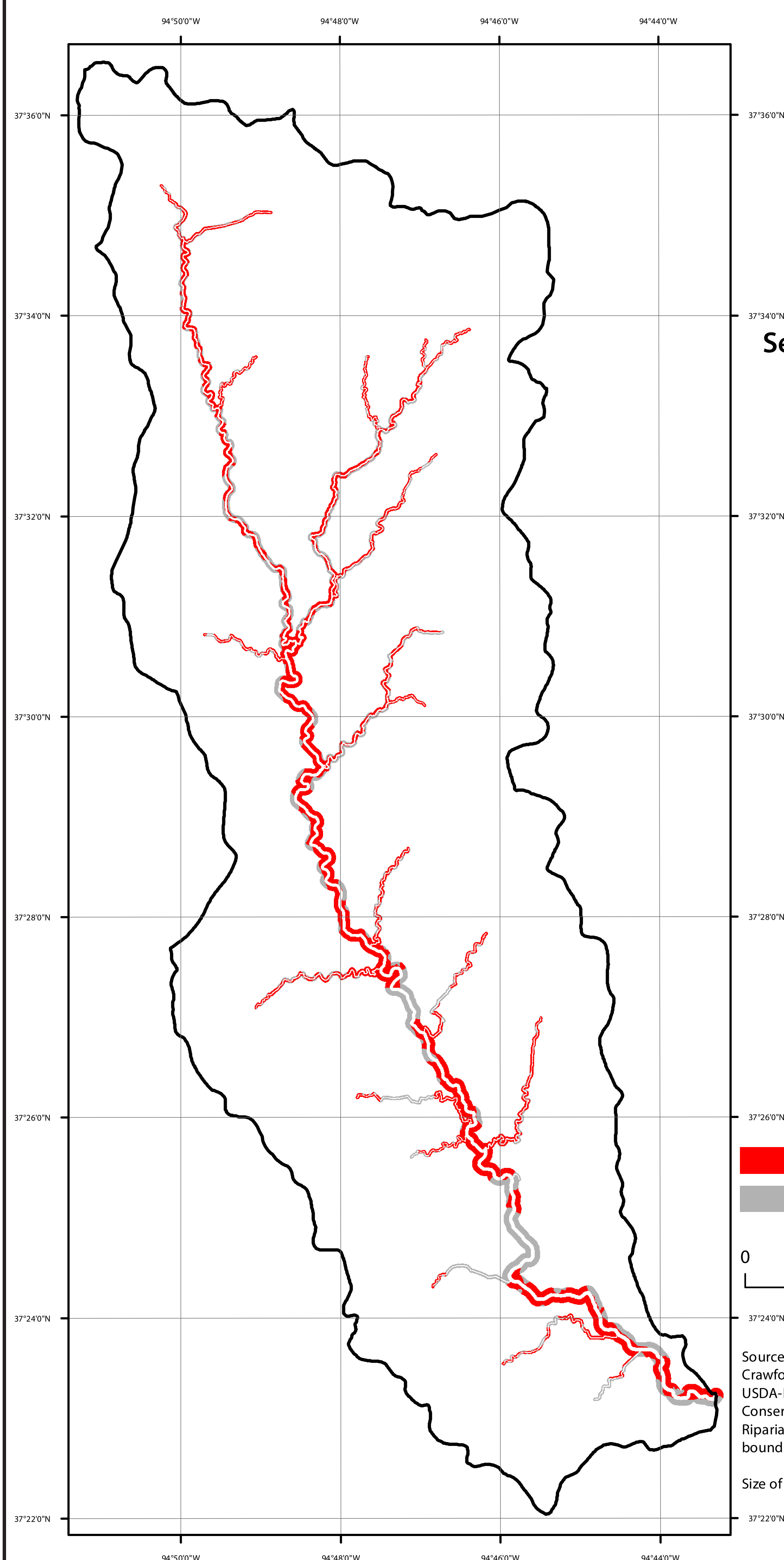


Figure 2. Willow Creek Watershed Detail

Riparian Forest Analysis Area

Second Cow Creek Watershed

Crawford County, Kansas



Riparian Forest Potential/Capability

2ACW Riparian Buffer

0 2 4 Miles

Sources:
Crawford County, Kansas LiDAR 2012
USDA-NRCS Soil Survey Geographic Database (SSURGO)
Conservation Tree & Shrub Suitability Group (CTSG) Soils 1 and 2.
Riparian Forest Potential/Capability defined by clipping 2ACW boundary by CTSG Soils 1 and 2 polygons.

Size of buffer features is exaggerated for clarity.

Figure 3. Riparian Forest Analysis Area: Second Cow Creek Watershed

Riparian Forest Analysis Area

Willow Creek and Shoal Creek Watersheds

Cherokee County, Kansas

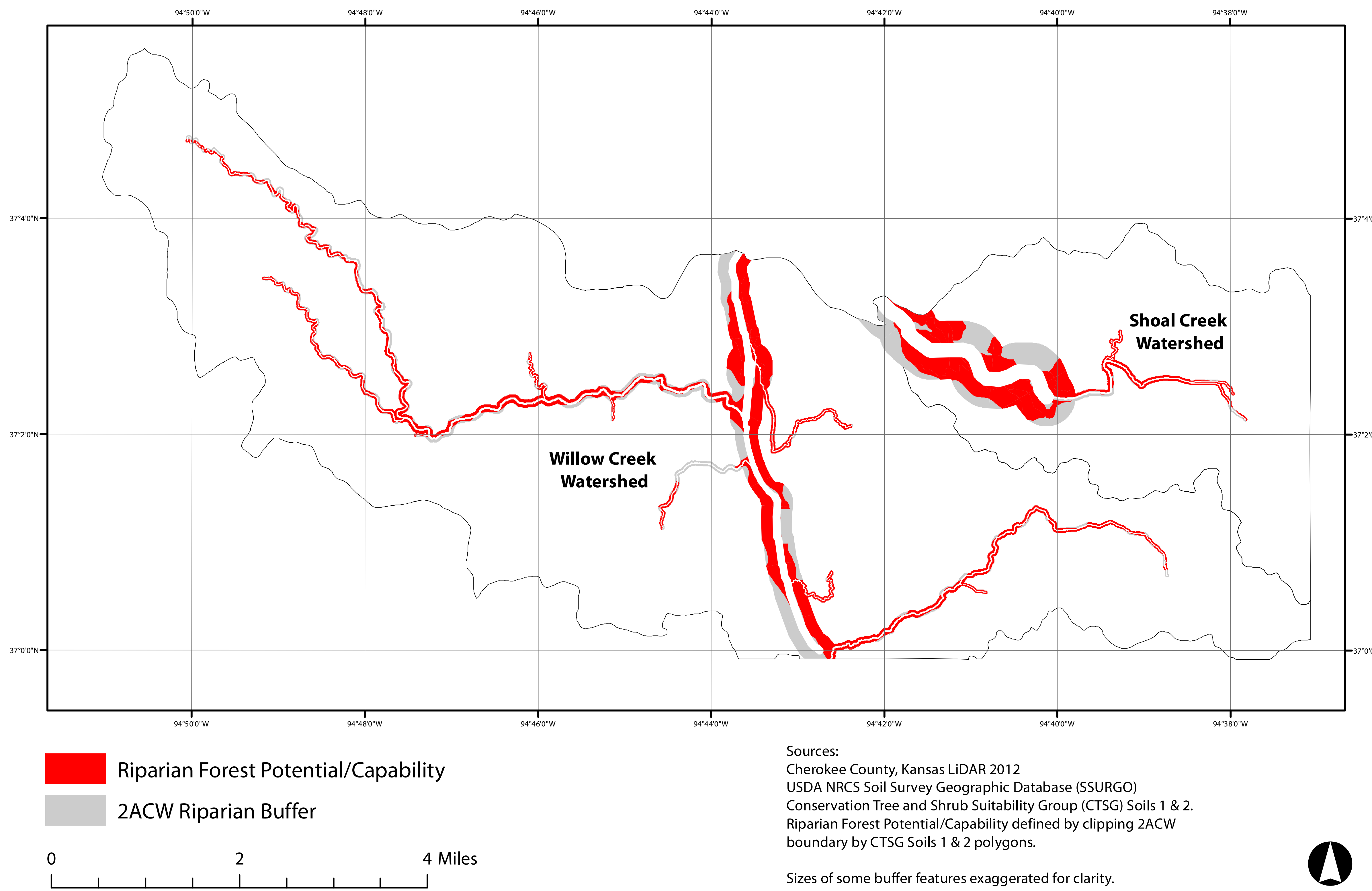
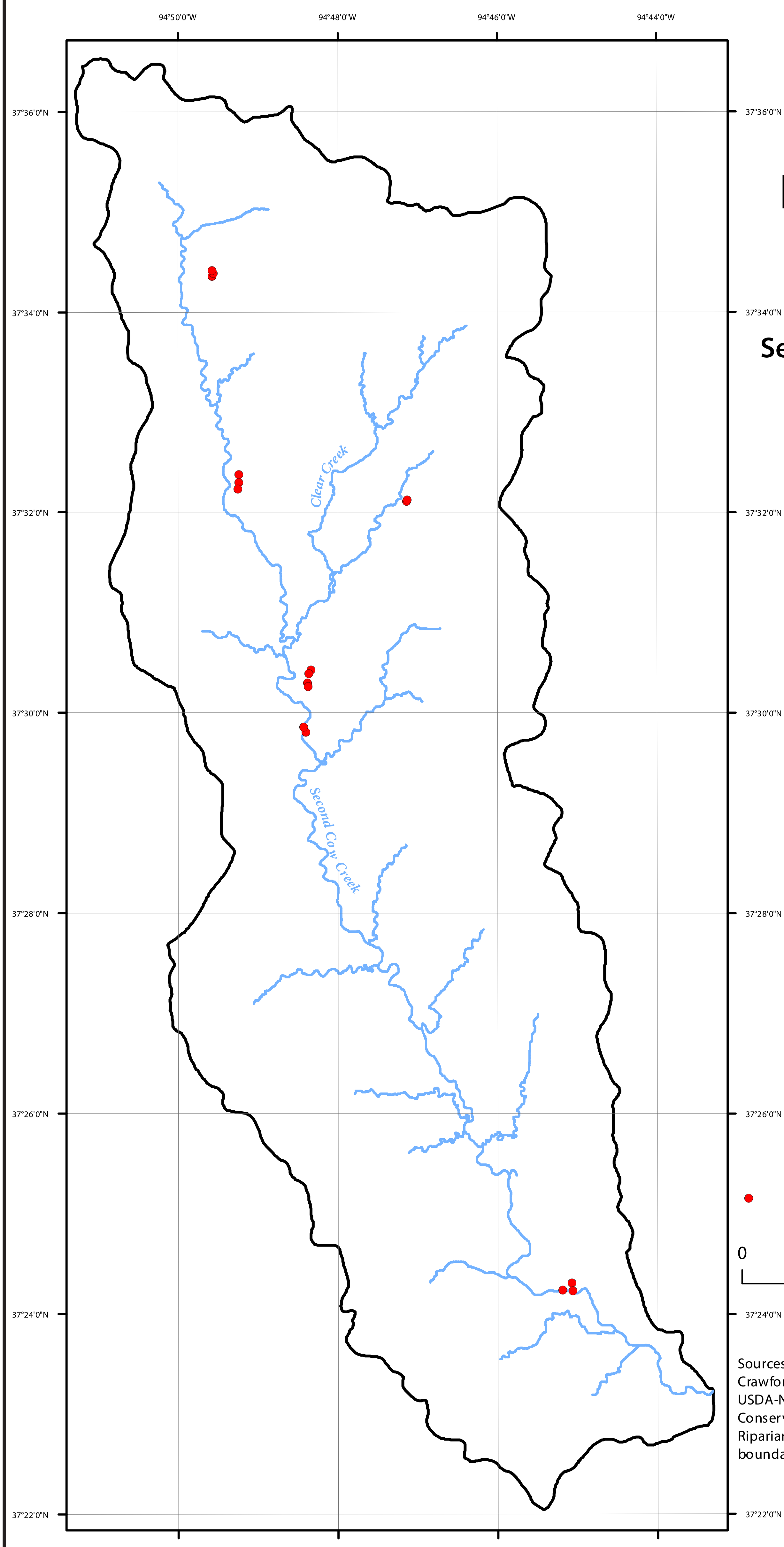


Figure 4. Riparian Forest Analysis Area: Willow Creek and Shoal Creek Watersheds

Figure 5. Willow Creek LiDAR Detail

Field Inventory Plot Locations

Second Cow Creek Watershed
Crawford County, Kansas



Field Inventory Plot Locations

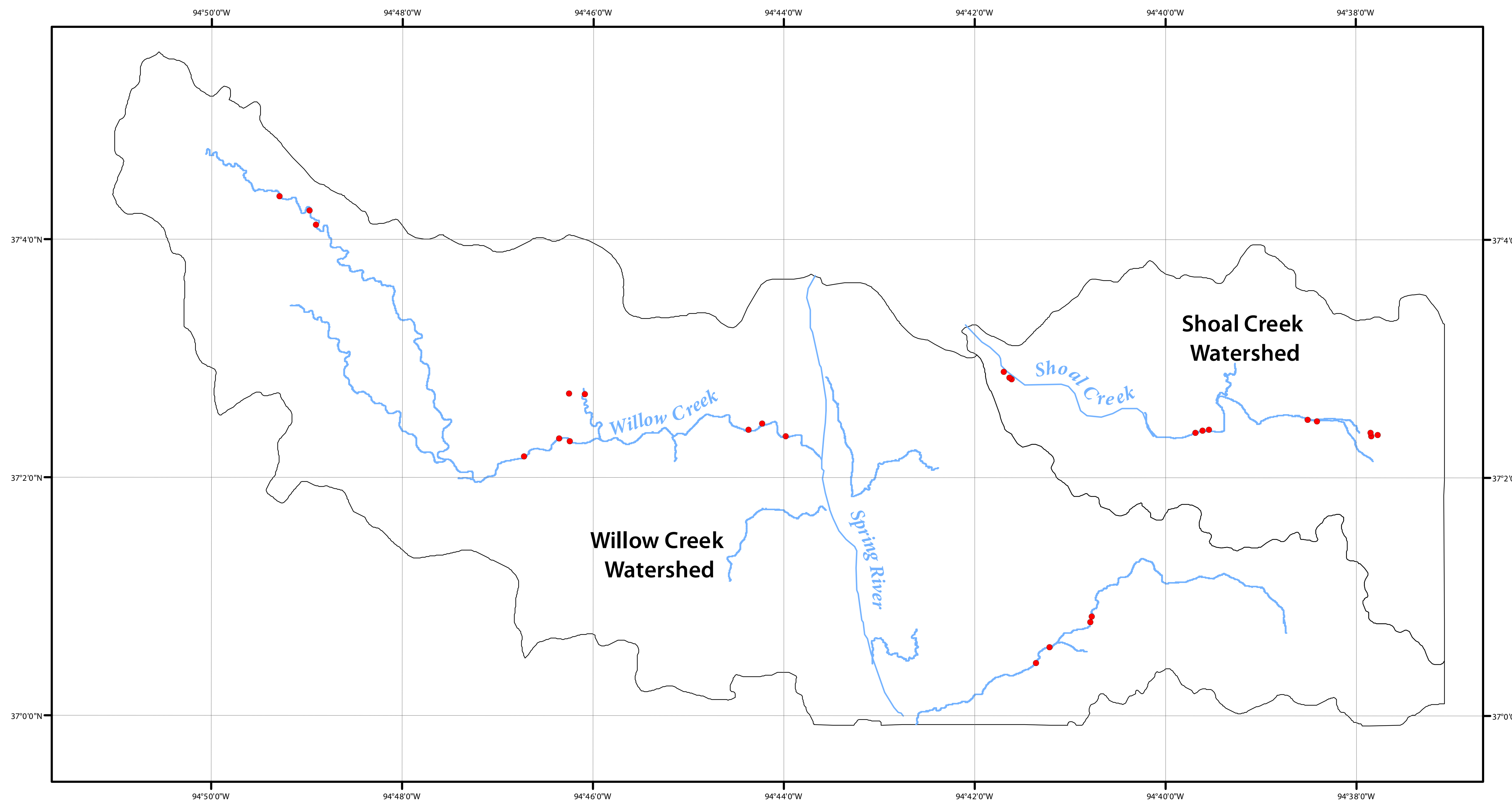
0 2 4 Miles

Sources:
Crawford County, Kansas LiDAR 2012
USDA-NRCS Soil Survey Geographic Database (SSURGO)
Conservation Tree & Shrub Suitability Group (CTSG) Soils 1 and 2.
Riparian Forest Potential/Capability defined by clipping 2ACW boundary by CTSG Soils 1 and 2 polygons.

Figure 6. Field Inventory Plot Locations: Second Cow Creek Watershed

Field Inventory Plot Locations

Willow Creek and Shoal Creek Watersheds



• Field Inventory Plot Locations

0 2.5 5 Miles

Sources:
Cherokee County, Kansas LiDAR 2012
USDA NRCS Soil Survey Geographic Database (SSURGO)
Conservation Tree and Shrub Suitability Group (CTSG) Soils 1 & 2.
Riparian Forest Potential/Capability defined by clipping 2ACW boundary by CTSG Soils 1 & 2 polygons.

Figure 7. Field Inventory Plot Locations: Willow Creek and Shoal Creek Watersheds

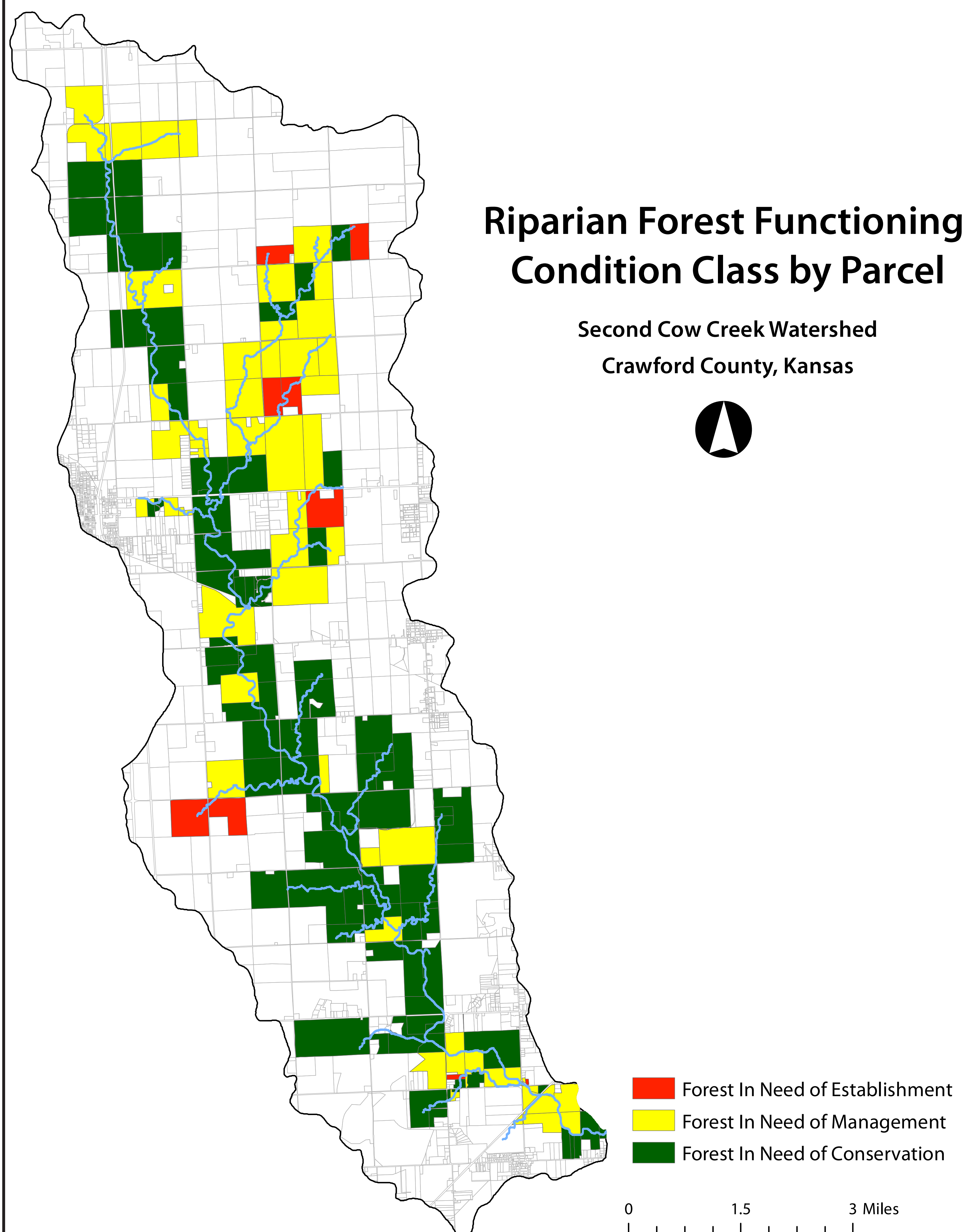


Figure 9. Riparian Forest Functioning Condition Class by Parcel: Second Cow Creek Watershed

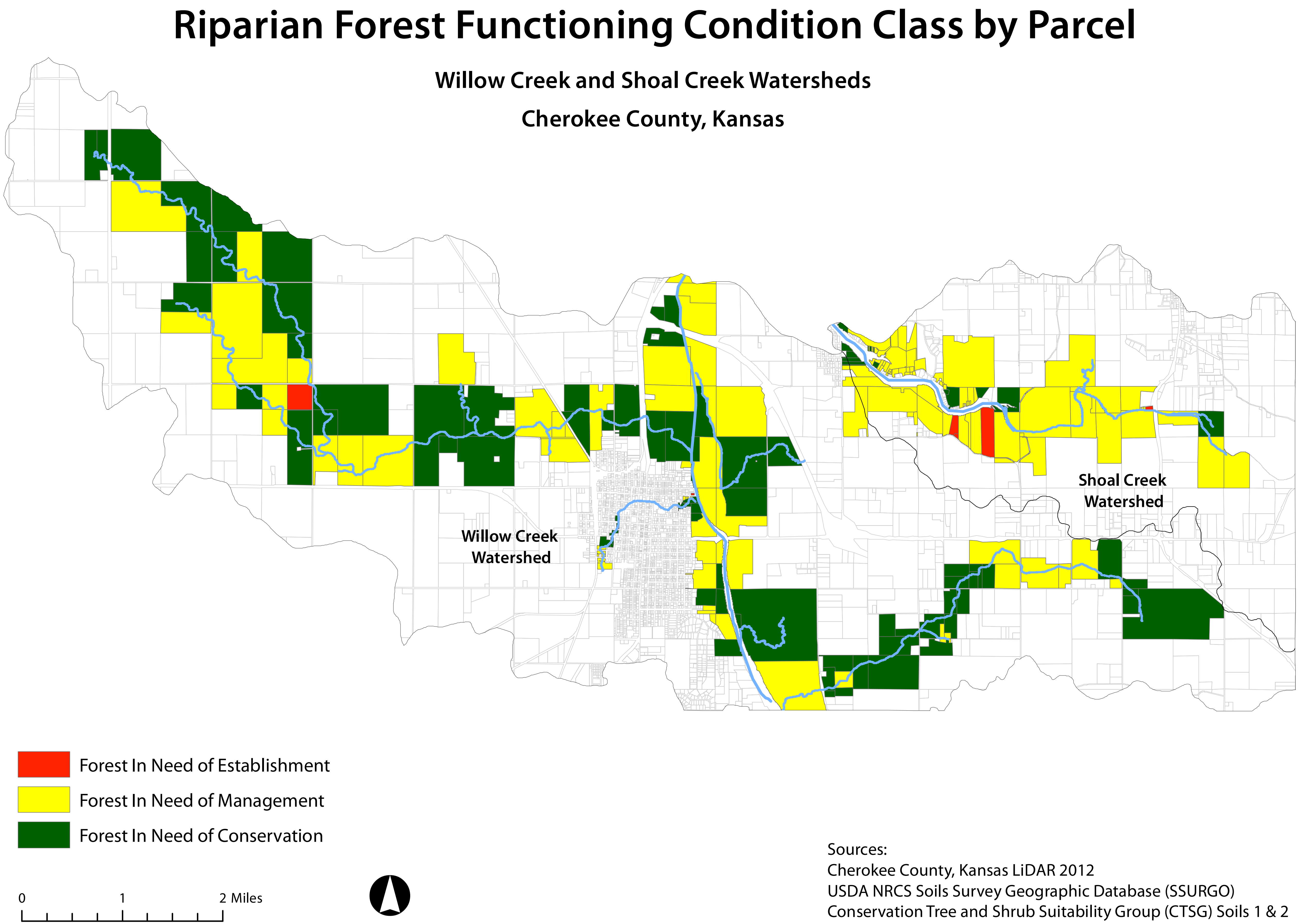


Figure 10. Riparian Forest Functioning Condition Class by Parcel: Willow Creek and Shoal Creek Watersheds

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