Final Report:

2015-2020 Kansas Forest Service Regional Conservation Partnership Program Riparian Assessment and Evaluation

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Funding provided by U.S. Department of Agriculture Natural Resource Conservation Service Cooperative RCPP Agreement #68-215-15-0009

We wish to acknowledge Mark Stadtlander (Department of Communications and Agricultural Education) for formatting of this document into publication form; Debra Baker (Kansas Alliance for Wetlands and Streams) and Dr. Craig Freeman (Kansas Biological Survey) for editorial and technical reviews of this document; Brock Emmert (The Watershed Institute) for assistance with application of regional curve regression equations to determine active channel width and riparian buffer extents for respective hydrophysiographic provinces for the study areas; Jennifer Delisle (Kansas Biological Survey) for provision of the historical Public Land Survey System forest polygon GIS files; Brent Miller (Kansas Data Access and Support Center) for compilation of LiDAR and color-infrared NAIP GIS files; and Angela Anderson and landowners within the Twin Lakes Study Area for their partnership and permission to validate remote assessment methods on their properties.

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Executive Summary

This final report documents and presents the results of the remote riparian assessment for 57 HUC-12 watersheds in ten study area basins (Twin Lakes, Marion Lake, Cottonwood River, Eagle Creek, Milford Lake, Upper Wakarusa River—Clinton Lake, Pomona Lake, Hillsdale Lake, Middle Neosho River, and Cheney Lake) as well as for the land area adjacent to four federal reservoirs (Milford Lake, Clinton Lake, Pomona Lake and Cheney Lake) within four hydrophysiographic provinces (Flint Hills, North-Central, Eastern, South-Central) in Kansas by the Kansas Forest Service (KFS) and the Kansas Alliance for Wetlands and Streams (KAWS). The work was performed as part of a 2014 Natural Resource Conservation Service (NRCS) Regional Conservation Partnership Program (RCPP) funding award to the Kansas Forest Service (KFS) and subaward agreement from KFS to KAWS.

The main objective of the remote riparian assessment was to classify the riparian area land use for two active channel widths along active stream channels located within study basins, primarily above federal reservoirs/ lakes, into actionable best management practice (BMP) opportunities associated with a range of NRCS practices and resource concerns related to stream and riparian health as well as wildlife and aquatic habitat and water quality.

Evaluation of the remote riparian assessment methods and method revisions to improve the quality of the assessment results were secondary objectives of the project as well as the following:

- evaluation of watershed characteristics, stream orders, and hydrophysiographic; variations;
- integration of NRCS resource concern characterization into remote assessment methods;
- initial development of a riparian planting guide to support riparian and stream functional considerations, the KFS mission and vision as well as NRCS' identification of resource concerns and targeting considerations for riparian and stream best management practices; and,
- generally, to provide technical assistance support to the NRCS as part of the 2014 NRCS RCPP award.

Within the Flint Hills Hydrophysiographic Province, *"Forests in need of conservation"* areas comprised 0.0% (0.2 acres, Twin Lakes Study Area) to 12.8%, (270.9 acres, Marion Lake Study Area) of the 2ACW riparian zone. *"Forests in need of management"* areas ranged from 32.5% (6922.7 acres, Cottonwood Study Area) to 71.9% (1533.7 acres, Twin Lakes Study Area) of the 2ACW riparian zone. *"Forests in need of establishment"* areas represented from 26.4% (564.0 acres, Twin Lakes Study Area) to 61.1% (13019.7 acres, Cottonwood Study Area) of the 2ACW riparian zone. Potential historical remnant forest acres ranged from 2.2% (46.6 acres Marion Lake Study Area) to 19.4% (598.2 acres, Eagle Creek Study Area) of the 2ACW riparian area.

The Milford Lake Study Area was the only study area located in the North-Central Hydrophysiographic Province. The HUC-12 watersheds assessed remotely in the study areas indicated significant opportunities for implementation of riparian forest establishment BMPs (47.5%, 9361.5 acres) and riparian forest management BMPs (38.4%, 7572.9 acres) of the 2ACW riparian zone. Approximately 0.5% (106.6 acres) of the 2ACW riparian zone was identified as *"Forest in need of conservation."* Potential historical remnant forest acres identified during the assessment were 3.7% (734.8 acres) of the 2ACW riparian area.

Within the Eastern Kansas Hydrophysiographic Province, *"Forests in need of conservation"* areas comprised 0.0% (0.0 acres, Hillsdale Lake Study Area) to 7.0% (394.8 acres, Upper Wakarusa Study Area) of the 2ACW riparian zone. *"Forests in need of management"* areas ranged from 41.9% (13,746.1 acres, Middle Neosho Study Area) to 69.2% (801.4 acres, Hillsdale Lake Study Area) of the 2ACW riparian zone. *"Forests in need of establishment"* areas represented from 25.5% (295.5 acres, Hillsdale Lake Study Area) to 46.4% (15,218.6 acres, Middle Neosho Study Area) of the 2ACW riparian zone. Potential historical remnant forest acres ranged from 13.6% (662.5acres, Pomona Lake Study Area) to 37.8% (437.8 acres, Hillsdale Lake Study Area) of the 2ACW riparian area.

Within the South-Central Hydrophysiographic Province, the only HUC-12 watersheds assessed were in the Cheney Lake Study Area. Results of the remote riparian assessment indicated that the Cheney Lake Study Area had substantial opportunity to implement riparian forest establishment BMPs (63.0%, 4008.2 acres), although this BMP should be evaluated relative to likely historical native vegetation to determine how much of the riparian buffer should be established in trees and how much in grasses and shrubs, owing to its westerly location in the state. Riparian forest management BMPs could be implemented for a moderate portion of the 2ACW riparian zone (30.6%, 1945.6 acres) within the study area. Opportunities to implement riparian conservation measures were identified as only

3.9% (247.4 acres), with no potential historical riparian remnant forests being identified in the 2ACW riparian zone of the Cheney Lake Study Area.

Remote riparian assessment of the riparian buffer zone around the lakes where they were encountered as part of the HUC-12 watershed study areas (in four of the study area basins) indicated that Milford Lake had the highest percentage of opportunities for riparian forestry establishment practices (56.8%, 4585.2 acres) followed by Cheney Lake (51.3%, 1259.4 acres), Pomona Lake (29.7%, 174.6 acres) and Clinton Lake (22.3%, 666.2 acres). Riparian forest management opportunities were highest at Clinton Lake (62.0%, 1855.3 acres) followed by Pomona Lake (51.5%, 302.7 acres), Milford Lake (28.4%, 2296.7 acres) and Cheney Lake (26.0%, 638.7 acres). Riparian forest conservation opportunities were identified as relatively negligible for all of the lakes ranging from 0.0 (Milford Lake) to 1.2% (Clinton Lake). Potential historical remnant forest acres ranged from 0.0% (0.0 acres, Cheney Lake) to 13.6% (405.9 acres, Clinton Lake) of the lake buffer area.

The most mean riparian BMP opportunities were identified in the Middle Neosho and Cottonwood Study Areas followed by Pomona Lake and Milford Lake Study Areas. The greatest number of mean potential historical riparian remnant acres were located in Middle Neosho and Cottonwood Study Areas followed by the Hillsdale Lake, Upper Wakarusa and Pomona Lake Study Areas.

The most total BMP opportunities were identified in the Middle Neosho, Cottonwood and Milford Lake Study Areas, which also comprised the greatest overall basin area. The greatest number of total potential historical riparian remnant acres were located in Middle Neosho and Cottonwood Study Areas followed by the Upper Wakarusa Study Area.

Based on Bureau of Land Management (BLM) guidance (2003) guidance, the following actions are recommended:

- On-site visits to assess potential historical riparian forest remnants by hydrophysiographic province, riparian zones and stream order to identify "reference conditions" and evaluate floristic quality and species composition of riparian zones;
- Further development of a riparian species list by hydrophysiographic province, riparian zone, stream order and hydrophysiographic province to guide riparian restorations in a graded approach from natural riparian plant communities to managed riparian plant communities to agricultural applications (e.g., native grass rangeland, pastures and cropland).

Based on evaluation of CTSG soil groups presented in this report, the following actions are recommended:

- Evaluation of KFS-refined CTSG soil groups to assess accuracy of soil map unit assignments of CTSG soil groups based on identified errors from other regions related to flood frequency, flood duration, floodplain connectivity and riparian soil drainage classes;
- In lieu of accuracy assessment outlined above, on-site visits that may include evaluation of flood frequency, flood duration, floodplain connectivity and riparian soil drainage classes to support riparian tree and shrub plantings in a zoned approach from PNC (first zone: native riparian vegetation) to capability classes (second zone: managed forest; third zone: integration with land owner interests [e.g., agriculture, agroforestry, developed]) and that preserve or create "Proper Functioning Condition (PFC)" and stabilize stream reaches be integrated with RCPP approach.

Based on evaluation of results related to classification of riparian zone into actionable categories, the following actions are recommended;

- "Riparian areas in need of establishment" should be addressed through riparian restoration practices that include a zoned approach grading from PNC to capability classes based on land owner interests, and include riparian tree, shrub and herbaceous understory plantings and seeding suited to the zoned approach;
- "Riparian areas in need of management" should be addressed through riparian management practices that include a zoned approach grading from PNC to capability classes based on land owner interests, and include timber stand improvement as well as riparian tree, shrub and herbaceous understory plantings and seeding suited to the zoned approach;
- "Riparian areas in need of conservation" should be based on assessment of potential historical riparian forest remnants, and high floristic quality remnants where identified, should be prioritized for voluntary and easement conservation practices that preserve and conserve these riparian areas in partnership with land owners;\
- Riparian buffers around lakes should be integrated with lake management activities and evaluated on-site relative to CTSG soil groups and land interests to achieve adequate riparian buffers to reduce adjacent land management concerns contributing to lake sedimentation, NPS pollution and harmful algae blooms.

Development of a riparian restoration guide that includes consideration of PNC and capability classes, CTSG soil groups, and species lists to support a zoned approach from PNC to capability class by stream order, hydrophysiographic province and riparian zone is recommended. This report includes a section on Native Riparian Species by Hydrodrophysiographic Province and Riparian Community Type with Appendices that can be utilized for development of such a comprehensive riparian restoration guide for the state.

Further development of methods to support and evaluate PFC for streams and riparian areas, such as identification of flood frequency, flood duration, floodplain connectivity riparian soil drainage classes, bank and channel erosion as well as examining riparian species distribution, survivability by riparian zone and development of riparian "management" techniques that support RCPP activities and KFS partner mission are also recommended.

Additional results and discussion of the remote riparian forest assessment and secondary objectives are presented herein within an array of supplemental information, tables, figures, maps and appendices.

Introduction

The Kansas Forest Service (KFS) as part of Kansas State University (KSU) was awarded a Natural Resource Conservation Service (NRCS) Regional Conservation Partnership Program (RCPP) grant in 2014, and perfected a cooperative agreement “68-215-15-0009“(NRCS and KFS, 2015) with NRCS on May 11, 2015, for the period to April 30, 2020. The goal of the cooperative agreement for NRCS and KFS is to engage in complementary and compatible activities related to providing financial and technical assistance to agricultural and forest producers through provisions of the RCPP. The Partnership activities include efforts to encourage conservation of natural resources, primarily associated with implementation, management and conservation riparian forestry practices within ten study area basins, with the primary goals of decreasing stream and lake sedimentation and addressing water quality concerns from non-point source pollution through provision of technical and financial assistance by KFS and NRCS to land owners.

KFS as part of KSU perfected subaward agreement “S16109” with the Kansas Alliance for Wetlands and Streams (KAWS) (KSU and KAWS, 2016) on March 23, 2016, which includes remote riparian assessment deliverables as outlined in the scope of work provided in the next section.

This final report documents and presents the results of the remote riparian assessment for 57 HUC-12 watersheds in ten study area basins (Twin Lakes, Marion Lake, Cottonwood River, Eagle Creek, Milford Lake, Upper Wakarusa River/ Clinton Lake, Pomona Lake, Hillsdale Lake, Middle Neosho River, and Cheney Lake) within four hydrophysiographic provinces (Flint Hills, North-Central, Eastern, South-Central) in Kansas by KFS and KAWS. Priority HUC-12 watersheds were identified in the ten study area basins in direct partnership with Kansas Department of Health and Environment (KDHE) Watershed Restoration and Protection Strategy (WRAPS) (KDHE, 2018) stake-holder leadership teams (SLTs) and the KDHE staff to address water quality impairments to lakes and streams within WRAPS watersheds. Larger study basins were identified in cooperation with and support of the Kansas Water Office (KWO) and its long-term water vision (KWO, 2015) for Kansas, which includes a major goal to reduce reservoir sedimentation and harmful algal blooms in federal reservoirs that serve as water supplies for the state and its citizens.

This final report is organized into the following sections as part of the delivery of the remote riparian assessment results per the scope of work:

- Hydrophysiogrpahic Provinces
- Conservation Tree and Shrub Suitability Groups (CTSG) of Soils
- Watershed Area and Miles
- Riparian Zone Determination
- Historical Riparian Forest
- Remote Riparian Forest Assessment
- Recommendations
- Native Riparian Species by Hydrodrophysiographic Province and Riparian Community Type
- References
- Appendices
    - Appendix A: Remote Riparian Assessment Maps for All RCPP Study Areas
    - Appendix B: Twin Lakes Riparian Assessment
    - Appendix C: Riparian Condition Class and Potential Historical Remnant Forest by Hydrophysiographic Province and Adjacent to Lakes
    - Appendix D: Riparian Species List by Hydrophysiographic Province and Riparian Community Type.

Scope of Work

The scope of work for the remote riparian assessments is defined in RCPP agreement "68-215-15-0009"(NRCS and KFS, 2015) and KAWS subaward agreement "S16109" (KSU and KAWS, 2016). The following remote riparian assessment deliverables were outlined as final work products in the NRCS-KFS award agreement (i.e., Award) and KFS-KAWS subaward agreement (i.e., Subaward):

- Perform LiDAR-based riparian assessment of 57 HUC-12 watersheds in ten basin study areas (Award and Subaward);
- Riparian buffer zone evaluation: determine two active channel width (2ACW) buffers for LiDAR-based streams using Kansas Regional Curves (Subaward).
- Evaluate riparian buffer zone land use relative to Conservation Tree and Shrub Suitability Group (CTSG) soils, including evaluation of current floodplain vegetation for 2ACW riparian zone relative to potential to support riparian forest species (Subaward);
- Determine riparian forest extent and canopy cover class for riparian buffer zone: use LiDAR first-return elevation data to map riparian forests in 2ACW riparian zone of streams and classify canopy cover using Normalized Difference Vegetation Index (NDVI) with four-band National Agriculture Imaging Program (NAIP) aerial photograghs (Subaward);
- Map pre-settlement (PLSS) forests for comparisons with riparian buffer zones and CTSG soils: produce maps of historical forest areas relative to potential to support riparian forest species (Subaward); and,
- Classify riparian forest into three actionable categories for application of riparian conservation programs and RCPP and EQIP practices, 1) "Forest in need of conservation," 2) "Forest in need of management," and 3) "Forest in need of establishment," through integration of all remote assessment datasets (Subaward).

This final report includes all of the RCPP agreement and subagreement deliverables in addition to a comprehensive evaluation of the riparian zones and their forestry components for all streams and rivers in the RCPP study areas by hydrophysiographic province and basin as well as inclusion of federal reservoir (i.e., lake) riparian buffers for consideration where applicable. One aspect of the comprehensive evaluation was development of descriptions of the potential of the riparian zones to support native tree, shrub and understory species by hydrophysiographic province and riparian community type (see Section Native Riparian Species by Hydrodrophysiographic Province and Riparian Community Type and Appendix D), which is intended as a foundation for developing a riparian planting guides for the state by hydrophysiographic province. This report also identifies potential applied research opportunities to improve our knowledge base to enhance riparian establishment and management practices and evaluate potential historical riparian forest remnants to improve our understanding of lesser-disturbed, old-growth riparian forest ecosystem conditions, which could possibly serve as "blue-prints" for riparian restoration and enhancement opportunities by hydrophysiographic province and contribute to riparian planting guides. Opportunities may exist to enhance or expand the field work component of the RCPP agreement and subagreement deliverables to assess potential historical riparian forest remnants to identify the "Potential Natural Community (PNC)" of riparian vegetation (BLM, 2003) and to further advance development of a state-wide riparian planting guide.

In addition to remote assessment deliverables, a final report on field work to validate the remote riparian assessment methods on the ground is included in Appendix B. This field work was designed to assess the applicability of remote riparian forest assessment methods to identify suitable sites for tree and shrub planting ("Riparian areas in need of establishment"), timber stand improvements and enhancements ("Riparian areas in need of management) and riparian forest conservation areas ("Riparian areas in need of conservation"), validate the accuracy of methods and inform opportunities for method revision prior to completing and incorporate revisions into the final remote riparian inventories, GIS database and maps. Field work to validate the methods was conducted in Twin Lakes Study Area in 2015 and results are included in Appendix B. Revisions to remote riparian assessment methods to improve their accuracy to classify the 2ACW riparian buffer zone for all streams, rivers and lakes in all RCPP study areas were integrated into the deliverables of this final report based on validation work completed in the Twin Lakes Study Area (Appendix B; KFS, 2017a) and previous method development (Neel et al, 2014; Beck et al, 2014; KFS, 2014a; KFS, 2014b). Maps and tables of results are presented in Appendix A and C and are summarized in Figures 5-6; together the results can be utilized to identify a range of RCPP practices, their acreages and locations for application.

In January 2018, the KFS RCPP agreement with NRCS was expanded to include in-stream practices related to natural channel restoration designs such as streambank and bed stabilization and implementation of grade controls to complement riparian forest establishment and management practices to address stream channel (bed and bank) and riparian instabilities for stream orders 1-3. Opportunities may now exist to complement field work components of original award and subaward agreements to identify the vegetative potential of riparian zones (part of objectives outlined in BLM guidance [2003], referred to as the "Potential Natural Community (PNC) through further assessment of potential historical riparian remnant forests to identify their floristic quality, species composition and to develop recommendations for riparian restoration designs by riparian zones and hydrophysiographic provinces.

Hydrophysiographic Provinces

Flint Hills Hydrophysiographic Province

The Flint Hills Hydrophysiographic Province encompasses the Flint Hills Ecoregion, the largest remaining intact tallgrass prairie in the Great Plains (Figure 1; Table 1). The Flint Hills are characterized by rolling hills composed of shale and cherty limestone, rocky soils, and by humid, wet summers. Average annual precipitation ranges from 28 to 35 inches increasing in an easterly direction. The Flint Hills marks the western edge of the tallgrass prairie. Erosion of the softer Permian limestone has left the more resistant chert (or flint) deposits, producing the hilly topography and coarse soils of the area. This rocky surface is difficult to plow.

Consequently, the region has historically supported very little cropland agriculture. The natural tallgrass prairie still exists in most areas and is used for range and pasture land, although it has been impacted by livestock grazing, fire management and anthropogenic fragmentation such as road, railroad and housing development. Some cropland agriculture has been implemented in river valleys and along the periphery of the Flint Hills, especially in the northwest corner of the region where the topography is more level. This northwest edge of the region is transitional between the cherty, rocky soils of the Flint Hills and the silty, loamy, loess-formed soils of the Smoky Hills.

The Twin Lakes Study Area is located in the Flint Hills Hydrophysiographic Province.

The Marion Lake Study Area is located in the Flint Hills Hydrophysiographic Province.

The Cottonwood Study Area is located in the Flint Hills Hydrophysiographic Province. However, the eastern extent of the Cottonwood Study Area extends into the Osage Cuestas ecoregion whose western extent is included in the Flint Hills Hydrophysiographic Province.

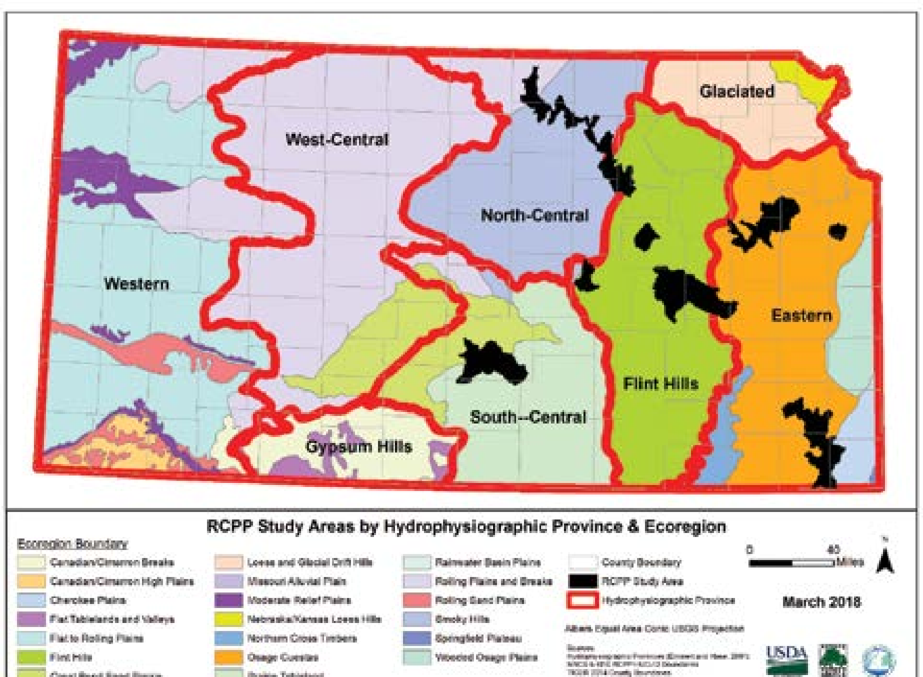
The Eagle Creek Study Area is in the Flint Hills Hydrophysiographic Province. However, the eastern extent of the Eagle Creek Study Area extends into the Osage Cuestas ecoregion whose western extent is included in the Flint Hills Hydrophysiographic Province.

Figure 1 summarizes how respective ecoregions overlay hydrophysiographic provinces established in Kansas and the locations of the RCPP study areas. The delineation of hydrophysiographic provinces used to support this work are based on the geomorphic assessment and classification of riparian conditions throughout Kansas by Emmert and Hase (2001), reflecting similar geomorphological characteristics, stream hydraulic properties (grouped by examination of the relationships between effective discharge and drainage area), underlying geology, precipitation inputs and usually exhibit a close association with ecoregions.

North-Central Hydrophysiographic Province

The North-Central Hydrophysiographic Province is located in the eastern Smoky Hills of Kansas (Figure 1; Table 1). There are three hill ranges in the Smoky Hills. Dakota sandstone makes up the first hill range

Figure 1. *RCPP Study Areas by Hydrophysiographic Province and Level 4 Ecoregion. The RCPP study areas represented four hydrophysiographic provinces (North-Central, South-Central, Flint Hills and Eastern), ten basins (Twin Lakes, Marion Lake, Cottonwood, Eagle Creek, Milford Lake, Upper Wakarusa, Pomona Lake, Hillsdale Lake, Middle Neosho, and Cheney Lake), and were comprised by 57 HUC-12 watersheds. Hydrophysiographic province boundaries were adapted from Emmert and Hase (2001).*



(eastern) and is where the study area basin is located. Thin layers of greenhorn limestone alternating with blueish-gray shale makes up the middle hill range (middle; sometimes called the Blue Hills) and comprises some of the drainage area to Milford Lake from the northwest in Nebraska. The third range (western) is the chalk bluffs extending from Kansas to the Rain Water Basins in Nebraska and is formed from outcrops in the Niobrara chalk formation. The first hill range (eastern) of the Smoky Hills is an undulating to hilly dissected loess plain with sandstone hills underlain by the Dakota Formation and comprises the major portion of the North-Central Hydrophysiographic Province and the majority of the Milford Lake Study Area. The region is transitional, with a variable climate and potential natural vegetation ranging from tallgrass prairie in the east to mixed-grass prairie in the west. Soils are silty and loamy, and formed in loess, which is thinner than in neighboring soils in the middle and third hill ranges to the west, and with areas of sandy soils formed in sandstone. Land use consists of cropland and grassland. Average annual precipitation ranges from 24 to 30 inches increasing in an easterly direction. The middle and third (western) hill ranges were historically mixed-grass prairie in the east grading to the short-grass prairie of the High Plains region to the west, and are parts of the West-Central Hydrophysiographic Province. Today, a mosaic of cropland agriculture and rangeland occurs throughout the region. Soils are silty, well drained, deep, and moderately permeable and formed in loess on uplands. The dissected plains of the Smoky Hills, with broad, undulating to rolling ridge-tops, are in contrast to the smoother High Plains region to the west and the broad, flat regions to the north in the Rain Water Basin Plains and Platte River Valley of Nebraska. The High Plains are characterized by a semi-arid to arid climate,

Table 1. *Hydrophysiographic provinces, ecoregions and native ecosystem types in the ten RCPP study area basins (57 HUC-12 watersheds) in Kansas. Native vegetation descriptions for hydrophysiographic provinces were interpreted from ecoregion descriptions by Chapman et al. (2001). A more detailed description of native riparian species by hydrodrophysiographic province and riparian community type is presented in a later section of this report and a species list is compiled in Appendix D.*

Flint Hills Hydrophysiographic Province		
Study Area	**Region**	**Native Vegetation**
Twin Lakes	Flint Hills	Tallgrass prairie, floodplain forests especially along major riparian corridors; riparian and prairie wetlands
Marion Lake	Flint Hills	Tallgrass prairie, floodplain forests especially along major riparian corridors; riparian and prairie wetlands
Cottonwood	Flint Hills, Osage Cuestas	Tallgrass prairie, floodplain forests especially along major riparian corridors; riparian and prairie wetlands
Eagle Creek	Flint Hills, Osage Cuestas	Tallgrass prairie, floodplain forests especially along major riparian corridors; riparian and prairie wetlands
North-Central Hydrophysiographic Province		
Milford Lake	Smoky Hills, High Plains (west drainage)	Tallgrass prairie (east), mixed-grass prairie (west drainage), short-grass prairie (far west drainage), floodplain forests especially along major riparian corridors; riparian and prairie wetlands
Eastern Hydrophysiographic Province		
Upper Wakarusa	Osage Cuestas	Tallgrass prairie mixed with oak-hickory forest and abundant floodplain forest; riparian and prairie wetlands
Pomona Lake	Osage Cuestas	Tallgrass prairie mixed with oak-hickory forest and abundant floodplain forest; riparian and prairie wetlands
Hillsdale Lake	Osage Cuestas	Tallgrass prairie mixed with oak-hickory forest and abundant floodplain forest; riparian and prairie wetlands
Middle Neosho	Osage Cuestas, Cherokee Plains	Tallgrass prairie mixed with oak-hickory forest and abundant floodplain forest and wetlands; riparian and prairie wetlands
South-Central Hydrophysiographic Province		
Cheney Lake	Great Bend Sand Prairie, Wellington-McPherson Lowlands	Sand-sage prairie (west), tallgrass prairie (east), floodplain forest especially along major riparian corridors; riparian and prairie wetlands

with annual precipitation ranging from 13 to 20 inches, and historically were composed of drought-tolerant short-grass prairie with some areas of mixed-grass prairie intermixing. In the High Plains region draining to Milford Lake, the area is typified by irregular to rolling plains and a mosaic of dryland and irrigated cropland and rangeland today. Soils range from shallower, silty and clayey loams formed from eolian sediments to thicker loess-capped uplands. The High Plains region is part of the Western Kansas Hydrophysiographic Province.

The Milford Lake Study Area straddles the North-Central and Flint Hills Hydrophysiographic Provinces in Kansas, with the major portion in the North-Central. However, much of the drainage area for Milford Lake originates in the West-Central Hydrophysiographic Province of the western Smoky Hills (middle and third hill range) from the northwest in Nebraska and the Western Hydrophysiographic Province of the High Plains from southwestern Nebraska, northwestern Kansas and northeastern Colorado—all of which are outside the North-Central Kansas Hydrophysiographic Province.

Eastern Hydrophysiographic Province

The Eastern Hydrophysiographic Province encompasses the Osage Cuestas, Cherokee Plains and Ozark Highlands regions in Kansas (Figure 1; Table 1). In general, the geology of the province is alternating sedimentary layers of limestone, shale and sandstone. Average annual precipitation ranges from 35 to 45 inches per year in this province increasing in an easterly and southeasterly direction, with highest quantities typically experienced in the far southeast of the province. The topography and soils of eastern Kansas are more favorable for cropland than in the Flint Hills. The Osage Cuestas are formed by a gently undulating cuesta plain composed of several alternating layers of sandstone, limestone, and shale. Topography is distinct from the more dramatic rolling hills of the Flint Hills to the west. Potential natural vegetation ranges from a mosaic of mostly tallgrass prairie in the western part of the province to a mixture of tallgrass prairie and oak-hickory forest in the east, with abundant floodplain forests along streams. The moist, silty clay loams are formed in material weathered from limestone and shale, and support a land use composite of cropland, woodland/forest, and grassland/rangeland. The Cherokee Plains region is a flat erosional plain with more poorly drained and less fertile soils than in the Osage Cuestas. Hardpan or clay-pan prairie types are common and found where soils have an impermeable or only slightly permeable, silty clayey subsoil below the loamier surface layer. Sites are seasonally wet and usually become extremely dry during the summers. The Cherokee Plains have an extensive mining history, and mine tailings still exist in some areas with widespread disturbances to the fluvial systems. None of the study areas were located in the Ozark Plateau so no description is provided.

The Upper Wakarusa Study Area is located in the Osage Cuestas Ecoregion of the Eastern Hydrophysiographic Province. The Pomona Lake Study Area is located in the Osage Cuestas Ecoregion of the Eastern Hydrophysiographic Province. The Hillsdale Lake Study Area is located in the Osage Cuestas Ecoregion of the Eastern Hydrophysiographic Province. The Middle Neosho Study Area is located in both the Osage Cuestas (north portion) and Cherokee Plains (southern portion) in the Eastern Hydrophysiographic Province.

South-Central Hydrophysiographic Province

The South-Central Hydrophysiographic Province straddles the Great Bend Sand Prairie region to the west and the Wellington-McPherson Lowland region to the east (Figure 1; Table 1). The Great Bend Sand Prairie is comprised by undulating to rolling sand plains and are in contrast to the hill ranges of the Smoky Hills to the north. A mantle of windblown sand, sandy outwash, and dunes supports a potential natural vegetation of sand prairie bunchgrass. Average annual precipitation in this province ranges from 24 to 30 inches per year, increasing in an easterly direction. Center pivot irrigation is implemented to a greater degree here than in surrounding regions. The flat lowland topography of the Wellington-McPherson Lowland distinguishes this region from the sand hills to the west and northwest, the undulating hill ranges of the Smoky Hills to the north, and the rolling chert and limestone hills of the Flint Hills to the east. Loess and river valley deposits support extensive cropland agriculture. The area is also underlain by shale, gypsum and salt from ancient Permian seas, most notably the Hutchinson salt member, which is mined for salt, and the northern area contains the alluvial Equus beds, an important aquifer.

The Cheney Lake Study Area is located in the South-Central Hydrophysiographic Province.

Conservation Tree and Shrub Suitability Groups (CTSG) of Soils

County level soil surveys can be used to classify soils into Conservation Tree and Shrub Suitability Groups (CTSG) to assist resource managers, consultants and technicians identify appropriate trees and shrubs for planting based on environmental site conditions. These county level surveys have been digitized into the Soil Survey Geographic (SSURGO) database. Soils can be classified into ten CTSG (i.e., 1-10) groups as summarized in Table 2, with subgroup modifiers that identify additional restrictions that affect the selection of trees and shrub species suited for planting and growing in a particular soil. A CTSG is a physiographic unit or area having similar climatic and edaphic (soil) characteristics that control the selection and height growth of trees and shrubs. State USDA offices are responsible for developing CTSG interpretations for Major Land Resource Areas (MLRAs) that occur wholly within their state and coordinating with neighboring state offices for MLRAs that extend across state boundaries to produce CTSG interpretations. After establishing the CTSGs for a state, trees and shrubs are assigned to each group using published references, direct observation, and records such as the National Forest Soil Data Base to determine which species have been observed on soils within a CTSG. When no data are available, publications, personal experience and local field personal experience are used if available.

In Kansas, 39% of the state's soils are not classified into a CTSG group and 3.5% of the soil map units are classified as group 10 (unsuitable for trees and shrubs) according to the national digital CTSG map product. Within a two active channel width of streams (where riparian forests are most likely), over 57% of the soil map units are not rated for CTSG (Table 3) as part of the national digital CTSG map product.

An analysis of the accuracy of the national digital CTSG classifications in Kansas has not been done, but in a study of Morrison County, Minnesota, the error rate for CTSG classification using the national digital CTSG product was 79% mostly due to misclassification of soil map units related to drainage classes and flood frequency and duration (34 of 43 soil map units were classified into incorrect CTSG groups). For the U.S., a closer examination of the national digital CTSG products indicated that more than half of the soil map units were classified in Group 10 signifying that they were unsuitable for tree or shrub establishment, which is likely inaccurate and related to various misclassification errors from erroneous interpretations. For Kansas, the national digital CTSG product is incomplete and it is not known how accurate the classifications and interpretations of CTSG soil groups are when using the national digital CTSG product to define soil map units into CTSG groups. CTSG soil classifications in Kansas need to be evaluated for accuracy and misclassification errors identified before application of the national digital CTSG product is heavily relied upon as definitive criteria for Farm Bill programs. Development of quality forest and shrub management plans, which are very important for our current initiative to restore and manage riparian forests within Kansas, will require the most accurate CTSG soils information possible to improve efficiencies beyond site visits to evaluate the local soils for suitability of tree and shrub species to the site conditions and improve their survivability.

Windbreaks, riparian forest buffers, waterways, agroforestry applications and wildlife habitat are conservation practices where trees and shrub establishment may be planted on land that does or does not naturally support trees or shrubs, particularly in the Great Plains states such as Kansas. Many agency employees are not trained in forestry practices and are in need of an accurate guide to help make species recommendations for practices that require the planting and management of trees and shrubs. This situation may be exacerbated when it comes to planting and management of riparian zones. An accurate "field friendly" system is needed to make species recommendations (especially native species) and predict tree/shrub growth on non-forest soils and forest soils and for reforestation and afforestation, particularly as relates to this effort to restore and enhance riparian forest buffers, which are often disturbed and inadequate in Kansas.

The Kansas Forest Service initiated development of a "user-friendly" on-line CTSG map product on their website (*www.kansasforests.org*: "Select the Right Tree for Your Soil"), based on refinements to the national digital CTSG product in 2015. This effort by KFS represents a major step in the direction of developing a comprehensive riparian planting guide and developing recommendations for riparian restoration in Kansas as well as providing more-informed support for tree and shrub planting recommendations within the state.

The potential impacts of incomplete or inaccurate CTSG soils information for Kansas may include the following: 1) Denying program applications or terminating contracts based on inappropriate application of program criteria for tree/shrub establishment practices; 2) recommending the wrong tree and shrub species for a project; 3) potential for an incomplete or inaccurate list of tree and shrub species; 4) increased cost of reestablishment for practice failures; 5) inefficient conservation planning; and 6) loss of credibility for agency making recommendations.

For purposes of our remote riparian forest assessment in all RCPP study areas, we identified the CTSG soils for a two-active channel width buffer on either side of the stream using the national digital CTSG map product but did not use it as restrictive criteria that would limit our evaluation of riparian forest stands or categorization into actionable forestry categories, due to potential for incompleteness or inaccuracies associated with the national digital CTSG product as it is currently available for Kansas.

In 2015, the Kansas Forest Service revised and updated the national digital CTSG map product for Kansas by addressing the large number of soil map units "not rated" in the national digital CTSG product. CTSG values for soil map units scored as "not rated" in the national digital CTSG product were reassigned to CTSG groups by KFS based on their interpretation of soil type descriptions and soil series information provided by historical hard copy county level NRCS soil surveys. The refinements completed by KFS to the national digital CTSG product in 2015 were a vast improvement to the quality and completeness of the national digital CTSG maps for Kansas and provided a timely update to the national digital CTSG map product. However, the emphasis of the refinements was on classifying the soil map units to CTSG groups, and not to further distinguish among subgroup modifier descriptions within the CTSG groups, so no subgroup modifiers are included in the KFS-refined CTSG product. In its current form, after refinement and publication on the KFS website, CTSG maps can now be utilized as a much more user-friendly, complete and publically available resource than was available previously. However, to date, no attempt has been made to evaluate the soil map unit boundaries for mapping accuracy or reassign map units to other soil types based on a comprehensive analysis to identify mapping errors for soil map units especially as may occur within the 2ACW riparian buffer and evaluate the impacts on accuracy of CTSG soil groups in general.

Refinements to the national digital CTSG product for Kansas by KFS are presented in Table 4. As discussed, the refinements are a vast improvement over the national digital CTSG product, but the refined CTSG product still may contain mapping errors associated with soil map unit misclassification within the 2ACW riparian zone of streams and rivers in Kansas, since it is still based on historical NRCS soil mapping which may have had lesser emphasis on tree and shrub planting suitability in riparian zones and where drainage classes, flood frequency and duration may have changed or may not be as accurately identified as technology now allows (e.g., accuracy issues identified with the national digital CTSG map product previously). Therefore, the refined CTSG product was not used as restrictive criteria in the remote riparian assessment of our study areas in order to ensure errors of commission (i.e., inclusion of soils that may not be suitable for riparian tree and shrub plantings in our assessment) over errors of omission (i.e., disqualifying soil map units suitable for riparian tree and shrub plantings). However, the refined CTSG product is a planning tool routinely used by foresters in evaluating potential project applications and forest planting designs in support of RCPP deliverables and the on-going mission of the KFS and their programs: "Care of natural resources and service to people through forestry." Therefore, we evaluated application of the KFS-refined CTSG product for purposes of this project compared to the national digital CTSG map product and to support its application for purposes of the RCPP, as the best available data for making tree and shrub species suitability recommendations, beyond local site visits by foresters and ecologists.

When analyzing the KFS-refined CTSG product for the 2ACW riparian zone, major emphasis of the interpretation was placed on CTSG groups 1-4 since these groups have been distinguished by KFS as the most suitable for woody riparian plantings, owing to typical topographic location, soil type, and available water conditions, without detrimental environmental restrictions for riparian tree growth other than potential flood disturbance and hydroperiod of the floodplains (Table 2). For the refined CTSG product for Kansas, the majority of soil map units within the 2ACW riparian zone of stream and rivers in our study area were CTSG soil groups 1 (66.3%), 2 (12.8%) and "No Species" of trees or shrubs recommended (9.1%) (Table 4). Approximately, 84.1% of the riparian soil map units were CTSG groups 1, 2, 3 or 4, which are soils supportive of riparian tree and shrub planting. Soil map units previously "Not Rated" in the national digital product were reduced from 57.8% to

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Table 2. *Conservation Tree and Shrub Suitability (CTSG) soil group and subgroup descriptions for soil map units encountered in the 2ACW riparian zone of the RCPP study areas.*

Conservation Tree and Shrub Suitability (CTSG) Soil Groups for 2ACW Riparian Zone of RCPP Study Areas		
Group 1	**Subgroup**	**Description**
1 (Wet Favorable)	General	Soils in this group are deep (at least 40 inches to a restrictive layer). There is a beneficial growing season water table within three to five feet of the surface; or they receive beneficial moisture from occasional flooding or runoff from adjacent land due to favorable landscape positions. These soils are well suited to all types of woody plantings, and all climatically suited trees and shrubs have the potential to grow well. Competition from grass and weeds is the principal concern in establishing and managing trees and shrubs. Occasionally, somewhat poorly drained soils may have excessive water for some species.
2 (Wet)	General	Soils in this group are deep (at least 40 inches to a restrictive layer). A seasonal water table within 1.5 to 3 feet of the surface contributes to a poorly drained or somewhat poorly drained condition. It is excessively wet or ponded during the spring or overflow periods. Wetness limits the selection of tree and shrub species suitable for planting on these soils and may reduce the growth rate. Competition from grass and weeds is the principal concern in establishing and managing trees and shrubs. Spring planting may be delayed because of wet conditions.
3 (Loamy)	General	Soils in this group are deep (at least 40 inches to a restrictive layer). The depth to a water table during the growing season is greater than five feet. Soils within this group are well drained, loamy textured soils with moderate and moderately slow permeability on uplands. Except for those trees and shrubs that require abundant moisture, all climatically suited trees and shrubs have the potential to grow well. Competition from grass and weeds is the principal concern in establishing and managing trees and shrubs on these soils. Water erosion is a concern on the gently sloping to moderately steep areas.
4 (Clayey Favorable)	General	Soil depth to a restrictive layer is at least 20 inches. Soils in this group have loamy surface textures with clayey subsoils. They have slow or very slow permeability, and occur on uplands. These soils are fairly well suited to woody plantings. Most of the climatically suited trees and shrubs grow well; however, optimum growth is not possible because of the limited available water capacity and root development zone. High clay content and water availability have an effect on the selection of tree and shrubs species suitable for these soils. Competition from grass and weeds is the principal concern in establishment and management of trees and shrubs. Water erosion is a concern on the gently sloping to moderately steep areas.
	4C (Clayey)	Soil depth to a restrictive layer is at least 20 inches. Soils in this group have clayey textures throughout the profile. They have slow or very slow permeability, and occur on uplands. These soils are fairly well suited to woody plantings. Most of the climatically suited trees and shrubs grow well; however, optimum growth is not possible because of the limited available water capacity and root development zone. High clay content and water availability have an effect on the selection of tree and shrubs species suitable for these soils. Competition from grass and weeds is the principal concern in establishment and management of trees and shrubs. The clayey soils are subject to severe wind erosion. Water erosion is a concern on the gently sloping to moderately steep areas.
5 (Droughty)	General	Soils in this group are deep (at least 40 inches to a restrictive layer), with loamy or sandy textured soils on uplands. This group typically includes soils that normally have adequate soil moisture (available water capacity ranges from 3.75 to 7.5 inches). These soils are well suited to woody plantings. All climatically suited trees and shrubs have the potential to grow well, except those that require abundant moisture. Competition from grass and weeds and abrasion from blowing are the principal concerns in establishing and managing trees and shrubs on these soils. These soils are subject to severe wind erosion.

Conservation Tree and Shrub Suitability (CTSG) Soil Groups for 2ACW Riparian Zone of RCPP Study Areas		
Group 1	**Subgroup**	**Description**
6 (Very Droughty)	General	Soil depth to a restrictive layer is at least 20 inches (50 cm). The depth to a water table during the growing season is at least 4 feet (120 cm). The depth to a water table may be less than 4 feet (120 cm) if it is for less than 2 months during the growing season. The available water capacity is between 3 and 6 inches (8 and 15 cm). In the upper 12 inches (30 cm) of the soil profile free carbonates do not exceed a concentration of 5 percent calcium carbonate equivalent, the range of pH is between 5.6 and 8.4, and electrical conductivity is 4 mmhos/cm or less. The soil has a non-sandy surface, and is loamy/ loamy skeletal over sands/gravels. The drainage class for the soil is excessively, somewhat excessively, or well drained.
7 (Sandy)	General	Soils in this group are deep, excessively to moderately well drained, sandy in texture, typically have low or very low available water capacity, and do not normally have adequate moisture. These soils are poorly suited to woody plantings. Coniferous trees are better suited than deciduous trees and shrubs. Optimum survival and growth should not be expected. Drought conditions and abrasion from soil blowing are the principal concerns in establishing and managing trees and shrubs on these soils. Specialized site preparation (due to sand that is subject to blowouts) and specialized planting methods (vegetation between the rows is normally left undisturbed) are needed to establish the trees and shrubs. Supplemental watering may be essential for successful establishment.
8 (Loamy-Calcareous)	General	Soils in this group are calcareous at or near the surface. They do not receive beneficial moisture from run-in, flooding, or seasonal high water table. These soils are poorly suited to woody plantings. It is possible to establish plantings but these soils contain enough calcium carbonate at or near the surface to adversely affect the survival and growth of trees and shrubs. High calcium content and competition from grass and weeds are the principal concerns in establishing and managing trees and shrubs on these soils. Water erosion is a concern on gently sloping to moderately steep areas.
9 (Saline/ Alkaline)	General	Soils in this group are affected by salinity and/or sodicity (dense claypan subsoil). These soils are very poorly suited to woody plantings. Concentrations of salt will severely affect the establishment, vigor, and growth of trees and shrubs on these soils.
	9L (Dry-Saline/ Alkaline)	Loamy saline and/or sodic soils with no seasonal high water table.
	9N (Natric-Saline/ Alkaline)	Saline and/or sodic soils with a natric subsoil.
10 (On-site Evaluation)	General	Soils in this group have one or more characteristics such as soil depth, texture, drainage, channeled phases, available water capacity, slope or salts which severely limit planting, survival or growth of trees and shrubs. Soils in this group are usually not recommended for farmstead and feedlot windbreaks, field windbreaks, and plantings for recreation and wildlife. However, onsite investigations may reveal that tree and shrub plantings can be made with special treatments (hand planting, scalp planting, specialized site preparation, drainage, or other specialized treatments). The selection of species must be tailored to the soil conditions existing at each site. Limiting conditions and the specialized treatments required to overcome these limitations must be documented on the planting plan.

Table 3. *Summary of CTSG soil groups within the two active channel width riparian buffer of ten RCPP basins (57 HUC-12 watersheds) in Kansas, as provided by the national digital CTSG product.*

	All RCPP Assessments: CTSG Soils	Acres	%
All HUC-12 Watersheds	1	30286.3	30.5
	2	5551.1	5.6
	3	637.3	0.6
	4	1255.8	1.3
	4c	190.3	0.2
	5	130.5	0.1
	6	2132.3	2.1
	8	2.9	0.0
	9l	55.8	0.1
	9n	12.0	0.0
	10	1607.0	1.6
	Not Rated	57334.5	57.8
Grand Total	All CTSG Soils	99195.8	100.0

Table 4. *Summary of CTSG soil groups within the two active channel width riparian buffer of ten RCPP basins (57 HUC-12 watersheds) in Kansas, as refined by Kansas Forest Service to address high percentage of "not rated" CTSG soil map units.*

	All RCPP Assessments: CTSG Soils	Acres	%
All HUC-12 Watersheds	1	65802.1	66.3
	2	12707.5	12.8
	3	1128.9	1.1
	4	3903.7	3.9
	5	524.5	0.5
	6	2888.6	2.9
	7	296.6	0.3
	8	408.3	0.4
	9	68.1	0.1
	10	2359.0	2.4
	No Species	9050.3	9.1
	Not Rated	58.3	0.1
Grand Total	All CTSG Soils	99195.8	100.0

0.1%, while 9.1% of these soil map units were reassigned to the "No Species" of trees or shrubs recommended based on best professional judgement for our study areas. Descriptions of the CTSG soil groups encountered within the 2ACW riparian zone of the RCPP study areas is presented in Table 2.

Based on hard copy NRCS soil survey descriptions used by KFS to interpret digital soil map unit boundaries provided by national digital CTSG product, the "Not Rated" and "No Species" soil map units (9.2%) would not likely support trees or shrub plantings or would encounter environmental restrictions making them poorly suited to tree and shrub plantings according to the KFS interpretation of the soil map units. In summary, the KFS refinements to the national digital CTSG map product significantly improved the ability to make recommendations for suitability of tree and shrub species for riparian plantings by greatly reducing uncertainty in the national digital CTSG groups through reassignments of "not rated" soil map units to CTSG groups.

Summaries of the KFS-refined CTSG soil groups by hydrophysiographic province and study area are presented in the following subsections.

Flint Hills Hydrophysiographic Province

Within the Flints Hills Hydrophysiographic Province, KFS-refined CTSG soils for the 2ACW riparian region ranged from a total of 84.9% (Twin Lakes Study Area) to 94.6% (Eagle Creek Study Area) for CTSG soil groups 1-4, with Cottonwood (87.2%) and Marion Lake Study Areas (93.5%) being intermediate (Table 5). For CTSG soils rated "No Species" or "Not Rated," Eagle Creek had the lowest percentage of these soils (2.6%) and Twin Lakes had the highest percentage (6.7%), with Marion (4.1%) and Cottonwood (6.3%) having intermediate values. The remainder of the soils had CTSG soil groups 6, 8, 9 and 10 ranging from 2.2% (Marion Lake Study Areas) to 8.4% (Twin Lakes Study Area) with intermediate values of 2.7% (Eagle Creek Study Area) and 6.6% (Cottonwood Study Area).

In the study areas of this hydrophysiographic province, the majority of the 2ACW riparian zone (CTSG soils 1-4) was rated for riparian tree and shrub planting, timber stand improvements and understory species suited or well suited to fluvial and riparian conditions. A more detailed description of recommended native riparian species by hydrodrophysiographic province and riparian community type is presented in a later section of this report and a species list is compiled in Appendix D.

Table 5. *CTSG soil groups in the Flint Hills Hydrophysiographic Province.*

Twin Lakes Study Area		
CTSG Soil Class	**Total Acres**	**%**
1	1639.8	76.9
3	27.6	1.3
4	142.4	6.7
6	179.5	8.4
10	0.1	0.0
No Species	143.3	6.7
Not Rated	0.0	0.0
Total	2132.6	100.0
Marion Lake Study Area		
CTSG Soil Class	**Total Acres**	**%**
1	1885.4	88.9
3	83.2	3.9
4	15.7	0.7
6	4.5	0.2
8	29.9	1.4
10	13.7	0.6
No Species	87.6	4.1
Not Rated	0.0	0.0
Total	2119.9	100.0
Cottonwood Study Area		
CTSG Soil Class	**Total Acres**	**%**
1	16521.5	77.5
2	1429.7	6.7
3	53.4	0.3
4	579.6	2.7
6	1005.6	4.7
8	375.1	1.8
9	11.8	0.1
No Species	1342.1	6.3
Not Rated	0.0	0.0
Total	21318.7	100.0
Eagle Creek Study Area		
CTSG Soil Class	**Total Acres**	**%**
1	2542.3	82.5
2	38.5	1.2
3	52.5	1.7
4	284.4	9.2
6	83.6	2.7
No Species	77.6	2.5
Not Rated	3.1	0.1
Total	3082.1	100.0

North-Central Hydrophysiographic Province

Within the North-Central Hydrophysiographic Province, the percentage of KFS-refined CTSG soils for the 2ACW riparian region was 79.7% for CTSG soil groups 1-4 (Table 6). CTSG soils rated “No Species” or “Not Rated” comprised 18.3% of the 2ACW riparian zone. The remainder of the soils had CTSG soil groups 5, 6, 7, 8 and 10, representing only 2.0% of the 2ACW riparian zone within the Milford Study Area.

In the HUC-12 watersheds of this study area for this hydrophysiographic province, the majority of the 2ACW riparian zone (CTSG soils 1-4) was rated for riparian tree and shrub planting, timber stand improvements and understory species suited or well suited to fluvial and riparian conditions. A more detailed description of recommended native riparian species by hydrodrophysiographic province and riparian community type is presented in a later section of this report and a species list is compiled in Appendix D.

Table 6. *CTSG soil groups in the North-Central Hydrophysiographic Province.*

Milford Lake Study Area		
CTSG Soil Class	**Total Acres**	**%**
1	14407.5	73.1
2	505.2	2.6
3	757.4	3.8
4	40.8	0.2
5	25.7	0.1
6	52.9	0.3
7	275.2	1.4
8	0.4	0.0
10	44.9	0.2
No Species	3581.7	18.2
Not Rated	17.7	0.1
Total	19709.3	100.0

South-Central Hydrophysiographic Province

For the South Central Hydrophysiographic Province, which was comprised of Cheney Lake Study Area only, 78.9% of the soils were classified as KFS-refined CTSG soil groups 1-4, and 0.1% of the soils were classified as “No Species” or “Not Rated,” leaving 21.0% classified as KFS-refined CTSG soil groups 5-10 (Table 7). Most of the CTSG soil groups 5-10 were in group 5 (7.8%), group 6 (4.3%) and group 10 (7.6%).

In the HUC-12 watersheds of this study area for this hydrophysiographic province, the majority of the 2ACW riparian zone (CTSG soils 1-4) was rated for riparian tree and shrub planting, timber stand improvements and understory species suited or well suited to fluvial and riparian conditions. A more detailed description of recommended native riparian species by hydrodrophysiographic province and riparian community type is presented in a later section of this report and a species list is compiled in Appendix D.

Table 7. *CTSG soil groups in the South-Central Province.*

Cheney Lake Study Area		
CTSG Soil Class	**Total Acres**	**%**
1	27.1	0.4
2	4865.4	76.5
3	119.0	1.9
4	7.3	0.1
5	498.7	7.8
6	274.1	4.3
7	21.3	0.3
8	3.0	0.0
9	56.0	0.9
10	483.9	7.6
No Species	6.7	0.1
Not Rated	0.0	0.0
Total	6362.5	100.0

Eastern Hydrophysiographic Province

Within the Eastern Hydrophysiographic Province, KFS-refined CTSG soils for the 2ACW riparian region ranged from a total of 73.0% (Upper Wakarusa Study Area) to 93.9% (Pomona Lake Study Area) for CTSG soil groups 1-4, with Middle Neosho (84.8%) and Hillsdale Lake (87.4%) being intermediate (Table 8). For CTSG soils rated "No Species" or "Not Rated," Pomona had the lowest percentage of these soils (0.8%) and Upper Wakarusa had an unusually high percentage (17.3%) with Hillsdale (3.0%) and Middle Neosho (8.5%) Study Areas having intermediate values. The remainder of the soils had CTSG soil groups 6, 9 and 10.

In the study areas of this hydrophysiographic province, the majority of the 2ACW riparian zone (CTSG soils 1-4) was rated for riparian tree and shrub planting, timber stand improvements and understory species suited or well suited to fluvial and riparian conditions. A more detailed description of recommended native riparian species by hydrodrophysiographic province and riparian community type is presented in a later section of this report and a species list is compiled in Appendix D.

Table 8. *CTSG soil groups in the Eastern Hydrophysiographic Province.*

Upper Wakarusa Study Area		
CTSG Soil Class	**Total Acres**	**%**
1	3805.3	67.3
2	21.2	0.4
3	9.7	0.2
4	290.6	5.1
6	126.2	2.2
10	424.5	7.5
No Species	979.6	17.3
Not Rated	0.6	0.0
Total	5657.7	100.0
Pomona Lake Study Area		
CTSG Soil Class	**Total Acres**	**%**
1	4196.6	86.0
2	153.1	3.1
3	19.5	0.4
4	215.4	4.4
6	256.1	5.2
9	0.3	0.0
No Species	39.4	0.8
Not Rated	0.0	0.0
Total	4880.5	100.0
Hillsdale Lake Study Area		
CTSG Soil Class	**Total Acres**	**%**
1	954.1	82.4
2	4.6	0.4
3	3.2	0.3
4	50.2	4.3
6	111.9	9.7
No Species	0.0	0.0
Not Rated	34.2	3.0
Total	1158.2	100.0
Middle Neosho Study Area		
CTSG Soil Class	**Total Acres**	**%**
1	19822.7	60.5
2	5689.9	17.4
3	3.2	0.0
4	2277.3	6.9
6	794.2	2.4
10	1391.9	4.2
No Species	2792.4	8.5
Not Rated	2.7	0.0
Total	32774.3	100.0

Lakes

For evaluation of riparian buffers around the lakes in Kansas, which were complementarily assessed as part of the RCPP, results were combined for the various hydrophysiographic provinces since not all of the lakes in all of the hydrophysiographic provinces were included in our study areas (Table 9). The riparian buffers adjacent the lakes were evaluated for Milford Lake (North-Central Hydrophysiographic Province), Clinton and Pomona Lakes (Eastern Hydrophysiographic Province) and Cheney Lake (South-Central Hydrophysiographic Province). No lakes were included as part of the study area in the Flint Hills Hydrophysiographic Province.

KFS-refined CTSG soil groups 1-4 comprised from 24.1% (Cheney Lake) to 58.0% (Milford Lake), with intermediate values ranging from 34.4% (Clinton Lake) to 57.4% (Pomona Lake). "No Species" and "Not Rated" CTSG soil classes were a relatively minor component of the CTSG soil classes ranging from 5.4% (Pomona Lake) to 15.2% (Milford Lake), and intermediate values from 8.7% (Upper Wakarusa) to 11.5% (Cheney Lake). The remainder of the CTSG soil groups were comprised of CTSG groups 5, 6, 7 and 10 ranging from 26.8% (Milford Lake) to 78.5% (Cheney Lake), with intermediate values of 37.2% (Pomona Lake) and 56.9% (Clinton Lake).

For the riparian buffer zone around the lakes, the percentages of CTSG groups 1-4 were variable and only comprised a majority of the soil groups at Milford Lake and Pomona Lake. The vast majority of soils comprising the riparian buffer at Cheney Lake were groups 5, 6 and 10, with group 10 representing 57.3% of the soil groups. At Clinton Lake, the majority of the soil groups for the riparian buffer zone were groups 5, 6 and 10, with group 10 representing 50.6% of the soil groups. Riparian buffer planting designs around the lakes, especially Cheney and Clinton Lakes and to a lesser extent Milford and Pomona Lakes, may require on-site soil evaluation of environmental conditions especially in those areas designated as unsuitable (CTSG group 10) or fairly unsuitable for tree and shrub plantings (CTSG groups 5, 6 and 7) and may require buffers comprised by suitable grass and forb species rather than trees and shrubs. Recommended species for tree, shrub and understory vegetation plantings within many of the riparian lake buffers should include site evaluations for areas comprised by soil groups 5, 6, 7 and especially 10, to determine suitable species for planting, as well as referring to recommended native riparian species by hydrodrophysiographic province and riparian community type as presented in a later section of this report and the species list compiled in Appendix D.

Table 9. *CTSG soil groups around study area lakes.*

Milford Lake		
CTSG Soil Class	**Total Acres**	**%**
1	766.5	9.5
2	175.4	2.2
3	2447.9	30.3
4	1293.7	16.0
5	540.0	6.7
6	1320.9	16.4
7	89.2	1.1
10	215.3	2.7
No Species	87.4	1.1
Not Rated	1138.3	14.1
Total	8074.6	100.0
Clinton Lake		
CTSG Soil Class	**Total Acres**	**%**
1	292.0	9.8
2	68.2	2.3
3	180.4	6.0
4	488.7	16.3
6	189.5	6.3
10	1512.6	50.6
No Species	201.4	6.7
Not Rated	57.9	1.9
Total	2990.7	100.0
Pomona Lake		
CTSG Soil Class	**Total Acres**	**%**
1	6.0	1.0
2	16.0	2.7
3	36.9	6.3
4	278.2	47.3
6	218.9	37.2
No Species	31.5	5.4
Not Rated	0.0	0.0
Total	587.6	100.0
Cheney Lake		
CTSG Soil Class	**Total Acres**	**%**
1	33.8	1.4
2	145.1	5.9
3	68.0	2.8
5	344.7	14.0
6	174.3	7.1
10	1407.4	57.3
No Species	229.5	9.3
Not Rated	51.8	2.1
Total	2454.6	100.0

Watershed Area and Miles

Calculations: Watershed Area, Stream Orders and Stream Miles

Watershed area was calculated using HUC-12 boundaries from NRCS and KFS for each of the study areas in the ten basins using Albers Equal Area USGS projection, so as to preserve fidelity related to accuracy of area calculations across larger geographic areas. Stream order was based on the Strahler stream order method utilized in the National Hydrography Dataset Plus (NHD-Plus). Stream miles were calculated using the NHD-Plus streams data clipped to the HUC-12 watershed boundaries for each study area using the Albers Equal Area USGS projection and were summarized by study area and grouped by hydrophysiographic province for comparison within and among basins and provinces.

While NHD-Plus streams were used to calculate stream miles by stream order, the actual stream delineations used in subsequent analyses were based on 1m-LiDAR derived streams with a 1-square-mile-drainage threshold since the LiDAR derived streams are more accurate delineations of the stream channel rather than the more generalized NHD-Plus stream lines. The more accurate 1m-LIDAR derived streams allow for better approximations of the location of the stream channel and their 2ACW riparian zone and typically capture more of the fluvial characteristics of the streams and rivers (e.g., sinuosity), but are still just approximations of flow paths since the method cannot accurately identify the thalweg and underwater physical features of the streams and rivers (i.e., deepest part of the stream channel and underwater fluvial geomorphological features cannot be typically detected by LiDAR due to obscuration by water) and can be confounded by false landscape depressions (LiDAR errors), culverts and bridges, and flow paths through and around impoundments (e.g., outflows obscured by water, spillway discharges). However, reduction of errors through application of Strahler stream order calculations to the 1m-LiDAR derived streams would have required vast topographic processing beyond the scope of this work to ensure accuracy (e.g., processing of bare-earth LiDAR to create breaches at all roads, culverts, bridges and impoundments to allow for accurate flow direction and accumulation processing of visually obscured flow-paths). Therefore, NHD-Plus streams with processed Strahler stream order were used to provide reasonable estimates of stream miles by stream order for each HUC-12, study area and hydrophysiographic province. Note that a 0-order stream is typically an isolated stream segment (e.g., oxbow channel, artificial channel) that is not defined as part of the main stream channel.

Flint Hills Hydrophysiographic Province

Within the Flint Hills Hydrophysiographic Province, four basins are represented by the RCPP study areas: Twin Lakes (two HUC-12s), Marion Lake (two HUC-12s), Cottonwood (nine HUC-12s) and Eagle Creek (three HUC-12s) for a total of 16 HUC-12s evaluated (Table 10). The mean size of the HUC-12 watersheds was 28,803.4 ±1279.0 acres. Lower stream order values (e.g., quantity of stream order 1 miles > stream order 2 miles) comprised the greatest quantity of stream miles progressively decreasing in a downstream direction, except for the notable exception of the largest river (i.e., Cottonwood River) which comprised a significant portion of the downstream watersheds, as all upstream and headwater watersheds were not included in the priority HUC-12 watersheds assigned by KDHE WRAPS in consultation with KFS for each study area. First order streams comprised 60.3% of the stream miles and, together with second order streams (18.3%) and third order streams (11.0%), constituted 89.6% of total stream miles in the Flint Hills Hydrophysiographic Province for the RCPP study areas.

Table 10. *Watershed size and stream miles by stream order in the Flint Hills Hydrophysiographic Province.*

Twin Lakes Study Area	
HUC-12	**Total Acres**
110702010101	28,234.4
110702010102	28,081.2
Total	56,315.6
Stream Order	Stream Miles
1	90.2
2	24.9
3	17.5
4	12.8
Total	145.4

Marion Lake Study Area	
HUC-12	**Total Acres**
110702020103	31,977.3
110702020104	23,096.3
Total	55,073.6
Stream Order	Stream Miles
0	1.4
1	111.1
2	36.5
3	17.6
4	6.1
Total	172.6

Eagle Creek Study Area	
HUC-12	**Total Acres**
110702010403	23,565.3
110702010404	26,628.8
110702010405	23,393.0
Total	73,587.1
Stream Order	Stream Miles
0	6.9
1	125.1
2	31.6
3	29.0
4	15.9
Total	208.5

Cottonwood Study Area	
HUC-12	**Total Acres**
110702030204	35,080.1
110702030205	25,574.3
110702030305	40,350.6
110702030401	37,328.1
110702030402	27,551.1
110702030403	28,204.6
110702030404	25,949.1
110702030405	31,100.3
110702030406	24,740.6
Total	275,878.8
Stream Order	Stream Miles
0	7.1
1	482.1
2	152.1
3	83.2
4	8.5
5	12.5
6	67.6
Total	813.1

North-Central Hydrophysiographic Province

Within the North-Central Hydrophysiographic Province, one basin is represented by the RCPP study areas: Milford Lake (twelve HUC-12s), for a total of 12 HUC-12s evaluated (Table 11). The mean size of the HUC-12 watersheds was 28,171.4 ±2341.6 acres. Lower stream order values comprised the greatest quantity of stream miles progressively decreasing in a downstream direction, except for the notable exception of the largest river (i.e., Republican River) which comprised a significant portion of the downstream watersheds, as all upstream and headwater watersheds were not included in the priority HUC-12 watersheds assigned by KDHE WRAPS in consultation with KFS for the study area. First order streams comprised 54.6% of the stream miles and together with second order streams (20.6%) and third order streams (6.8%) constituted 81.9% of total stream miles in the Flint Hills Hydrophysiographic Province for the RCPP study areas.

Table 11. *Watershed size and stream miles by stream order in the North-Central Hydrophysiographic Province.*

Milford Lake Study Area	
HUC-12	**Total Acres**
102500170202	29,904.7
102500170204	30,084.9
102500170303	17,057.6
102500170304	17,659.6
102500170310	23,055.0
102500170409	40,033.9
102500170508	27,971.3
102500170602	24,427.7
102500170604	32,304.2
102500170607	40,154.3
102500170608	36,099.5
102500170609	19,303.6
Total	338,056.3
Stream Order	Stream Miles
0	29.3
1	486.4
2	183.2
3	60.8
4	5.2
5	0.03
7	126.4
Total	891.3

Eastern Hydrophysiographic Province

Within the Eastern Hydrophysiographic Province, four basins were represented for the RCPP study areas: Upper Wakarusa (five HUC-12s), Pomona Lake (three HUC-12s), Hillsdale Lake (one HUC-12) and Middle Neosho (twelve HUC-12s), for a total of 21 HUC-12s evaluated (Table 12). The mean size of the HUC-12 watersheds was 26,895.0 ±1721.8 acres. Lower stream order values comprised the greatest quantity of stream miles progressively decreasing in a downstream direction, except for the notable exceptions of the largest rivers (i.e. Dragoon Creek, Neosho River) which comprised a significant portion of downstream watersheds, as all upstream and headwater watersheds were not included in the priority HUC-12 watersheds assigned by KDHE WRAPS in consultation with KFS for the study areas. First order streams comprised 61.2% of the stream miles and, together with second order streams (19.1%) and third order streams (6.3%), constituted 86.6% of total stream miles in the Eastern Hydrophysiographic Province for the RCPP study areas.

Table 12. *Watershed size and stream miles by stream order in the Eastern Hydrophysiographic Province.*

Upper Wakarusa Study Area	
HUC-12	**Total Acres**
102701040104	34,233.9
102701040105	27,814.1
102701040106	16,556.2
102701040107	32,150.4
102701040108	34,716.9
Total	145,471.5
Stream Order	**Stream Miles**
0	0.5
1	219.9
2	63.7
3	28.4
4	36.8
5	1.1
Total	350.4
Pomona Lake Study Area	
HUC-12	**Total Acres**
102901010203	24,702.7
102901010205	31,318.6
102901010207	36,754.5
Total	92,775.8
Stream Order	Stream Miles
0	1.5
1	164.5
2	64.5
3	3.3
4	9.0
5	18.6
Total	261.4
Hillsdale Lake Study Area	
HUC-12	**Total Acres**
102901020101	29,846.4
Total	29,846.4
Stream Order	**Stream Miles**
1	53.3
2	11.7
3	11.7
Total	76.7
Middle Neosho Study Area	
HUC-12	**Total Acres**
110702050101	38,064.5
110702050109	35,413.8
110702050201	24,339.2
110702050202	14,995.2
110702050204	29,035.0
110702050205	11,810.1
110702050305	27,959.1
110702050403	30,633.3
110702050501	30,453.0
110702050505	21,674.5
110702050601	15,323.6
110702050605	17,000.4
Total	296,701.7
Stream Order	**Stream Miles**
0	17.9
1	485.5
2	149.1
3	51.4
4	17.1
5	27.8
6	71.8
Total	820.5

South-Central Hydrophysiographic Province

Within the South-Central Hydrophysiographic Province, one basin was represented by the RCPP study areas: Cheney Lake (eight HUC-12s), for a total of eight HUC-12s evaluated (Table 13). The mean size of the HUC-12 watersheds was 31,943.8 ± 1799.5 acres. Lower stream order values comprised the greatest quantity of stream miles progressively decreasing in a downstream direction, except for the notable exceptions of the largest river (i.e., North Fork Ninnescah River) which comprised a significant portion of downstream watersheds, as all upstream and headwater watersheds were not included in the priority HUC-12 watersheds assigned by KDHE WRAPS in consultation with KFS for the study area. First order streams comprised 66.7% of the stream miles and, together with second order streams (17.7%) and third order streams (8.0%), constituted 92.4% of total stream miles in the South-Central Hydrophysiographic Province for the RCPP study areas.

Table 13. *Watershed size and stream miles by stream order in the South-Central Hydrophysiographic Province.*

Cheney Lake Study Area	
HUC-12	**Total Acres**
110300140109	33,725.3
110300140204	32,903.1
110300140205	28,186.2
110300140301	22,295.2
110300140302	33,210.5
110300140303	31,128.2
110300140304	34,259.1
110300140305	39,842.7
Total	255,550.3
Stream Order	**Stream Miles**
0	10.0
1	403.5
2	107.0
3	48.1
4	19.1
5	16.8
Total	604.5

Considerations for All Hydrophysiographic Provinces

Note that the HUC-12 watersheds selected for inclusion in the RCPP study areas were based on priority ranking by the KDHE Watershed Restoration and Protection Strategy (WRAPS) stakeholder leadership teams (SLTs) based on consultation with state agencies and universities reporting on water quality concerns and total maximum daily load goal (TMDL) exceedances, and priorities for watersheds were ranked based on such concerns. Therefore, many of the HUC-12 watersheds included in the RCPP study basins were the most impacted by a water quality concern and were not comprised of all of the HUC-12 watersheds in the basin (e.g., those watersheds comprising less impacted streams and rivers and their riparian areas—many of which were in more upstream and headwater [lower stream order] watersheds). Many times the HUC-12s in the RCPP study basins were not contiguous, so in some instances, patterns in watershed characteristics may vary from predicted values (e.g., progressively less stream miles encountered as stream order increases in value [higher order streams] in a downstream direction) since the entire basin was not included in the riparian and stream order analysis. However, in general except for notable exceptions of overrepresentation of higher order streams (e.g., Cottonwood River, Republican River, North Fork Ninnescah River, Neosho River and Dragoon Creek) due to all HUC-12s of a basin study area not being included in the analysis, most of the stream miles were associated with stream orders 1-3 in a predictable manner.

Riparian Zone Determination

Calculations: Two Active Channel Width (2ACW) Riparian Zone

Table 14 presents the regression formula used to determine the recommended 2ACW riparian buffer zone along all one-square-mile-drainage-area streams based on reference stream conditions (bankfull [active channel] width) encountered in the hydrophysiographic provinces of interest. These regression estimates were based on reference conditions established for relatively stable streams and rivers through various studies conducted throughout Kansas (SCC and Tetra Tech, 2005; Emmert and Hase, 2001) and are the best available information for approximating bankfull (active channel) widths of streams and the 2ACW riparian zone in Kansas to our knowledge, without conducting a geomorphological survey in the field for specific reaches or somehow automating the survey procedures to increase total quantity of stream miles surveyed for further analyses.

One way to characterize 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% of the time. Intermittent streams flow only during wet periods (usually 30–90% of the time), and they flow in well-defined channels. Ephemeral streams only flow during runoff resulting from 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 stormwater runoff, so these streams only have a limited water supply for riparian forests. Intermittent and perennial streams interact with the water table (i.e., ground water) and have base flow during portions or all of the year.

Since the major focus of this riparian inventory was on the quantity and quality of riparian forest in the 2ACW riparian zone which would support riparian trees (riparian water table), we used a

Table 14. *Bankfull regression equations based on geomorphological stream surveys of Kansas reference reaches (SCC and Tetra Tech, 2005; Emmert and Hase, 2001). The bankfull width regression equations were used to estimate the extent of two bankfull (active) channel width (2ACW) riparian buffers beyond the bankfull stream channel to complete remote riparian assessments of ten RCPP study basins (57 HUC-12 watersheds) located in four different hydrophysiographic provinces of Kansas. The other regression equations (bankfull discharge, bankfull cross (X)-sectional area, bankfull depth) can be used in site visits and as part of SVAP2 assessments and RCPP project designs as guidelines associated with stable reference reaches but should not be used as a substitute for actual geomorphological survey and engineering calculations at sites of interest. * i ndicates that upstream drainage area at Hardy, NE, for Milford Study Area was 22,908 square miles and bankfull active channel width was 177 ft. on the Republican River at Hardy, NE, with drainage area and bankfull active channel width increasing in a downstream direction on the main stem Republican River; so the main stem Republican River below Hardy, NE, the* $W^* = 177 + 1.35(x-22908)^{0.6494}$ *equation was used, and for all tributaries of the Republican River in Milford Study Area,* $W^* = 1.35x^{0.6494}$ *equation was used, where x = drainage area in square miles.*

Hydrophysiographic Province	Bankfull Regression Equations (All Reference Stream Types)			
	Discharge (Q) ft^3s^{-1}	X-Sec Area (A) ft^2	Width (W) ft	Depth (D) ft
Flint Hills	$Q = 65.48x^{0.7769}$	$A = 20.78x^{0.6885}$	$W = 20.04x^{0.3743}$	$d = 1.04x^{0.3136}$
	($r^2 = 0.961$)	($r^2 = 0.972$)	($r^2 = 0.921$)	($r^2 = 0.858$)
North-Central	$Q = 3.60x^{0.9465}$	$A = 8.81x^{0.6617}$	$W^* = 177 + 1.35(x-22908)^{0.6494}$ or $1.35x^{0.6494}$	$d = 4.29x^{0.0683}$
	($r^2 = 0.864$)	($r^2 = 0.844$)	($r^2 = 0.881$)	($r^2 = 0.015$)
Eastern Kansas	$Q = 176.75x^{0.6212}$	$A = 49.60x^{0.6119}$	$W = 24.53x^{0.3459}$	$d = 1.95x^{0.2656}$
	($r^2 = 0.966$)	($r^2 = 0.978$)	($r^2 = 0.875$)	($r^2 = 0.915$)
South-Central	$Q = 5.28x^{0.9189}$	$A = 4.00x^{0.7914}$	$W = 10.56x^{0.3851}$	$d = 7.83x^{0.2741}$
	($r^2 = 0.954$)	($r^2 = 0.878$)	($r^2 = 0.461$)	($r^2 = 0.348$)

one-square-mile-drainage-area as the minimum threshold for determining the watershed riparian zones of streams and rivers to study, which roughly correlates with the major contribution of intermittent streams and includes all perennial stream contributions as delineated on U.S. Geological Service (USGS) 1:24K topographic maps (Figure 2). Generally, ephemeral streams and small portions of intermittent streams occur higher in the watershed than the one-square-mile-drainage-area threshold.

The 2ACW riparian zone buffer was based on a 1-square-mile (1 mi^2) flow accumulation threshold applied to 1m-LiDAR derived streams to define the stream course and then successively applying the bankfull regression equation for bankfull (active channel) width to calculate a successive 2ACW riparian buffer every two meters downstream along the stream course using GIS operations (i.e., the 2ACW riparian buffer gets wider every two meters you move downstream) (Figure 3). To account for a 1ACW stream channel and a 2ACW riparian buffer, a multiplication factor of 2.5 was applied to the 1ACW calculation determined using the bankfull regression equations outlined in Table 14 to create a 2ACW buffer on either side of the LiDAR stream line which also included the 1ACW stream channel according to Figure 3 (i.e, riparian area is 2ACW wide on either side of a 1ACW stream). This procedure effectively expands the 2ACW riparian buffer perpendicularly from the active (bankfull) stream channel in a stepwise fashion (i.e., every two meters downstream) (Figures 2-3), so that the riparian zone increases in width in a downstream direction, thus increasing in width as stream order increases (i.e., as more water flows down the stream, the stream channel gets wider and the riparian buffer area gets wider).

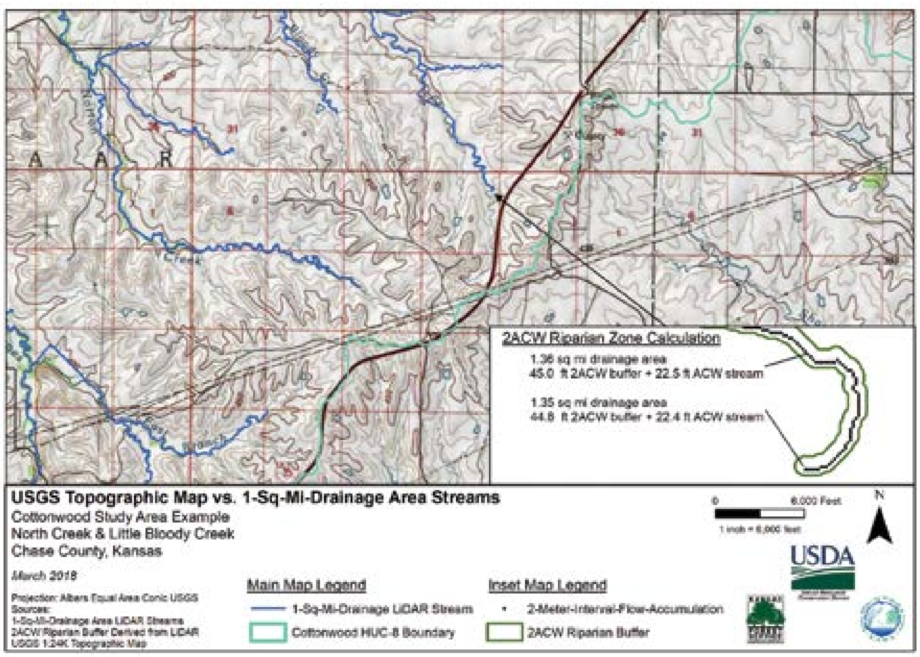
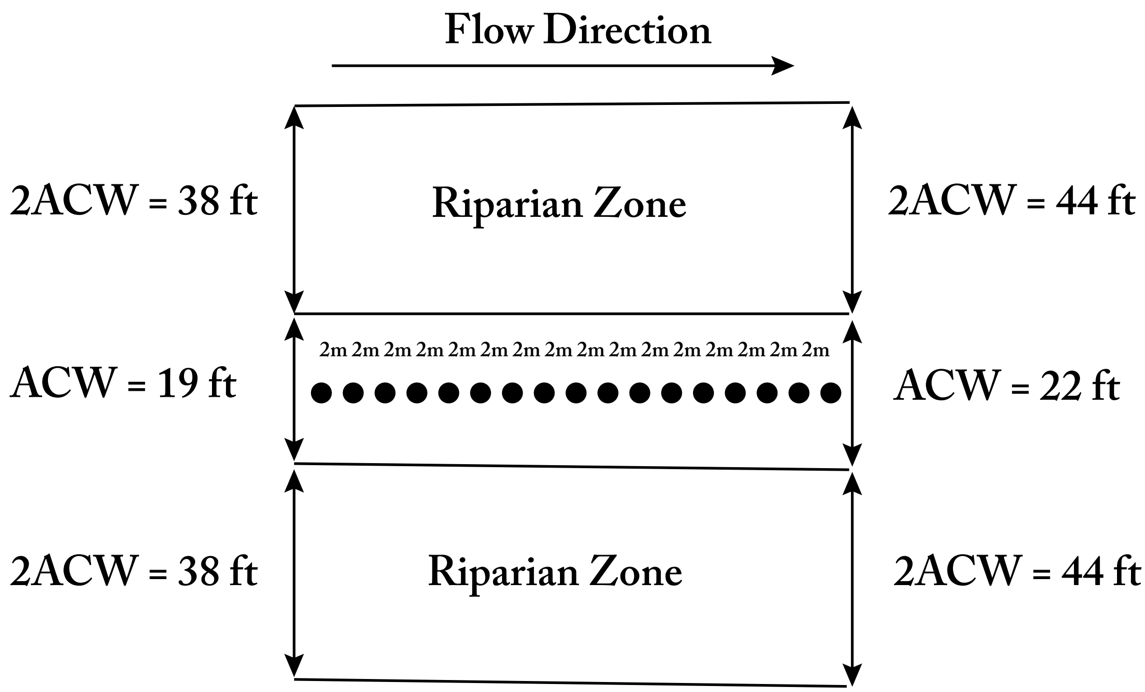


Figure 2. *Summary of how 1-square-mile-drainage-area streams overlie intermittent and perennial streams delineated on USGS 1:24K topographic map, and how the 2ACW riparian buffer and ACW of the stream channel can be calculated progressively downstream from LiDAR-based flow accumulation based on a minimum drainage threshold. In this example, the Cottonwood Study Areas is located in the Flint Hills Hydrophysiographic Province, so the equation* $W = 20.04x^{0.3743}$*, where x = drainage area in square miles, was used to derive the ACW of the active (bankfull) channel plus a 2ACW riparian buffer on either side of the stream, every 2 m moving downstream from where the 1-square-mile-drainage-area threshold is achieved to define a stream.*

Figure 3. *Depiction of how 2ACW riparian buffer and stream channel expand in width every 2 meters downstream based on a progressive flow accumulation calculation for every LiDAR point in the stream channel.*



Historical Riparian Forest

A common question asked in Kansas is "Where did woodlands and forests occur naturally in Kansas before European settlement"? This question is difficult to answer since there are very limited records and few photographs from the period of westward migration through the U.S. and during settlement of Kansas. 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 historical PLSS-based Kansas forest maps provide an estimated snapshot of what the potential vegetation for the 2ACW riparian area was historically, given environmental and management conditions at the time (1850s-60s), even though westward migration was already underway during that time period with some impacts to the riparian areas (e.g., gold rushes and west coast settlements, explorative surveys, etc.) as well as historical impacts by Native Americans.

Riparian vegetation, including its forest component, is constantly being affected by land use and landscape management changes, flood disturbances, drought, climate change, and anthropogenic and natural channel migration and evolutionary processes. Often, land use change and landscape management (on the land, in the stream, and via artificial drainages and impoundments) interact to impact the hydrology of fluvial systems with cascading effects through the fluvial and riparian system, which include complex interactions that are not easily discerned. So, while the historical PLSS-based Kansas forest maps provide us an estimated, historical snapshot of potential vegetation for the 2ACW riparian zone at the time, the streams and rivers have migrated since that time period (1850s-60s). The riparian zone has migrated with the streams and rivers and has been affected by a myriad of land use and landscape management changes. At best, we only have remnants of the riparian vegetation from the historical time period remaining to evaluate its PNC and we do not know where they all are. Many potential remnants may have been, and probably have been, cut at one time or another, sometimes including clear cutting or bulldozing and conversion to agriculture. Therefore, the most easily accessible interpretation and use of the historical PLSS-based Kansas forest maps is to identify areas where potential, remnant, late-seral-stage riparian areas may still remain (PNC), evaluate them to determine where they do still remain and assess what species they are comprised by as well as their floristic quality, and allow them to provide us with reference condition information which may be helpful for a better understanding of the ecological vegetation potential of the riparian areas across the state. Such an analysis of potential remnant riparian vegetation could provide us with a "blueprint" of the diversity and quality of "natural" riparian buffers associated with each of the hydrophysiographic provinces occurring within the state and guide our efforts to restore their function in locations where it has been lost. This information could be combined with advancements in our understanding of floodplain connectivity and its timing (e.g., flood frequency intervals and extent) to assist in determinations of where the riparian vegetation is functioning properly, is at-risk or is simply not functioning due to disconnection with most flood events (entrenched beyond floodplain connectivity) as well as distinguish among the riparian zones potential (PNC) and capability (BLM, 2003). For a summary of the Bureau of Land Management's criteria (BLM, 2003) to determine "Proper Functioning Condition (PFC)" and factors and resources to evaluate PNC of riparian vegetation and assessing the PNC relative to its current capability (i.e., limiting factors), refer to Table 15.

For purposes of this RCPP riparian forest assessment work, the potential riparian remnants within the hydrophysiographic provinces comprising the study area basins could be identified and evaluated to:

1. assist in better understanding of the vegetative potential of riparian zones (PNC) and their species diversity, composition and seral stage succession by hydrophysiographic province;
2. provide prescriptions for what restoration of riparian vegetative potential (PNC) would entail if we are interested in achieving its vegetative potential and proper ecological functioning condition (BLM, 2003);
3. allow consideration of how these prescriptions might be achieved (e.g., how do you accelerate establishment and seral-state succession of riparian vegetation plantings and enhancements to achieve its vegetative and ecological potential PFC, and in an expedited manner?);
4. guide riparian restoration and management recommendations, perhaps, in a zoned approach (grading from fluvial disturbance species to late-seral stage native tree, shrub and understory species to forestry and agroforestry species as one moves from the stream to the full 2ACW extent) (Figure 4);
5. support development of a riparian buffer vegetation restoration guide for each of the hydrophysiographic provinces in study area basins,

Table 15. *Terminology relevant to assessing the "Proper Functioning Condition" of riparian vegetation and factors and resources for assessing the potential natural community of vegetation relative to its current capability (BLM, 2003).*

Terminology	Definition
Potential	Defined as the highest ecological status a riparian-wetland area can attain given no political, social, or economic constraints (potential natural community [PNC])
Capability	Defined as the highest ecological status a riparian-wetland area can attain given political, social, or economic constraints (limiting factors)
Proper Functioning Condition	In accordance with capability and potential, riparian areas should: 1) dissipate energies associated with wind action, wave action, overland flow from adjacent sites, thereby reducing erosion and improving water quality; 2) filter sediment and aid floodplain development; 3) improve flood-water retention and groundwater recharge; 4) develop root masses that stabilize island and shoreline features against cutting action; 5) develop diverse ponding characteristics to provide the water depth, duration and temperature to support fish production, water-bird breeding, greater biodiversity and other uses.
Functional-at-Risk- Condition	In accordance with capability and potential, riparian areas: possess some or even most of the PFC elements above, but have at least one attribute/process that gives it a high probability of degradation with wind action, wave action and overland flow event(s).
Non-Functional Condition	In accordance with capability and potential, riparian areas: clearly lack the PFV elements listed above.

Factors and Recourse for Assessing Potential and Capability of the Riparian Zone
• ID riparian reference areas (remnant areas, enclosure, preserves, ext.).
• Analyze historic photos, survey notes, and/or documents that indicate historic conditions.
• Evaluate species list (plants and animals-historic and present).
• Determine species habitat needs (plant and animals) related to species that are/were present.
• Examine the soil and determine soil saturation conditions throughout the seasons.
• Examine the hydrology; establish the frequency, duration and the extent of flooding/ponding
• Identify riparian vegetation that currently exist and determine if the same species occurred historically.
• Determine the entire watershed's general condition and identify its major landform(s).
• Identify limiting factors, both human-caused and natural, and determine if correction/attenuation is possible.

perhaps with an emphasis on compatible plant guilds and restoration recommendations.

Flint Hills Hydrophysiographic Province

Within the Flint Hills Hydrophysiographic Province, four basins are represented by the RCPP study areas: Twin Lakes (two HUC-12s), Marion Lake (two HUC-12s), Cottonwood (nine HUC-12s) and Eagle Creek (three HUC-12s) for a total of 16 HUC-12s evaluated. For all HUC-12s within the province, 31.1% of the current 2ACW riparian zone was historically forest according to the PLSS surveys completed in the area in the 1850s-60s. Note that this does not include riparian forest associated with the historical course of the stream as recorded at the time of the PLSS survey and which now is located outside the current 2ACW riparian zone. Currently, riparian forest extent within the 2ACW riparian zone is estimated at 38.5% for all of the study areas in the Flint Hills Hydrophysiographic Province. Analysis of the overlap of the historical riparian forest and the current riparian forest within the 2ACW riparian zone indicates that approximately 12.6% of its current extent could contain remnants of historical riparian forest. These potential remnants should be evaluated to determine if they are indeed remnants, and if so, could help to guide understanding of the vegetative and ecological potential of the riparian zone (PNC). Additionally, these potential remnants may be

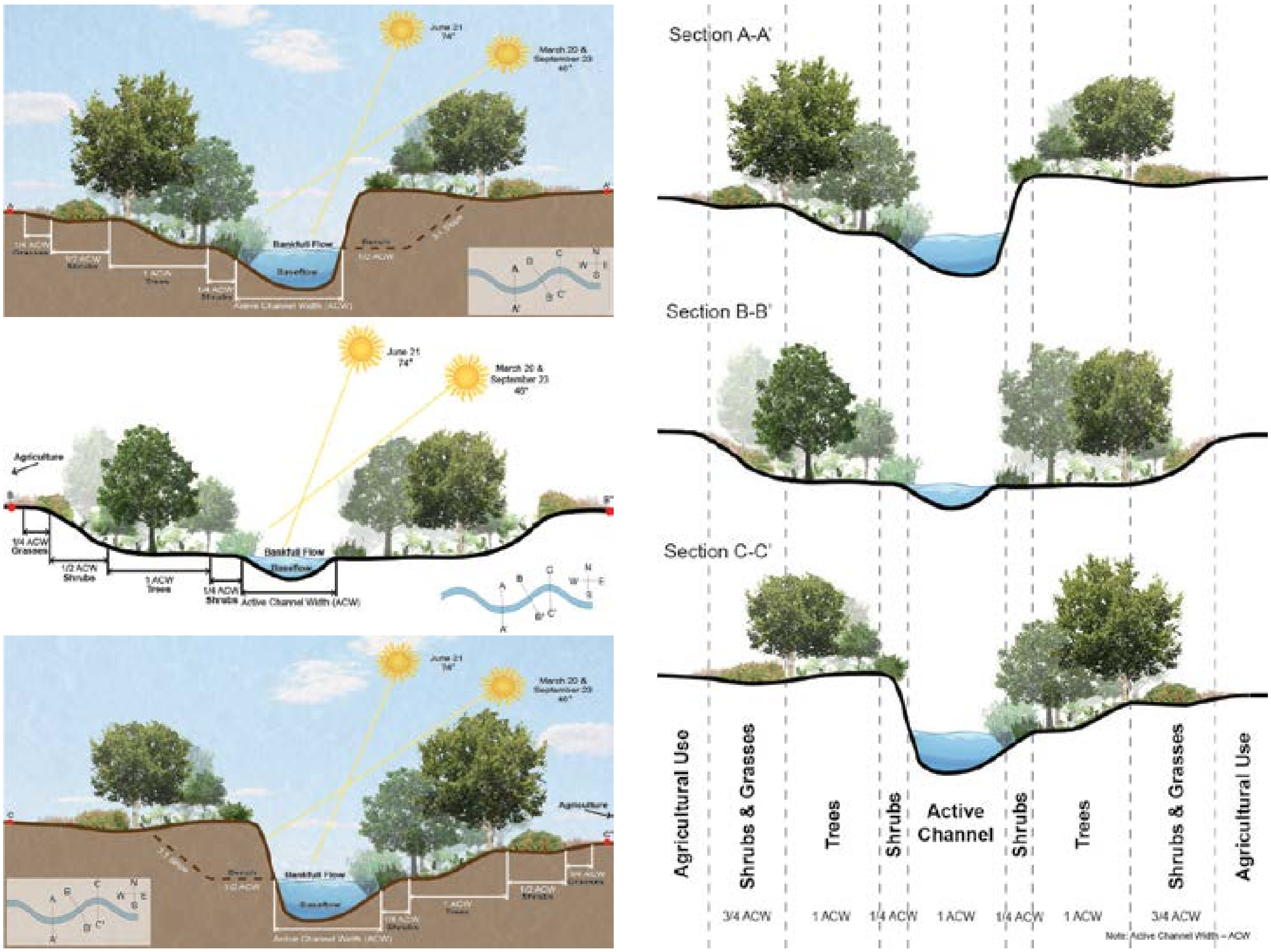


Figure 4. *Conceptual designs of a planted riparian forest buffer. The ideal buffer is two times wider than the active channel width (ACW). A zoned approach is recommended to maximize the functional value of the planting. Within the 2ACW area, three to four planting zones are designated that correspond to anticipated hydrologic, geomorphic, biologic, silvicultural, and agricultural influences. The buffer begins with disturbance-adapted species (willow, buttonbush, false indigo, etc.) in the narrow, often unstable zone nearest the stream. It then transitions to forest species (sycamore, oak, chokecherry, etc.) of high, long-term value for riparian wildlife in a large, low-disturbance conservation zone. A moderate-disturbance production zone follows where valuable forestry and agroforestry species (walnut, hazelnut, elderberry, etc.) are managed for harvest. An additional outermost zone may be delineated for grass, forb, and legume species (bluestem, sunflower, clover, etc.) to provide wildlife and beneficial insect support. Zone widths may vary, and some overlap in the composition, purpose, and use of adjoining zones is expected and encouraged. Planting zone arrangement is consistent regardless of high-bank vs. low-bank situations, but species recommendations may change according to the plants' flood tolerance and water demands. In eroding high-bank areas, structural stabilization projects may reshape the channel along the illustrated dashed line to form a low bench and 3:1 slope before planting. In the absence of bank reshaping, large tree species should not be planted in the near-stream zone where bank failure would cause them to fall into the stream, potentially creating channel blockages and inducing lateral scour erosion.*

sites of riparian areas in need of conservation and could be assessed to determine their functioning condition and effectiveness at stabilizing the fluvial system where they are encountered as well as serve as a "blueprint" for development of riparian restoration guides for the Flint Hills Hydrophysiographic Province.

The percentage of the 2ACW riparian zone which may contain these remnants ranged from 2.2% (Marion Lake Study Area, most westerly and fewest miles of largest stream orders) to 19% or greater (Cottonwood and Eagle Creek Study Areas, most southeasterly located watersheds and greatest miles of largest stream orders), with a mean value of 12.6%. Predictive patterns for

Table 16. *Potential historical remnant forest in 2ACW riparian zone in the Flint Hills Hydrophysiographic Province.*

HUC-12	2ACW Acres	2ACW PLSS Acres	Current 2ACW Forest	Potential Remnant Acres
Twin Lakes Study Area				
110702010101	971.6	38.9	539.6	27.3
110702010102	1161.0	501.2	764.4	378.3
Total	2132.6	540.1	1303.9	405.5
Marion Lake Study Area				
110702020103	1326.8	81.1	592.7	46.6
110702020104	793.1	0.0	443.6	0.0
Total	2119.9	81.1	1036.3	46.6
Cottonwood Study Area				
110702030204	2415.5	609.4	693.0	179.4
110702030205	2207.9	621.0	680.0	229.1
110702030305	2152.0	555.6	764.4	259.0
110702030401	2135.2	559.2	687.2	209.2
110702030402	1886.9	758.4	743.7	278.8
110702030403	2227.6	751.9	724.5	278.8
110702030404	2171.3	804.2	777.1	243.2
110702030405	3695.3	1280.5	1071.5	430.0
110702030406	2426.9	1339.3	858.2	441.7
Total	21318.7	7279.6	6999.5	2549.2
Eagle Creek Study Area				
110702010403	913.7	353.6	538.1	212.4
110702010404	1256.4	399.5	730.2	262.4
110702010405	912.0	270.5	429.1	123.4
Total	3082.1	1023.7	1697.4	598.2

percentage of potential historical remnant forest seemed to follow the average annual precipitation gradient increasing in the percentage of the potential historical remnant forest component of 2ACW riparian zone in a southeasterly direction and as stream miles associated with larger stream orders increased.

For a more detailed summary of potential historical forest remnants by HUC-12 within each of the study areas located in the Flint Hills Hydrophysiographic Province, please refer to Table 16.

North-Central Hydrophysiographic Province

Within the North-Central Hydrophysiographic Province, only one basin is represented for the RCPP study area: Milford Lake with a total of 12 HUC-12s evaluated. For all HUC-12s within the province, 8.4% of the current 2ACW riparian zone was historically forest according to the PLSS surveys completed in the area in the 1850s-60s. Note that this does not include riparian forest associated with the historical course of the stream as recorded at the time of the PLSS survey and which now is located outside the current 2ACW riparian zone. Currently, riparian forest extent within the 2ACW riparian zone is estimated at 39.0% for all of the study areas in the North-Central Hydrophysiographic Province. Analysis of the overlap of the historical riparian forest and the current riparian forest within the 2ACW riparian zone indicates that approximately 3.7% of its current extent could contain remnants of historical riparian forest. These potential remnants should be evaluated to determine if they are indeed remnants, and if so, could help to guide understanding of the vegetative and ecological potential of the riparian zone (PNC). Additionally, these potential remnants may be sites of riparian areas in need of conservation and could be assessed to determine their functioning condition and effectiveness at stabilizing the fluvial system where they are encountered as well as serve as a "blueprint" for development of riparian restoration guides for the North-Central Hydrophysiographic Province.

The percentage of the 2ACW riparian zone which may contain these remnants ranged from 0.0% (HUC-12 = 102500170602) to 7.5% (HUC-12 = 10250017204). There were no obvious predictive patterns for percentage of potential historical remnant forest in the Milford Lake Study Area, except that the majority of the potential remnants occurred along the Republican River, which is the highest order stream in the Milford Lake Study Area.

For a more detailed summary of potential historical forest remnants by HUC-12 within each of the study areas located in the North-Central Hydrophysiographic Province, please refer to Table 17.

Eastern Kansas Hydrophysiographic Province

Within the Eastern Hydrophysiographic Province, four basins were represented by the RCPP study areas: Upper Wakarusa (five HUC-12s), Pomona Lake (three HUC-12s), Hillsdale Lake (one HUC-12) and Middle Neosho (twelve HUC-12s), for a total of 21 HUC-12s evaluated. For all HUC-12s within the province, 53.2% of the current 2ACW riparian zone was historically forest according to the PLSS surveys completed in the area in the 1850s-60s. Note that this does not include riparian forest associated with the historical course of the stream as recorded at the time of the PLSS survey and which now is located outside the current 2ACW riparian zone. Currently, riparian forest extent within the 2ACW riparian zone is estimated at 50.0% for all of the study areas in the Flint Hills Hydrophysiographic Province. Analysis of the overlap of the historical riparian forest and the current riparian forest within the 2ACW riparian zone indicates that approximately 24.3% of its current extent could contain remnants of historical riparian forest. These potential remnants should be evaluated to determine if they are indeed remnants, and if so, could help to guide our understanding of the vegetative and ecological potential of the riparian zone (PNC). Additionally, these potential remnants may be sites of riparian areas in need of conservation and could be assessed to determine their functioning condition and effectiveness at stabilizing the fluvial system where they are encountered as well as serve as a "blueprint" for development of riparian restoration guides for the Eastern Kansas Hydrophysiographic Province.

Table 17. *Potential historical remnant forest in 2ACW riparian zone in the North-Central Hydrophysiographic Province.*

Milford Lake Study Area				
HUC-12	**2ACW Acres**	**2ACW PLSS Acres**	**Current 2ACW Forest**	**Potential Remnant Acres**
102500170202	1,032.7	146.3	518.4	75.5
102500170204	1,768.3	251.2	875.7	133.1
102500170303	829.8	117.7	349.9	52.2
102500170304	867.3	57.5	459.9	32.4
102500170310	1,420.4	102.2	577.1	40.7
102500170409	4,578.5	366.4	1650.4	163.5
102500170508	4,088.8	265.3	1519.1	126.3
102500170602	1,229.5	0.0	398.3	0.0
102500170604	2,038.8	331.9	563.9	106.1
102500170607	90.1	2.7	59.6	0.9
102500170608	48.9	1.1	25.8	0.8
102500170609	1,716.2	4.6	681.5	3.3
Total	19,709.3	1,647.0	7679.5	734.8

The percentage of the 2ACW riparian zone which may contain these remnants ranged from 13.6% (Pomona Lake Study Area, western location) to 37.8% (Hillsdale Lake Study Area, eastern location), with a mean value of 24.3%. A predictive pattern for percentage of potential historical remnant forest component of 2ACW riparian zone was not evident in this hydrophysiographic province, other than the two study areas that were the most easterly located had the highest percentages of potential historical remnant forest ranging from 26.1% (Middle Neosho Study Area) to 37.8% (Hillsdale Lake Study Area). However, Hillsdale Lake was the smallest study area with fewest higher order stream miles and Middle Neosho was the largest study area with the most higher order stream miles in the Eastern Kansas Hydrophysiographic Province. It is unclear why the small-sized Hillsdale study area with the fewest higher order stream miles (comprised only by stream orders 1-3) had the largest percentage of potential remnant riparian forest.

For a more detailed summary of potential historical forest remnants by HUC-12 within each of the study areas located in the Eastern Kansas Hydrophysiographic Province, please refer to Table 18.

Table 18. *Potential historical remnant forest in 2ACW riparian zone in the Eastern Hydrophysiographic Province.*

Upper Wakarusa Study Area				
HUC-12	**2ACW Acres**	**2ACW PLSS Acres**	**Current 2ACW Forest**	**Potential Remnant Acres**
102701040104	1832.2	275.0	1164.8291	180.6
102701040105	1382.9	376.8	990.5	267.4
102701040106	766.1	392.2	471.2	227.9
102701040107	893.6	254.6	598.2	209.5
102701040108	783.0	341.5	577.0	239.8
Total	5657.7	1,640.1	3801.7	1125.1
Pomona Lake Study Area				
HUC-12	**2ACW Acres**	**2ACW PLSS Acres**	**Current 2ACW Forest**	**Potential Remnant Acres**
102901010203	1656.8	355.3	922.9	216.0
102901010205	1854.1	434.2	994.9	207.6
102901010207	1369.6	344.5	825.4	238.9
Total	4880.5	1,134.0	2743.2	662.5
Hillsdale Lake Study Area				
HUC-12	**2ACW Acres**	**2ACW PLSS Acres**	**Current 2ACW Forest**	**Potential Remnant Acres**
102901020101	1,158.2	608.6	801.4	437.7
Total	1,158.2	608.6	801.4	437.7
Middle Neosho Study Area				
HUC-12	**2ACW Acres**	**2ACW PLSS Acres**	**Current 2ACW Forest**	**Potential Remnant Acres**
110702050101	2,892.9	1,320.8	1,534.4	646.4
110702050109	4,222.8	2,696.5	1,569.0	891.5
110702050201	3,055.4	2,103.6	1,469.4	1,111.2
110702050202	2,525.4	1,773.9	730.8	509.1
110702050204	2,572.6	1,338.0	1,219.8	515.4
110702050205	3,694.8	3,433.1	1,385.4	1,257.1
110702050305	2,293.9	1,155.3	1,420.7	684.0
110702050403	1,867.6	615.0	1,110.4	390.1
110702050501	2,057.8	971.6	1,101.7	554.7
110702050505	1,481.3	566.4	792.7	260.7
110702050601	3,088.3	2,598.0	1,169.0	932.4
110702050605	3,021.3	1,701.1	1,407.4	815.1
Total	32,774.3	20,273.3	14,910.7	8,567.9

South-Central Hydrophysiographic Province

Within the South-Central Hydrophysiographic Province, one basin was represented for the RCPP study area: Cheney Lake (eight HUC-12s), for a total of eight HUC-12s evaluated. No historical remnant or PLSS riparian forest data were identified within the Cheney Lake Basin. Other watersheds and basins within the South Central Hydrophysiographic Province did indicate historical PLSS riparian forest but they were not a part of the RCPP study areas, so were not included in this analysis. Riparian forest likely comprised a lesser extent of the 2ACW riparian zone prior to settlement and was likely primarily located on major streams and rivers, so this should be taken into consideration when designing riparian forest BMPs for the Cheney Lake Study Area.

For more detailed accounting of the summary of potential historical forest remnants by HUC-12 within the Cheney Lake Study Area located in the South-Central Hydrophysiographic Province, please refer to Table 19.

Table 19. *Potential historical remnant forest in 2ACW riparian zone in the South-Central Hydrophysiographic Province.*

Cheney Lake Study Area				
HUC-12	**2ACW Acres**	**2ACW PLSS Acres**	**Current 2ACW Forest**	**Potential Remnant Acres**
110300140109	1347.4	0.0	232.9	0.0
110300140204	610.7	0.0	215.2	0.0
110300140205	814.6	0.0	226.7	0.0
110300140301	819.1	0.0	248.5	0.0
110300140302	607.7	0.0	294.6	0.0
110300140303	1124.4	0.0	439.8	0.0
110300140304	793.6	0.0	419.7	0.0
110300140305	244.9	0.0	115.6	0.0
Total	6362.5	0.0	2193.0	0.0

Potential Historical Riparian Forest Remnants around Study Area Lakes

Four lakes were part of the HUC-12 watersheds within the RCPP study areas. Lake riparian buffer zones were considered separately from the stream and river riparian zones. The land use comprising the riparian buffer zone around Clinton Lake (Upper Wakarusa Study Area, Eastern Kansas Hydrophysiographic Province), Pomona Lake (Pomona Lake Study Area, Eastern Kansas Hydrophysiographic Province), Milford Lake (Milford Lake Study Area, North-Central Hydrophysiographic Province) and Cheney Lake (Cheney Lake Study Area, South-Central Hydrophysiographic Province) was delineated and assessed with a focus on riparian forest extent. The riparian buffer zone around Clinton, Pomona and Cheney lakes was 600 feet and around Milford Lake was 873 feet; 600 feet was considered the minimum riparian buffer distance around federal reservoirs, and only when the upstream riparian zone exceeded 600 feet was a higher buffer value used as was the case on the Republican River above Milford Lake.

Clinton (63.2%) and Pomona (51.6%) lakes had the highest percentage of current riparian forest around them and were the most easterly located lakes. Milford (28.4%) and Cheney (26.1%) lakes had the lowest percentage of current riparian forest buffer around them, with Cheney Lake the most westerly of all the lakes. Clinton Lake had 13.6% of its lake riparian buffer comprised by potential remnant riparian forest, with Pomona and Milford lakes only having 2.6% and 1.8%, respectively, and Cheney Lake having no potential remnants remaining. For more detailed accounting of the summary of potential historical forest remnants by around the study area lakes, please refer to Table 20.

Table 20. *Potential historical remnant forest in the riparian zone around the lakes in the study areas.*

Potential Historical Riparian Forest Remnants around Lakes				
Lake	**Buffer Acres**	**Buffer PLSS Acres**	**Current Buffer Forest**	**Potential Remnant Acres**
Milford	8074.6	481.5	2296.7	142.3
Clinton	2990.7	616.9	1891.2	405.9
Pomona	587.6	30.2	303.2	15.4
Cheney	2454.6	0.0	640.7	0.0

Additional Discussion

Impacts to the 2ACW riparian zone prior to the historical PLSS survey are not known but may have occurred through the influence of earlier westward migrations by settlers (e.g., riparian forest utilization during west coast explorations, gold rushes and settlement migrations) and native American activities (e.g., induced fire and riparian settlement and utilization). As well, the estimates of historical riparian forest are based on extrapolation from historical mapping and notes of surveyors when the original PLSS surveys were completed, with variable quality dependent on surveyors' attentions, experience and priority considerations, with likely a greater emphasis on larger trees of commercial or construction value and less emphasis on smaller trees becoming established in the 2ACW riparian zone, so comparisons with our current methods may be incomplete at best. Based on ecoregion descriptions, upland portions of watersheds (e.g., stream order 1 and portions or all of stream order 2) were likely tallgrass prairie in the majority of the RCPP study areas (except western drainage of Milford Lake and Marion Lake Study Areas and most if not all of Cheney Lake Study Areas where mixed grass prairie may have dominated), especially for ephemeral and intermittent streams in many of these ecoregions and hydrophysiographic provinces, where floodplain soil water to support trees and interactions with fire and grazing may have influenced riparian forest extent. Likely, prior to settlement of the area, riparian forests expanded in a downstream direction to represent a larger portion of the 2ACW riparian zone as perennial flows and riparian water tables were encountered, grading to tallgrass prairie in a lateral direction upslope away from the stream (1ACW to 2ACW). Finally, the potential historical riparian forest remnants and PLSS historical forest data were determined for the stream and river courses at the time of the survey and cannot account for the movement of the 2ACW riparian zone that occurred as the stream and river channels migrated naturally (or anthropogenically) across the floodplains, so only a portion of the historical data is applicable for use in quantifying the historical riparian component of the current 2ACW riparian zone. All that being said, the historical PLSS data may prove very useful for identifying potential historical remnant forest parcels and evaluating the PNC of these parcels as part of riparian zones to develop riparian planting and restoration guides and make species recommendations. The historical PLSS data may also prove useful for identifying historical riparian remnants for voluntary and easement riparian conservation programs.

Remote Riparian Forest Assessment

Calculations: Current Riparian Land Use

Riparian forest extent was determined by using leaf-off LiDAR imagery (various dates throughout study areas from 2011-2015) 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 study area watersheds on date of LiDAR acquisition: [First return LiDAR] – [Bare earth LiDAR]. Trees were defined where the difference between first return and bare earth reflectance height equaled or exceeded one meter and then all the 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 therefore, 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 values for productive cropland vs. riparian forest).

NDVI was calculated for 2015 1-m color-infrared National Agriculture Imagery Program (NAIP) imagery clipped to the 2ACW riparian area of study area watersheds as the ratio of: ([near-infrared band] – [visible red band])/ ([near-infrared band] + [visible red band]) and then this value was converted to a digital number from 0 to 255 for visual display.

A combination of NDVI, 2015 Kansas Land Cover Patterns land use data, and buffered roads and railroad tracks were used to assign non-forest land uses to 2ACW riparian buffer zones. Where trees did not occur within the 2ACW riparian buffer zone, areas comprised primarily of road and railroads and their buffers were classified as "Developed." Areas identified as cropland, pasture or grassland by the 2015 Kansas Land Cover Patterns (KLCP) data in the non-forest riparian areas were classified as "Riparian Areas in Need of Establishment." Areas that occurred outside the LiDAR-derived forested area and were identified as water or wetland by the 2015 KLCP data were classified as "Water." Finally, areas occurring within the LiDAR-derived forested area but scoring a very low NDVI score (≤ 70 digital number) were classified as "Water" (since the very low NDVI scores were highly correlated with standing water) and areas scoring a low NDVI score (71-122) were classified as "Forest in Need of Establishment" (since the low NDVI scores were highly correlated with barren soil or sparse vegetation gaps within the forested area). Table 21 summarizes the classification method. Note that methods were revised based on in-field surveys of the riparian areas for the Twin Lakes study area (KFS, 2017; APPENDIX B) and based on prior work to develop these methods (Neel et al., 2014; Beck et al., 2014).

There were two exceptions to application of the above methods to perform the remote riparian

Table 21. *Summary of remote riparian forest assessment methods into actionable categories for best management practice (BMP) implementation and application of riparian conservation programs.*

Riparian Class	Methods for Study Area Basins with First-Return LiDAR*
Forest	([First Return LiDAR Elevation] - [Bare Earth LiDAR Elevation]) > 1 m = "Potential Forest"
Conservation	[NDVI of 2015 4-band NAIP "Potential Forest"] > 158
Developed	Road and Railroad Buffer Intersection with "Potential Forest"
Establishment	[NDVI of 2015 4-band NAIP "Potential Forest"] = 70 to 122
Management	[NDVI of 2015 4-band NAIP "Potential Forest"] = 122 to 158
Water	[NDVI of 2015 4-band NAIP "Potential Forest"] < 70
Non-Forest	Extract "Potential Forest," then 2015 KLCP ID of Remaining LU and Road & Railroad Buffer Intersection
Developed	Road and Railroad Buffer Intersects "Forest" and/or 2015 KLCP = "Urban"
Establishment	2015 KLCP = "Cropland," "Grassland," "CRP" or "Pasture"
Water	2015 KLCP = "Water" or "Wetland"

**For Milford Lake Study Area, "Potential Forest" = Extract KFS Forest & Water, then same methods*

**For Middle Neosho Study Area, "Potential Forest" = Heads-up Digitization, then same methods* assessment. LiDAR quality was insufficient (i.e., too many errors in First Return LiDAR) within the Middle Neosho Study Area, so instead of using the [First Return LiDAR] minus the [Bare Earth LiDAR] elevation values to delineate the riparian forest, heads-up digitization was used in lieu of LiDAR to delineate riparian forest and tree polygons occurring within the 2ACW riparian zone. Based on previous work to develop methods (Neel et al, 2014; Beck et al, 2014) and preliminary visual analysis, methods produced similar results except heads-up digitization was very time consuming. Additionally, no [First Return LiDAR] was available for the entire Milford Lake Study Area. However, at the time of the remote riparian assessment for Milford Lake Study Area, the KFS forest land use layer was completed for the Milford Lake Study Area using object-based classification of 1-m NAIP Imagery (KFS, 2017b). The KFS riparian forest data layer was overlaid with heads-up digitization for a portion of the Milford Lake Study Area and based on analysis was determined to be sufficient for use rather than using the more time-consuming heads-up digitization methods to delineate riparian forest within the 2ACW riparian zone. Riparian forest polygons for the 2ACW riparian zone obtained from the KFS riparian forest data layer were used as a surrogate within the above methods for the Milford Lake Study Area over heads-up digitization (too time consuming) or LiDAR analysis (first-return LiDAR unavailable for all of the Milford Lake Study Area at time of analysis).

Assigning Riparian Forest Functioning Condition Class

Functioning condition class was determined by estimating the percentage of forest cover occurring within the riparian area where LiDAR-derived trees (or surrogate methods to identify riparian forest polygons) were identified using NDVI values. Based on NDVI values, riparian forest areas exhibiting approximately 5 to 85% cover were classified as "*Forest in need of management*" (forests that exhibited less-than-ideal canopy coverage) and those with 86 to 100% forest cover were classified as "*Forest in need of conservation*" (forests that had adequate canopy coverage to protect streambanks). *"Forest in need of establishment"* (areas lacking forest canopy cover/ bare streambank sites) were those with less than 5% forest cover and included cropland, pasture, grassland, and sparse vegetation and barren gaps in forested areas. *"Water"* and *"Developed"* areas were also classified as described in the previous section.

A high threshold for the functioning condition class of "*Forest in need of conservation*" was used in the remote riparian assessments due to field work within Twin Lakes Study Area which indicated that only a low percentage of the 2ACW riparian zone consisted of high quality, diverse and healthy riparian forest exhibiting late-seral stage riparian communities of trees, saplings, seedlings, and understory vegetation, or its PNC of riparian vegetation (KFS, 2017a), which could be highlighted for conservation and preservation practices (e.g., voluntary and easement conservation programs).

The intent of classifying the 2ACW riparian zone into actionable categories was to support identification of sites to implement EQIP practices and other partnership BMP and conservation programs to support RCPP, WRAPS and the KWO Water Vision. Direct support of NRCS through EQIP and RCPP required consideration of their SVAP2 protocols (NRCS, 2009) for evaluating riparian vegetation and function and identifying potential resource concerns. To do this remotely, attempts were made to integrate the following factors from SVAP2 as presented in Table 22 into the remote riparian assessment and classify the 2ACW riparian zone in all the study areas into actionable categories. Riparian quantity was the major SVAP2 scoring element integrated into the remote riparian assessment methods. Remote assessment of riparian quality for purposes of SVAP2 requires identification of composition, density, and age structure of the 2ACW riparian zone as well as identification of invasive species and concentrated flow paths in the riparian area. Use of NDVI to classify the riparian trees and forest into actively photosynthesizing cover classes was used as a "surrogate" to estimate a riparian quality component, but during field work in Twin Lakes Study Area, observations and data analysis indicated relatively poor floristic quality relative to the PNC. Methods to classify the 2ACW riparian zone into "Riparian areas in need of conservation" which would also be the riparian areas with good quantity and quality according to SVAP2 (Table; NRCS, 2009), were adjusted to be more conservative (i.e., underestimate acreage of good quality riparian areas in order to not underestimate potential resource concerns). Bank condition and channel condition could not be assessed remotely as part of the RCPP scope of work (however, efforts have been underway and are advancing to develop such methods). However, the simple assumption of this work was that where riparian quantity and quality are of the highest values, bank condition will be good (i.e., stable banks protected by roots of native vegetation and wood; fewer bank failures) as will channel condition (i.e., less bank erosion; less lateral migration; less stressed vegetation). Additional field work and on-site visits will be necessary to fully examine those relationships.

Table 22. *Stream Visual Assessment Protocol (SVAP2) scoring elements relevant to assessing riparian area function and stability (adapted from NRCS, 2009).*

Stream Visual Assessment Protocol (SVAP2): Riparian Area Function and Stability Scoring				
Scoring of Riparian Functioning Condition and Resource Concerns				
Element	**Good**	**Fair**	**Poor**	**Very Poor**
Riparian Quantity	Natural plant community extends > 2ACW and contiguous across site	Natural plant community extends at least 1ACW and generally contiguous across site, with vegetation gaps < 10%	Natural plant community extends at least 1/2 ACW and vegetation gaps < 30%	Natural plant community extends 1/3 ACW or less with vegetation gaps > 30%
Riparian Quality	Natural and diverse riparian vegetation with composition, density and age structure appropriate to site; no invasive species or concentrated flow paths	Natural and diverse riparian vegetation with composition, density and age structure appropriate to site; invasive species < 20% cover and few or no concentrated flow paths	Natural vegetation compromised; evidence of concentrated flow paths through riparian area and invasive species >20% and <50% cover	Little or no natural vegetation; evidence of concentrated flow paths through riparian areas and invasive species >50% cover
Channel Condition	Natural, stable channel connected to floodplain at natural intervals (no incision or aggradation)	Some channel incision or aggradation, but active channel and floodplain connected in some areas; minimal lateral migration and bank erosion	Active channel incision, stressed vegetation, steep failing streambanks evident and channel disconnected from floodplain; moderate channel migration and deposition	Active channel incision, sparse vegetation, head cuts and surface cracks on banks, steep failing streambanks prominent and channel disconnected from floodplain; severe lateral migration and deposition
Bank Condition	Stable banks protected by roots of natural vegetation, wood and rock; no excessive erosion, bank failures, livestock access or rec use	Moderately stable banks protected by roots of natural vegetation, wood or rock; limited number of structures on bank; evidence of erosion or bank failures with some reestablishment of vegetation; rec use and livestock do not negatively impact bank condition	Moderately unstable banks with very little protection by roots of natural vegetation, wood or rock; structures cover portion of bank; excessive bank erosion or failures; livestock access and rec use contributing to bank instability	Unstable banks with no protection by roots of natural vegetation, wood or rock; structures dominate banks; excessive bank erosion or failures; livestock access and rec use contributing to bank instability

The historical PLSS forest GIS data layer developed by KBS provides location information for potential historical remnants of riparian forest and was used to facilitate identification of reference quality late-seral stage vegetative complexity and representative of good ecological condition (i.e. good quality riparian areas in SVAP2; PNC in BLM, 2003). The historical PLSS forest data were based on survey notes describing and mapping the location of forests occurring at section lines, along with visual estimation of boundaries for the forest expanse in between, at the time of the survey (1850s to 60s). The overlap of the historic PLSS locations of forest with riparian forest polygons mapped during the present using NDVI represents a potentially better-informed approach for identifying historical riparian remnant forest rather than interpretation of NDVI alone (i.e., greenness index extrapolated to cover, with little ability to remotely sense forest species or size classes) from a single CIR-NAIP image. LiDAR point cloud analysis integrated with CIR-NAIP analysis may be able to yield some examination of size classes and heights of riparian forest trees, but that analysis was beyond the scope of this project since an experimental approach. So, in addition to the "*Forest in need of conservation*" condition classes determined for all RCPP study areas (except Cheney Lake where no historical PLSS forest data or remnants could be identified), the analysis of the potential historical remnants should be used to supplement understanding of this condition class beyond the remote assessment. Further analysis and delineation of the potential historical riparian forest remnants, and possibly the remotely assessed NDVI-derived "*Forest in need of conservation*" condition classes, may be prudent and necessary to successfully implement riparian forest conservation BMPs as part of the RCPP agreement and future riparian forest conservation initiatives and programs.

Flint Hills Hydrophysiographic Province

Within the Flint Hills Hydrophysiographic Province, *"Forests in need of conservation"* areas comprised 0.0% (Twin Lakes Study Area) to 12.8% (Marion Lake Study Area) of the 2ACW riparian zone (Table 23). *"Forests in need of management"* areas ranged from 32.5% (Cottonwood Study Area) to 71.9% (Twin Lakes Study Area) of the 2ACW riparian zone. *"Forests in need of establishment"* areas represented from 2.4% (Twin Lakes Study Area) to 61.1% (Cottonwood Study Area) of the 2ACW riparian zone. *"Developed"* areas were only small components of the 2ACW riparian zone in all of the study areas in the Flint Hills Hydrophysiographic Province (0.4 to 1.1%) and "Water" represented from 0.9% to 5.7% of the 2ACW riparian area.

Based on results of the remote riparian forest assessment, the Cottonwood Study Area was identified as having the greatest opportunity to implement riparian forestry BMPs such as tree and shrub planting, timber stand improvement and vegetative enhancements to improve riparian cover, health and floristic quality within the 2ACW riparian zone (establishment) in the Flint Hills Hydrophysiographic Province, followed by the Marion, Eagle Creek and Twin Lakes study areas, respectively. Twin Lakes Study Area had the highest opportunity for management of riparian areas followed by the Eagle Creek, Marion Lake and Cottonwood study areas.

Table 23. *Riparian BMP classes from riparian assessment of the Flint Hills Hydrophysiographic Province.*

Twin Lakes Study Area		
Riparian Class	**Total Acres**	**%**
Conservation	0.2	0.0
Developed	15.2	0.7
Establishment	564.0	26.4
Management	1533.7	71.9
Water	19.5	0.9
Total	2132.6	100.0
Marion Lake Study Area		
Riparian Class	**Total Acres**	**%**
Conservation	270.9	12.8
Developed	23.1	1.1
Establishment	939.4	44.3
Management	765.4	36.1
Water	121.1	5.7
Total	2119.9	100.0
Cottonwood Study Area		
Riparian Class	**Total Acres**	**%**
Conservation	76.8	0.4
Developed	123.7	0.6
Establishment	13019.7	61.1
Management	6922.7	32.5
Water	1175.9	5.5
Total	21318.7	100.0
Eagle Creek Study Area		
Riparian Class	**Total Acres**	**%**
Conservation	61.6	2.0
Developed	12.8	0.4
Establishment	1248.9	40.5
Management	1635.8	53.1
Water	123.0	4.0
Total	3082.1	100.0

Opportunities for riparian conservation programs (conservation) ranged from 0.0% (Twin Lakes Study Area) to 12.8% (Marion Lake Study Area) of the 2ACW riparian zone, without consideration for potential historical riparian remnants forest.

However, analysis of potential historical riparian remnants, which will require further in-field evaluation to assess their floristic quality for addition of these parcels as potential "Riparian Areas in Need of Conservation", indicated that Marion Lake Study Area had the lowest percentage of potential remnants (2.2%) and the Cottonwood and Eagle Creek study areas had the highest percentage of potential remnants

(19.0% or greater). Together, the "Riparian Areas in Need of Conservation" and potential remnant riparian forest should be considered simultaneously and further evaluated with regard to their floristic quality and those riparian areas of the highest quality should be conserved and preserved through voluntary and easement practices, with opportunities to manage and/or enhance lower quality riparian areas.

A potential for overlap between conservation and potential historical remnant acres exists, so the values and percentages are not additive for the study areas. However, the combined potential conservation and preservation opportunities for the Flint Hills Hydrophysiographic Province are presented in Table 24.

Table 24. *Conservation and preservation BMP opportunities within the Flint Hills Hydrophyisographic Province. Note: there is a potential overlap between conservation and potential historical remnant acres so not additive values.*

Twin Lakes Study Area		
Conservation & Preservation Opportunities	**Acres**	**%**
Conservation	0.2	0.0
Potential Remnant	405.5	19.0
Marion Lake Study Area		
Conservation & Preservation Opportunities	**Acres**	**%**
Conservation	270.9	12.8
Potential Remnant	46.6	2.2
Cottonwood Study Area		
Conservation & Preservation Opportunities	**Acres**	**%**
Conservation	76.8	0.4
Potential Remnant	2549.2	12.0
Eagle Creek Study Area		
Conservation & Preservation Opportunities	**Acres**	**%**
Conservation	61.6	2.0
Potential Remnant	598.2	19.4

North-Central Hydrophysiographic Province

The Milford Lake Study Area was the only study area located in the North-Central Hydrophysiographic Province. The HUC-12 watersheds assessed remotely in the study areas indicated significant opportunities for implementation of riparian forest establishment BMPs (47.5% of 2ACW riparian zone) and riparian forest management BMPs (38.4% of the 2ACW riparian zone) (Table 25). The opportunity for riparian conservation programs was identified as negligible since only 0.5% of the 2ACW riparian zone was identified as "Forest in need of conservation," without consideration for potential historical riparian remnant forest. "Water" comprised approximately 11.8% of the study areas. "Developed" areas in the riparian zone were only 1.7% of the 2ACW riparian buffer.

However, analysis of potential historical riparian remnants, which will require further in-field evaluation to assess their floristic quality for addition of these parcels as potential "Riparian Areas in Need of Conservation," increased the potential riparian area to which riparian conservation and preservation practices may be applied. Potential historical riparian remnants in the Milford Lake Study Area totaled 3.7% (734.8 acres) of the 2ACW riparian area. Together, the "Riparian Areas in Need of Conservation" and potential remnant riparian forest should be considered simultaneously and further evaluated with regard to their floristic quality and those riparian areas of the highest quality should be conserved and preserved through voluntary and easement practices, with opportunities to manage and/or enhance lower quality riparian areas.

A potential for overlap between conservation and potential historical remnant acres exists, so the values and percentages are not additive for the study areas. However, the combined potential conservation and preservation opportunities for the Milford Lake Study Area and North-Central Hydrophysiographic Province are presented in Table 26.

Table 25. *Riparian BMP classes from riparian assessment of the North-Central Hydrophysiographic Province.*

Milford Lake Study Area		
Stream Riparian Class	**Total Acres**	**%**
Conservation	106.6	0.5
Developed	339.6	1.7
Establishment	9361.5	47.5
Management	7572.9	38.4
Water	2328.8	11.8
Total	19709.3	100.0

Table 26. *Conservation and preservation BMP opportunities within the North-Central Hydrophyisographic Province. * Note: there is a potential overlap between conservation and potential historical remnant acres so not necessarily additive values.*

Milford Lake Study Area		
Conservation & Preservation Opportunities	**Acres**	**%**
Conservation	106.6	0.5
Potential Remnant*	734.8	3.7

Eastern Kansas Hydrophysiographic Province

Within the Eastern Kansas Hydrophysiographic Province, *"Forests in need of conservation"* areas comprised 0.0% (Hillsdale Lake Study Area) to 7.0% (Upper Wakarusa Study Area) of the 2ACW riparian zone (Table 27). *"Forests in need of management"* areas ranged from 41.9% (Middle Neosho Study Area) to 69.2% (Hillsdale Lake Study Area) of the 2ACW riparian zone. *"Forests in need of establishment"* areas represented from 25.5% (Hillsdale Lake Study Area) to 46.4% (Middle Neosho Study Area) of the 2ACW riparian zone. *"Developed"* areas were only small components of the 2ACW riparian zone in all of the study areas in the Eastern Kansas Hydrophysiographic Province (0.4 to 1.2%) and "Water" represented from 1.9% to 7.6% of the 2ACW riparian area.

Based on results of the remote riparian forest assessment, the Middle Neosho Study Area was identified as having the greatest opportunity to implement riparian forestry BMPs such as tree and shrub planting, timber stand improvement and vegetative enhancements to improve riparian cover, health and floristic quality within the 2ACW riparian zone (establishment) in the Eastern Kansas Hydrophysiographic Province, followed by the Pomona Lake, Upper Wakarusa and Hillsdale Lake study areas, respectively. Hillsdale Lake Study Area had the highest opportunity for management of riparian areas followed by the Upper Wakarusa, Pomona Lake and Middle Neosho study areas

Opportunities for riparian conservation programs (conservation) ranged from 0.0% (Hillsdale Lake Study Area) to 7.0% (Upper Wakarusa Study Area) of the 2ACW riparian zone, without consideration for potential historical riparian remnants forest.

However, analysis of potential historical riparian remnants, which will require further in-field evaluation to assess their floristic quality for addition of these parcels as potential "Riparian Areas in Need of Conservation", indicated that Pomona Lake Study Area had the lowest percentage of potential remnants (13.6%) and the Hillsdale Study Area had the highest percentage of potential remnants (37.8%) in the 2ACW riparian area. Together, the "Riparian Areas in Need of Conservation" and potential remnant riparian forest should be considered simultaneously and further evaluated with regard to their floristic quality and those riparian areas of the highest quality should be conserved and preserved through voluntary and easement practices, with opportunities to manage and/or enhance lower quality riparian areas.

A potential for overlap between conservation and potential historical remnant acres exists, so the values and percentages are not additive for the study areas. However, the combined potential conservation and preservation opportunities for the Eastern Hydrophysiographic Province are presented in Table 28.

Table 27. *Riparian BMP classes from riparian assessment of the Eastern Hydrophysiographic Province.*

Upper Wakarusa Study Area		
Stream Riparian Class	**Total Acres**	**%**
Conservation	394.8	7.0
Developed	21.8	0.4
Establishment	1574.1	27.8
Management	3406.9	60.2
Water	260.2	4.6
Total	5657.7	100.0
Pomona Lake Study Area		
Stream Riparian Class	**Total Acres**	**%**
Conservation	188.7	3.9
Developed	24.9	0.5
Establishment	2021.0	41.4
Management	2554.6	52.3
Water	91.3	1.9
Total	4880.5	100.0
Hillsdale Lake Study Area		
Riparian Class	**Total Acres**	**%**
Conservation	0.0	0.0
Developed	14.2	1.2
Establishment	295.5	25.5
Management	801.4	69.2
Water	47.1	4.1
Total	1158.2	100.0
Middle Neosho Study Area		
Riparian Class	**Total Acres**	**%**
Conservation	1164.7	3.6
Developed	156.7	0.5
Establishment	15218.6	46.4
Management	13746.1	41.9
Water	2488.2	7.6
Total	32774.3	100.0

Table 28. *Conservation and preservation BMP opportunities within the Eastern Hydrophyisographic Province. * Note: there is a potential overlap between conservation and potential historical remnant acres so not necessarily additive values.*

Upper Wakarusa Study Area		
Conservation & Preservation Opportunities	**Acres**	**%**
Conservation	394.8	7.0
Potential Remnant	1125.1	19.9
Pomona Lake Study Area		
Conservation & Preservation Opportunities	**Acres**	**%**
Conservation	188.7	3.9
Potential Remnant	662.5	13.6
Hillsdale Lake Study Area		
Conservation & Preservation Opportunities	**Acres**	**%**
Conservation	0.0	0.0
Potential Remnant	437.8	37.8
Middle Neosho Study Area		
Conservation & Preservation Opportunities	**Acres**	**%**
Conservation	1164.7	3.6
Potential Remnant*	8567.9	26.1

South-Central Hydrophysiographic Province

Within the South-Central Hydrophysiographic Province, the only HUC-12 watersheds assessed were in the Cheney Lake Study Area. Results of the remote riparian assessment indicated that the Cheney Lake Study Area had substantial opportunity to implement riparian forest establishment BMPs (63.0%; although native riparian forest was likely a smaller component of the 2ACW riparian zone compared to the remotely assessed study areas within other hydrophysiographic provinces) (Table 29). Riparian forest management BMPs could be implemented for a moderate portion of the 2ACW riparian zone (30.6%) within the study area. Opportunities to implement riparian conservation measures were only 3.9%, as no potential historical riparian remnants were identified in the 2ACW riparian zone of the Cheney Lake Study Area. *"Developed"* areas were only 0.6% of the 2ACW riparian zone, and *"Water"* comprised 2.0% of the 2ACW riparian zone.

Table 29. *Riparian BMP classes from riparian assessment of the South-Central Hydrophysiographic Province.*

Cheney Lake Study Area		
Stream Riparian Class	**Total Acres**	**%**
Conservation	247.4	3.9
Developed	36.1	0.6
Establishment	4008.2	63.0
Management	1945.6	30.6
Water	125.2	2.0
Total	6362.5	100.0

Lakes

Four lakes were part of the RCPP study area HUC-12 watersheds (Table 30). Lake riparian buffer zones were considered separately from the stream and river riparian zones. The land use comprising the riparian buffer zone around Clinton Lake (Upper Wakarusa Study Area, Eastern Kansas Hydrophysiographic Province), Pomona Lake (Pomona Lake Study Area, Eastern Kansas Hydrophysiographic Province), Milford Lake (Milford Lake Study Area, North-Central Hydrophysiographic Province) and Cheney Lake (Cheney Lake Study Area, South-Central Hydrophysiographic Province) was delineated and assessed with a focus on riparian forest extent. The riparian buffer zone around Clinton, Pomona and Cheney lakes was 600 feet and around Milford Lake was 873 feet; 600 feet was considered the minimum riparian buffer distance around federal reservoirs, and only when the upstream riparian zone exceeded 600 feet was a higher buffer value used as was the case on the Republican River above Milford Lake.

Remote riparian assessment of the riparian buffer zone around the lakes where they were encountered as part of the HUC-12 watershed study areas (in four of the study area basins) indicated that Milford Lake had the highest percentage of opportunities for riparian forestry establishment practices (56.8%) followed by Cheney Lake (51.3%), Pomona Lake (29.7%) and Clinton Lake (22.3%). Riparian forest establishment BMPs around lakes could help to reduce shoreline erosion from wave action especially during elevated lake water levels, reduce non-point source inputs of sediment, nutrients and pesticides to the lakes from adjacent cropland (e.g., conversion of cropland leased to farmers by KDWPT and COE to riparian forest, wetlands and grasslands), and increase wildlife habitat for hunting, birding, recreation and tourism. Riparian forest management opportunities were highest at Clinton Lake (62.0%) followed by Pomona Lake (51.5%), Milford Lake (28.4%) and Cheney Lake (26.0%). Riparian forest conservation opportunities, without regard for potential historical riparian forest remnants were relatively negligible for all of the lakes ranging from 0.0 to 1.2%.

Analysis of potential historical riparian remnants, which will also require further in-field evaluation to assess their floristic quality for addition of these parcels as potential "Riparian Areas in Need of Conservation," indicated that Cheney Lake Study Area had no potential remnants (0.0%) and that the percentages of potential remnants around Milford Lake (1.8%) and Pomona Lake (2.6%) were low while Clinton Lake had 13.6% potential historical riparian remnant forest comprising its lake buffer (Table 31). Together, the "Riparian Areas in Need of Conservation" and potential remnant riparian forest should be considered simultaneously and further evaluated with regard to their floristic quality and those riparian areas of the highest quality should be conserved and preserved through voluntary and easement practices, with opportunities to manage and/or enhance lower quality riparian areas.

Table 30. *Riparian BMP classes from riparian assessment of the study area lakes.*

Milford Lake		
Lake Riparian Class	**Total Acres**	**%**
Conservation	0.0	0.0
Developed	335.5	4.2
Establishment	4585.2	56.8
Management	2296.7	28.4
Water	857.2	10.6
Total	8074.6	100.0
Clinton Lake		
Lake Riparian Class	**Total Acres**	**%**
Conservation	35.9	1.2
Developed	16.3	0.5
Establishment	666.2	22.3
Management	1855.3	62.0
Water	417.0	13.9
Total	2990.7	100.0
Pomona Lake		
Lake Riparian Class	**Total Acres**	**%**
Conservation	0.6	0.1
Developed	1.5	0.3
Establishment	174.6	29.7
Management	302.7	51.5
Water	108.2	18.4
Total	587.6	100.0
Cheney Lake		
Lake Riparian Class	**Total Acres**	**%**
Conservation	2.0	0.1
Developed	35.7	1.5
Establishment	1259.4	51.3
Management	638.7	26.0
Water	518.8	21.1
Total	2454.6	100.0

A potential for overlap between conservation and potential historical remnant acres exists for the four lakes, so the values and percentages are not additive. However, the combined potential conservation and preservation opportunities for the riparian areas around the lakes are presented in Table 31.

Table 31. *Conservation and preservation BMP opportunities for riparian buffers of the study area lakes. * Note: there is a potential overlap between conservation and potential historical remnant acres so not necessarily additive values.*

Milford Lake		
Conservation & Preservation Opportunities	**Total Acres**	**%**
Conservation	0.0	0.0
Potential Remnant*	142.3	1.8

Clinton Lake		
Conservation & Preservation Opportunities	**Total Acres**	**%**
Conservation	35.9	1.2
Potential Remnant*	405.9	13.6

Pomona Lake		
Conservation & Preservation Opportunities	**Total Acres**	**%**
Conservation	0.6	0.1
Potential Remnant*	15.4	2.6

Cheney Lake		
Conservation & Preservation Opportunities	**Total Acres**	**%**
Conservation	2.0	0.1
Potential Remnant*	0.0	0.0

Summary of Riparian Forest Condition Class and BMP Opportunities by Study Area

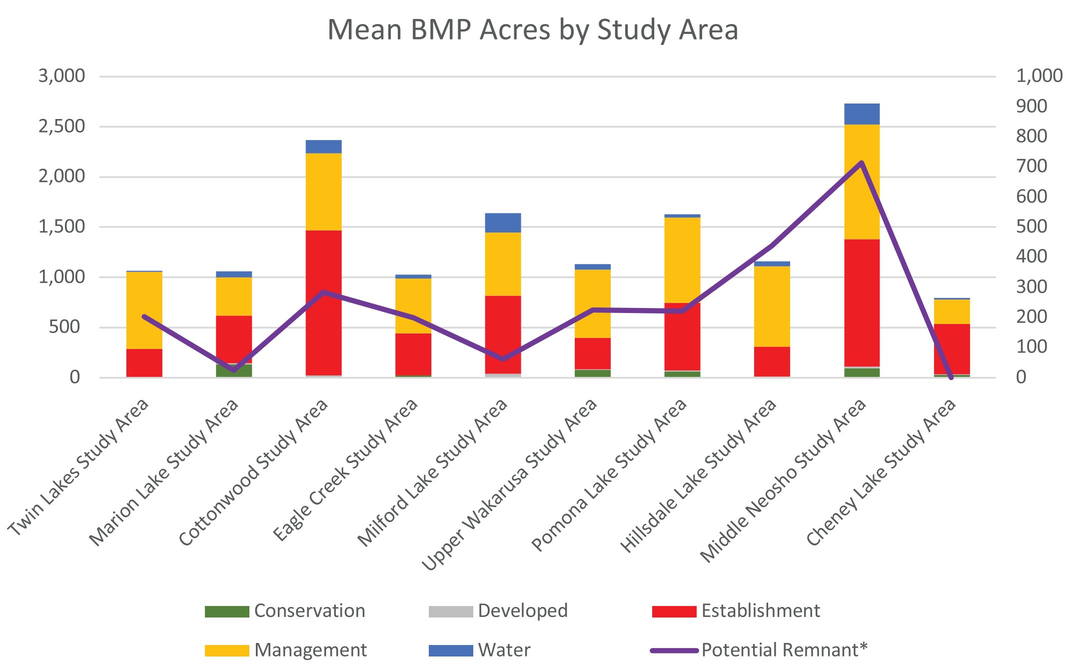
The mean acres for riparian forest condition class and BMP opportunities across HUC-12 watersheds by study area are presented in Figure 5. The most mean riparian forest BMP opportunities were in the Middle Neosho and Cottonwood Study Areas followed by Pomona Lake and Milford Lake Study Areas. This summary figure can be used to visualize where the most mean BMP opportunities by riparian forest condition class exist for targeting of BMPs. This figure can be used in combination with Tables 23-31, maps in Appendix A, and tables in Appendix C for more detailed targeting of BMPs by riparian forest condition class, study areas, hydrophysiographic province and HUC-12s depending on conservation priorities of interest by users.

The greatest number of mean potential historical riparian remnant acres were located in Middle Neosho and Cottonwood Study Areas followed by the Hillsdale Lake, Upper Wakarusa and Pomona Lake Study Areas. These results can be used to prioritize efforts to further evaluate potential historical riparian forest remnants to populate riparian forest planting guides of the PNC and its capability given limiting factors by hydrophysiographic province (Table 15; Figure 4) as well as prioritize efforts for preservation of historical riparian reference conditions of floristic quality and PFC through easements and voluntary efforts.

The total acres for riparian forest condition class and riparian forest BMP opportunities by study area are presented in Figure 6. The most total BMP opportunities were in the Middle Neosho, Cottonwood and Milford Lake Study Areas, which also comprised the greatest basin area. This summary figure can be used to visualize where the most total BMP opportunities by riparian forest condition class exist for targeting of BMPs. This figure can be used in combination with Tables 23-31, maps in Appendix A, and tables in Appendix C for more detailed targeting of BMPs by riparian forest condition class, study areas, hydrophysiographic province and HUC-12s depending on conservation priorities of interest by users.

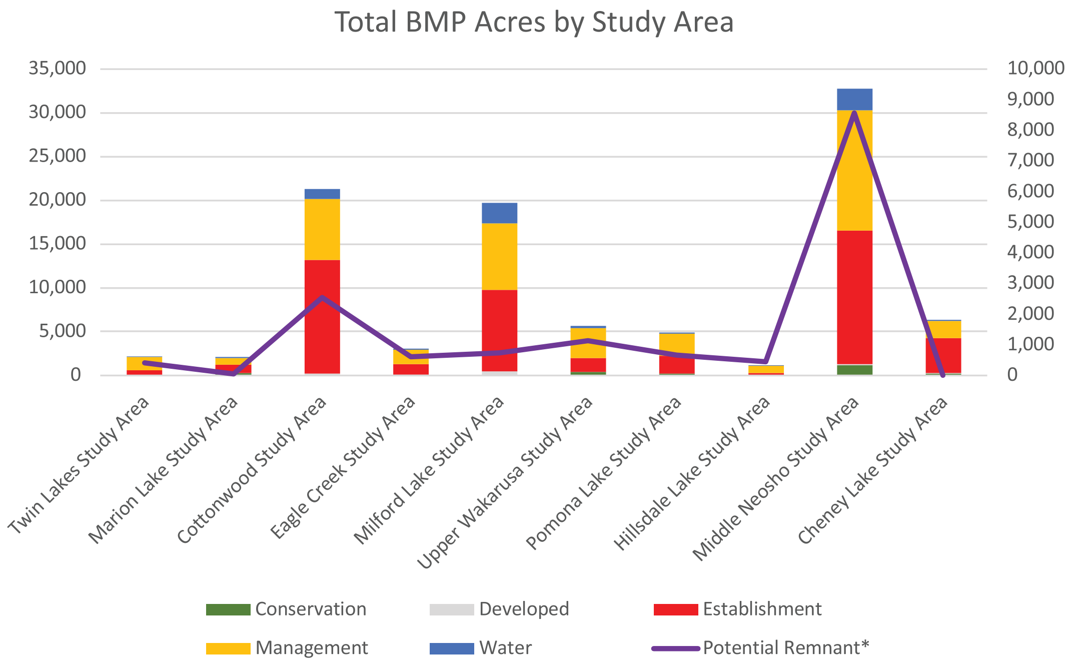
The greatest number of total potential historical riparian remnant acres were located in Middle Neosho and Cottonwood Study Areas followed by the Upper Wakarusa Study Area. These results can be used to prioritize efforts to further evaluate potential historical riparian forest remnants to populate riparian forest

Figure 5. *The mean acres for riparian forest condition class and Best Management Practice (BMP) opportunities by study area. * Note: potential remnant forest overlaps with conservation and management BMPs. The axis on the left is for the bar graphs of BMP opportunities and the right is for the potential historical remnant line graph.*



planting guides of the PNC and its capability given limiting factors by hydrophysiographic province (Table 15; Figure 4) as well as prioritize efforts for preservation of historical riparian reference conditions of floristic quality and PFC through easements and voluntary efforts. Areas with the greatest total potential riparian remnant acres likely represent the greatest opportunities to identify actual historical riparian forest remnants, which can serve as a blueprint for further development of riparian planting guides by hydrophysiographic province.

Figure 6. *The total acres for riparian forest condition class and Best Management Practice (BMP) opportunities by study area. *Note: potential remnant forest overlaps with conservation and management BMPs. The axis on the left is for the bar graphs of BMP opportunities and the right is for the potential historical remnant line graph.*



Recommendations

- Based on BLM (2003) guidance (referring to PNC relative to potential vs. capability of the riparian vegetation and the PFC of the stream and riparian zone), and SVAP2 criteria for evaluating riparian quantity, riparian quality and bank condition (NRCS, 2009), the following actions are recommended:
    - On-site visits to assess potential historical riparian forest remnants by hydrophysiographic province, riparian zones and stream order to identify "reference conditions" and evaluate floristic quality and species composition of riparian zones;
    - Further development of a riparian species list by hydrophysiographic province, riparian zone, stream order and hydrophysiographic province to guide riparian restorations in a graded approach from natural riparian plant communities to managed riparian plant communities to agricultural applications (e.g., native grass rangeland, pastures and cropland).
- Based on evaluation of CTSG soil groups presented in this report, the following actions are recommended:
    - Evaluation of KFS-refined CTSG soil groups to assess accuracy of soil map unit assignments of CTSG soil groups based on identified errors from other regions related to flood frequency, flood duration, floodplain connectivity and riparian soil drainage classes;
    - In lieu of accuracy assessment outlined above, on-site visits that may include evaluation of flood frequency, flood duration, floodplain connectivity and riparian soil drainage classes to support riparian tree and shrub plantings in a zoned approach from PNC (first zone: native riparian vegetation) to capability classes (second zone: managed forest; third zone: integration with land owner interests [e.g., agriculture, agroforestry, developed]) and that preserve or create PFC and stabilize stream reaches be integrated with RCPP approach.
- Based on evaluation of results related to classification of riparian zone into actionable categories, the following actions are recommended;
    - "Riparian areas in need of establishment" should be addressed through riparian restoration practices that include a zoned approach grading from PNC to capability classes based on land owner interests, and include riparian tree, shrub and herbaceous understory plantings and seeding suited to the zoned approach;
    - "Riparian areas in need of management" should be addressed through riparian management practices that include a zoned approach grading from PNC to capability classes based on land owner interests, and include timber stand improvement as well as riparian tree, shrub and herbaceous understory plantings and seeding suited to the zoned approach;
    - "Riparian areas in need of conservation" should be based on assessment of potential historical riparian forest remnants, and high floristic quality remnants where identified, should be prioritized for voluntary and easement conservation practices that preserve and conserve these riparian areas in partnership with land owners;
    - Riparian buffers around lakes should be integrated with lake management activities and evaluated on-site relative to CTSG soil groups and land interests to achieve adequate riparian buffers to reduce adjacent land management concerns contributing to lake sedimentation, NPS pollution and harmful algae blooms.
- Development of a riparian restoration guide that includes consideration of PNC and capability classes, CTSG soil groups, and species lists to support a zoned approach from PNC to capability class by stream order, hydrophysiographic province and riparian zone.
- Further development of methods to support and evaluate PFC for streams and riparian areas, such as identification of flood frequency, flood duration, floodplain connectivity riparian soil drainage classes, bank and channel erosion as well as examining riparian species distribution, survivability by riparian zone and development of riparian "management" techniques that support RCPP activities and KFS partner mission.

Development of Riparian Planting Guide: Native Riparian Species by Hydrophysiographic Province and Riparian Community Type

The type of vegetation found in the riparian area of a river or stream depends on numerous factors including those dealing with the waterbody itself (e.g., incision, width and size, bed type, base flow, and flood tendencies), the adjacent topography (e.g., wide flat floodplain with rolling terrain with depressions and high points, steep slopes limiting floodplain establishment), the soil type on the floodplain (e.g., sandy, rocky, clayey), soil moisture regime, and rainfall patterns. These factors plus the plant's adaptability and tolerance to flooding and soil type affect the establishment and maintenance of vegetation within and adjacent to the stream channel. Related factors include grazing pressure by ungulates like deer, elk, and buffalo and livestock where access is available and wild or managed fire regimes where topography, flooding frequency, and fuel loads allow for a burn to reach the stream and its floodplain.

Without documentation of conditions prior to European settlement, developing a list of pre-settlement plant communities complete with descriptions involves a substantial amount of conjecture so a few broad assumptions were made during the initial stages of this effort. These assumptions are:

- It is reasonable to assume that the rivers, streams, and creeks located in the eastern one-half of Kansas were less incised and more connected to their floodplains historically than those of today. Watersheds were intact prior to European settlement so most rainfall infiltrated back to the groundwater through the deep roots of the existing vegetation like the prairie grasses and forbs, and runoff not caught by the lush prairie vegetation and deep soils slowly flowed to the streams and rivers, much of it through subsurface flows. Base flow in the watercourses was also likely present given this historic hydrologic dynamic. Considering this backdrop, it is also reasonable to assume that the floodplains had a wetter hydrology than during present times due to interaction with more active groundwater tables and hyporheic exchanges within the floodplain.
- The plant communities observed today in Kansas were likely present in one form or another during pre-European settlement times. For example, the cottonwood-willow floodplain forest of today was likely found 300 years ago, but the dominants and overall composition and structure may have been quite different. Differences would be expected over time just as they are observed in different watersheds and regions in modern Kansas as well as elsewhere in the Midwest. With that said, it is likely that the floodplains in the four hydrophysiographic provinces of interest were vegetated by forests, woodlands, shrubland, herbaceous plant communities, and in-channel mud flats or sand bars.
- Given this lack of certainty of the type and composition of these likely historic plant communities, each is characterized broadly with general descriptions of vegetation, hydrology and other factors.

Several botanical references were consulted to provide a foundation for development of historic natural vegetation communities (PNC) in the 10 study area basins contained in the four hydrophysiographic provinces of interest in Kansas. The sources included publications (Küchler 1974, Lauver et al. 1999, Nelson 2005), on-line data set of NatureServe, and public land survey maps from the 1850s and 1860s [as mapped at the *Kansas Applied Remote Sensing (KARS) Program* (*http://kars.ku.edu/maps/naturalresourceplanner/*) and in this document] as well as discussions with Dr. Craig Freeman, Curator of the RL McGregor Herbarium at the University of Kansas.

Lauver et al. (1999) provided the first hierarchical classification of natural vegetation in Kansas; that classification is still pertinent today. It was created using the natural vegetation map of Küchler (1974) as well as physiographic, geologic, and pedologic information for Kansas. Categories of vegetation were based on differences in physical features — topography, soils, water chemistry, hydroperiod, and climate — that contributed to differences in species composition. Lauver et al. (1999) separated plant communities by canopy cover: forests (canopy cover of 61 to 100% and trees > 5m), woodland (canopy cover of 20 to 60% and trees > 5m tall), shrubland (i.e., shrubs and trees 0.5 to 5m tall forming >25% cover) and herbaceous vegetation (i.e., graminoids and/or forbs with >25% cover; woody cover <25%), and sand flats-bars with sparse vegetation with a total cover of <10%.

The important book by Nelson (2005)—*The Terrestrial Natural Communities of Missouri*—was reviewed for its plant community descriptions including the physical characteristics, natural processes, and vegetative composition. The information was especially useful for those physiographic regions bordering Kansas (e.g., Osage Plains) as it supplemented the general classification scheme of Lauver et al. (1999) and provided more insight into the landscape ecology, flooding regime, and plant assemblages of the floodplain communities in eastern Kansas. In addition, it provided an opportunity to use more general terms for floodplain communities instead of the specific plant communities described in Lauver et al. (1999; e.g., mesic bottomland forest instead of pecan-hackberry floodplain forest or riverfront forest instead of eastern cottonwood-black willow-silver maple floodplain forest

Of the 60 plant communities identified by Lauver et al. (1999), 24 vegetation assemblages were utilized in our treatment. All occur in floodplains receiving some flooding and include forest and woodland bottomland, wet and wet-mesic prairie, herbaceous and shrubby wetlands, and in-stream/in-river mud flats or sand bars. Lauver et al. (1999) is consistent with more recent classifications such as TNC's NatureServe at *http://explorer.natureserve.org/classeco.htm*.

With these considerations in mind, natural vegetation occurring historically in riparian areas (including within two active channel widths of the stream or river channel) was developed for each hydrophysiographic province in Kansas as described below.

Eastern Hydrophysiographic Province

As described in main portion of the report, the Eastern Hydrophysiographic Province encompasses the Osage Cuestas, Cherokee Plains and Ozark Highlands regions in Kansas (Figure 1). In general, the geology of the province is alternating sedimentary layers of limestone, shale and sandstone. Average annual precipitation ranges from 35 to 45 inches per year increasing in an easterly and southeasterly direction, with highest quantities typically experienced in the far southeast. Potential natural vegetation ranges from a mosaic of mostly tallgrass prairie in the western part of the province to a mixture of tallgrass prairie and oak-hickory forest in the east, with abundant floodplain forests along streams and rivers. Plant communities in riparian areas of perennial streams and large and small rivers vary depending on local and regional abiotic and biotic factors. Historically, larger rivers with wide, expansive floodplains may have had numerous plant assemblages including wet to wet-mesic prairies, herbaceous or emergent wetlands, scrub-shrub wetlands, open water habitat, bottomland forests, riparian woods, upland forests, and in-stream/in-river mud flats or sand bars. These plant communities are composed of numerous plant species as described below.

Wet Prairie

Wet[1] or lowland prairie is an herbaceous, wetland plant community dominated by a dense cover of grasses and graminoids with heights of four to seven feet and located on nearly level, deep, poorly drained soils on floodplains along rivers, streams, and creeks in the eastern one-third of Kansas. Soils of this plant community are often saturated from a high water table throughout much of the year or temporarily flooded with shallow surface water during the winter or spring. Depth of floodwater is typically only a few inches; temporary flooding is for brief periods during the growing season.

Dominant plant species include prairie cordgrass (*Spartina pectinata*), which may form near monocultures in some areas as well as spike-rushes [e.g., blunt spike-rush (*Eleocharis obtusa*), bald spike-rush (*E. erythropoda*), and creeping spike-rush (*E. macrostachya*)], southern blue flag (*Iris virginica*), and numerous sedges [e.g., yellow-fruited sedge (*Carex annectans*), crested sedge (*Carex cristatella*), wooly sedge (*Carex pellita*), Frank's sedge (*Carex frankii*), and fox sedge (*Carex vulpinoidea*)].

Other species characteristic of wet prairie habitat include big bluestem (*Andropogon gerardii*), Virginia wild rye (*Elymus virginicus*), switch grass (*Panicum virgatum*), rice cutgrass (*Leersia oryzoides*), green bulrush (*Scirpus atrovirens*), Torrey's rush (*Juncus torreyi*), winged loosestrife (*Lythrum alatum*), swamp milkweed (*Asclepias incarnata*), false nettle (*Boehmeria cylindrica*), panicled aster (*Symphyotrichum lanceolatum*), water parsley (*Sium suave*), saw-tooth sunflower (*Helianthus grosseserratus*),

1 *Soil moisture or drainage class used to describe relative soil moisture availability. 'Wet' means poorly drained, where water is removed so slowly that the soil is wet and often saturated at shallow depths for significant periods throughout the growing season and often remains wet for long periods (Nelson 2005). Plants are especially adapted and generally obligate to wetland conditions.*

bushy seedbox (*Ludwigia alternifolia*), common water hound (*Lycopus americanus*), American germander (*Teucrium canadense*), swamp smartweed (*Persicaria amphibia*), dotted smartweed (*Persicaria punctata*), and blue vervain (*Verbena hastata*).

Wet-Mesic Prairie

Wet prairie may grade into wet-mesic[2] prairie as the topography shifts onto slightly higher ground in floodplains of rivers, streams, and creeks of the eastern third of Kansas. Consequently, hydrology varies slightly from that of wet prairie, with winter and spring floods and a seasonal high water table receding during the summer months. Ponding is minimal and soils are somewhat poorly drained. Given these slight differences in hydrology and soils, vegetative composition between wet and wet-mesic prairies differs subtly.

Wet-mesic prairie is an herbaceous wetland plant community dominated by a dense cover of grasses and graminoids to four to six feet. It is dominated by big bluestem, prairie cord grass, switch grass, and various sedges [e.g., fox sedge, heavy sedge (*Carex gravida*), Bicknell's sedge (*Carex bicknelli*), and Frank's sedge]. Characteristic species of wet-mesic prairie habitat include saw-tooth sunflower, American germander, Allegheny monkey flower (*Mimulus ringens*), hemp dogbane (*Apocynum cannabinum*), false dragonhead (*Physostegia virginiana*), eastern gama grass (*Tripsacum dactyloides*), inland rush (*Juncus interior*), Sullivant's milkweed (*Asclepias sullivantii*), smooth beard tongue (*Penstemon digitalis*), Culver's root (*Veronicastrum virginicum*), and purple meadow rue (*Thalictrum dasycarpum*).

Emergent Wetland or Marsh

Emergent wetlands are dominated by herbaceous vegetation subject to periodic inundation from over-bank flooding or contribution from groundwater or both. Inundation ranges from seasonal (i.e., extended periods especially early in the growing season) to almost the entire year (semi-permanent flooding), with depths of six inches to up to three feet. Soils are typically deep, poorly drained clays, silty clays and in some cases peat and muck often formed in alluvium. These wetlands are found in a variety of habitats including swales, oxbows, and other depressions along rivers and streams. Composition of vegetation is highly variable in response to water depth, flood duration, and other factors. Vegetative mosaics occur with slight changes in water depths. These zones would include a dense cover of one- to three-foot tall, perennial and annual forbs in shallow water; moderate to dense cover of three to six feet tall graminoids in waters of moderate depth; or sparse to moderate cover of floating and submerged aquatic species in deep water. As water depths increase, vegetative cover becomes sparse. An occasional tree and shrub may be found at the edge of the wetland.

Dominant plant species include broad-leaf cattail (*Typha latifolia*), various bulrushes—green bulrush, river bulrush (*Bolboschoenus fluviatilis*), and soft-stem bulrush (*Schoenoplectus tabernaemontani*), giant bur-reed (*Sparganium eurycarpum*), common arrowhead (*Sagittaria latifolia*), American lotus (*Nelumbo lutea*), rice cutgrass, smartweeds—swamp smartweed and mild water-pepper smartweed (*Persicaria hydropiperoides*), water parsley, and sedges—yellow-fruited sedge, fox sedge, raven-foot sedge (*Carex crus-corvi*), hop sedge (*C. lupulina*), and shoreline sedge (*C. hyalinolepis*).

Other species characteristic of emergent wetlands include swamp milkweed, nodding and bearded beggar-ticks (*Bidens cernua* and *B. frondosa*), common water hound, pondweed (*Potamogeton spp.),* hard-stem and chair-maker's bulrushes (*Schoenoplectus acutus* and *S. pungens*), southern blue flag, floating primrose (*Ludwigia peploides*), blunt, bald, and creeping spike-rushes, lizard's tail (*Saururus cernuus*), Torrey's rush, and spatterdock (*Nuchal lutea*), and duckweed (*Lemna minor*). Trees and shrubs at the edge of the marsh include eastern cottonwood (*Populus deltoides*), sandbar and black willows (*Salix exigua* and *S. nigra*), and buttonbush (*Cephalanthus occidentalis*).

Community Variation and Subtypes

1. The bulrush-cattail marsh subtype is a seasonally flooded wetland on very poorly drained peat, muck, and clay soils found on swales and depressions associated with river systems in the Cherokee Lowlands, Osage Cuestas, and Flint Hills. Surface water depths range from one to three feet. Dominants include soft-stem bulrush, broad-leaf cattail, giant bur-reed, swamp smartweed, and fox, Frank's, and shoreline sedges.
2. The cattail-bulrush marsh subtype is a semi-permanently flooded wetland on poorly drained clays and silt clays found in oxbows and low areas along streams and creeks in the eastern half of Kansas. Surface water depths are up to three feet. Dominants include broad-leaf cattail and green

2 Soil moisture or drainage class meaning somewhat poorly drained where water is removed slowly so that the soil is seasonally or intermittently wet at a shallow depth for significant periods of time but lowers during the summer months (Nelson 2005). Obligate wetland species are prevalent.

bulrush along with characteristic species such as shoreline sedge, several spike-rushes, duckweed, and common arrowhead.

3. The bulrush-spike-rush marsh subtype is a semi-permanently flooded wetland on poorly drained clays and silt clays found in basins, oxbows and low lands along streams and creeks statewide. Surface water ranges from one to three feet in depth. Dominants include chair-maker's bulrush and blunt, bald, or creeping spike-rushes along with other characteristic species such as duckweed, common arrowhead, broad-leaf cattail, and saltmarsh bulrush.
4. The pondweed aquatic wetland subtype is semi-permanently flooded wetland on poorly drained clays and silt clays found in oxbows and low areas along rivers, streams and creeks in the eastern third of Kansas. Surface water depths are up to three feet. Dominants include pondweed, duckweed, spatterdock, and American lotus. Broad-leaf cattails, common arrowhead, and various bulrushes, and spike-rushes are also found in the wetland.

Open Water Aquatic Habitat

Open water aquatic habitat is semi-permanently flooded wetland on poorly drained clays and silt clays found in oxbows and low areas along rivers, streams and creeks in the eastern third of Kansas. Surface water depths are up to three feet. Dominants include pondweed, duckweed, spatterdock, and American lotus. Broad-leaf cattail, common arrowhead, river, soft-stem, and hard-stem bulrushes, and various spike-rushes are also found in the wetland.

Scrub-shrub Wetland

Scrub-shrub or shrubby wetlands are dominated by scattered patches of short woody vegetation with limited ground cover. Inundation from over-bank flooding or contribution from groundwater or both is almost continuous throughout the year except during droughts. Soils are deep, very poorly drained peat or muck, formed in alluvium. These wetlands are found in inundated depressions, oxbow ponds, and sloughs of stream and river floodplains in the Cherokee Lowlands and Osage Cuestas. Buttonbush is the dominant species in the shrub layer comprising up to 90% of the cover in water three to six feet in deep. Dominant species in the ground cover include Frank's and fox sedges, and swamp and dotted smartweeds.

Characteristic plant species, albeit with limited cover, would include common arrowhead, nodding beggar-ticks, duckweed, rice cutgrass, green, hard-stem, and soft-stem bulrushes, and blunt and creeping spike-rushes. Trees tolerant of inundation, such as black willow and peach-leaf willow (*Salix amygdaloides*), sometimes occur along the edge of the shrubland.

Bottomland or Floodplain Forests

Forests are often defined as covering more than 10 acres and being dominated by large trees that form a canopy greater than 60% cover, with multiple layers of shade tolerant trees, shrubs, vines, grasses, and forbs in the understory. Flooding and soil saturation are the key influences in the development of bottomland forests. The intensity, regularity, extent, and depth of inundation affect the species composition. Intense flooding typically occurs at the outer bends of a river or stream. This kind of flooding causes the deposition of coarser sediments, which scour the land. Riverfront forests develop under this flood regime. Less dramatic flooding occurs outside of the active stream channel often in extensive down-stream areas of the floodplain (e.g., backwater or slack-water) where mesic[3], wet-mesic, and wet bottomland forests develop.

Riverfront Forests

Given the dynamics of flooding and resultant scouring and deposition of sediments, this forest community may be early successional in nature developing on bare, moist soil on recently formed sandbars, front-land ridges, and well-drained flats (Nelson 2005). More established forests can be found on well-drained ridges of "first" bottom. There, soils are formed in alluvium, are deep, medium-textured, and with adequate or excessive moisture available for vegetation during the growing season.

Successional communities are dominated by black willow in the understory along with sandbar willow (*Salix exigua*), teal lovegrass (*Eragrostis hypnoides*), bearded sprangletop (*Leptochloa fascicularis*), golden dock (*Rumex fueginus*), bushy cinquefoil (*Potentilla paradoxa*), and bearded (*Bidens polylepis*) and nodding beggar-ticks.

As the floodplain becomes more stable, the tree canopy can reach 100 feet and is dominated by black willow, eastern cottonwood, and silver maple (*Acer saccharinum*), with green ash (*Fraxinus pennsylvanica*), box-elder (*Acer negundo*), sycamore (*Platanus occidentalis*), and American elm (*Ulmus americana*) as common constituents. The shrub layer may be absent

3 *Soil moisture or drainage class meaning moderately well-drained; water is removed from the soil somewhat slowly so that the profile is wet for a small but significant part of time (Nelson 2005).*

or contain seedlings and sampling of canopy trees as well as pale and rough-leaf dogwoods (*Cornus amomum* and *C. drummondii*). Vines may include poison ivy, trumpet creeper (*Campsis radicans*), Virginia creeper (*Parthenocissus quinquefolia*), raccoon grape, and winter, gray-bark, and river-bank grapes (*Vitis vulpina*, *V. cinerea*, and *V. riparia*). The ground cover may be thick, but often is patchy and sparse due to frequent inundation. Species found there include silky and Virginia wild-ryes (*Elymus villosus* and *E. virginicus*), various sedges, rice cutgrass, various beggar-ticks, and panicled aster (*Symphyotrichum lanceolatum*), wood nettle (*Laportea canadensis*), mist-flower (*Eupatorium coelestinum*), goldenglow (*Rudbeckia laciniata*), tall bellflower (*Campanula americana*), and late goldenrod (*Solidago gigantea*). Stands of scouring rush (*Equisetum hyemale*) and smooth horsetail (*Equisetum laevigatum*) also occur in riverfront forest. In sites that have experienced recent disturbance, giant ragweed (*Ambrosia trifida*) can be quite abundant. The riverfront forest occurs statewide in Kansas.

Bottomland Forests

As one moves away from the active channels of the streams and rivers towards areas that flood with slackwater and backwater or upslope in the floodplain, the forest composition changes. Three types of flood-plain forests occur in these topographic settings: mesic, wet-mesic, and wet bottomland.

Mesic bottomland forests tend to occupy level to gently sloping terrain on terraces of rivers and streams. Soils are moderately well to well-drained and are rarely flooded (up to 2 weeks at the most). Flood water is shallow (less than two feet), occurring during the fall, winter, or early spring. During the growing season, surface water or saturated soils are present for brief periods. The water table is well below the ground surface for most of the season.

Dominant plants include green ash, American elm, hackberry, bur oak, and bitternut hickory in the tree canopy. The pecan (*Carya illinoinensis*) could be prevalent in lower lying, less poorly drained soils. Other tree species may include black walnut (*Juglans nigra*), basswood (*Tilia americana*), silver maple, sycamore, chinquapin oak (*Quercus muehlenbergii*), and eastern cottonwood. Subcanopy species include paw paw (*Asimina triloba*) and slippery elm (*Ulmus rubra*). Shrubs and vines found in this bottomland habitat include poison ivy, Virginia creeper, buck brush (*Symphoricarpos orbiculatus*), river-bank grape, bristly green brier (*Smilax hispida*), rough-leaved dogwood, wirestem muhly (*Muhlenbergia frondosa*), Missouri gooseberry (*Ribes missouriense*), and western buckeye (*Aesculus glabra*). The ground cover includes Virginia wild-rye, woodland sea oats (*Chasmanthium latifolium*), nodding fescue (*Festuca subverticillata*), and spring avens (*Geum canadense*), and wood nettle (*Laportea canadensis*).

Community Variation and Subtypes

- The ash-elm-hackberry type is a temporarily flooded forest found on nearly level bottoms and terraces along major streams and rivers in the eastern half of Kansas. Soils are poorly drained to well-drained, formed in silty and clayey recent alluvium.
- The pecan-hackberry type is a temporarily flooded forest found on nearly level floodplains along major streams and rivers in the Osage Cuestas and Cherokee Lowlands. Soils are deep, well-drained formed in silty and clayey recent alluvium.
- The mixed oak type is dominated by bur oak, Shumard's oak (*Quercus shumardii*), bitternut hickory, and woodland sea oats and is a temporarily flooded forest found on nearly level to undulating floodplains in the Osage Cuestas. Soils are deep, medium textured, formed in alluvium.

Wet-mesic Bottomland Forests tend to occur on lower perennial streams and rivers and swales adjacent to or succeeding from old oxbows, backswamps, low ridges, and flats on both lower and elevated river bottoms. Soils are moderately well to somewhat poorly drained. It is seasonally flooded and/or saturated in the fall, winter, or spring with a high water table. Flooding is shallow (less than three feet) and can last for over one month during the fall, winter, or early spring. During the growing season, surface water or saturated soils are present for brief periods. The water table is well below the ground surface for most of the season.

Canopy trees may include pecan, green ash, bur oak, pin oak (*Quercus palustris*), and eastern cottonwood. The shrub layer may contain seedlings and saplings of canopy trees, as well as pale and rough-leaf dogwoods. Vines may include poison ivy, trumpet creeper, Virginia creeper, raccoon grape, and winter, gray-bark, and river-bank grapes. Species found in the ground layer include Virginia wild-rye, hop (*Carex lupulina*) and Frank's sedge, fowl manna grass (*Glyceria striata*), rice cutgrass, marsh muhly (*Muhlenbergia racemosa*), panicled aster, spotted and pale touch-me-nots (*Impatiens capensis* and *I. pallida*), false nettle (*Boehmeria cylindrica*), clear weed (*Pilea pumila*), goldenglow, and late goldenrod.

Community Variation and Subtypes

- The pecan-hackberry type is a temporarily flooded forest found on nearly level floodplains along major streams and rivers in the Cherokee Lowlands and

Osage Cuestas. Soils are deep, poorly drained, and formed in silty and clayey recent alluvium.
- The cottonwood-sycamore type is a temporarily flooded forest found on nearly level to undulating soils on floodplains along major rivers and streams in the Flint Hills, Cherokee Lowlands, and Osage Cuestas. Soils are poorly drained, and formed in silty and clayey recent alluvium. Dominant trees include eastern cottonwood and sycamore. Other common trees include box elder, pecan, hackberry, and black willow.

Wet Bottomland Forests are associated with larger streams and rivers, especially forming around old oxbows, swales, and backswamps. Soils are poorly drained clayey alluvium, saturated and wet for significant periods especially during the fall, winter, and spring. Ponding is evident and often persistent. Seasonal flooding often occurs every year. Dominant trees include green ash, silver maple, eastern cottonwood, and black willow; poison ivy as a common vine, and clearweed, spotted touch-me-not, and Gray's sedge (*Carex grayii*) occur in the ground layer. Other trees found in wet bottomland forests may include pin oak, sycamore, and American elm. Common water horehound, pale (*Rumex altissimus*) and swamp (*R. verticillatus*) dock, false nettle, dotted smartweed, and rice cutgrass are also found in the ground layer. This bottomland forest type occurs statewide. A more detailed description of this bottomland forest can be found under riverfront floodplain above.

Bottomland or Floodplain Woodland

Woodlands are highly variable plant communities with a relatively open canopy (cover ranging from 25 to 60%) and a sparse to moderately open midstory (10 to 50% cover). The openness of the woods allows sunlight to reach the ground promoting a dense and diverse cover of forbs, grasses, and sedges in the ground layer. A combination of flooding, soil saturation, and fire influenced the development of bottomland woodland over time. Mesic and wet-mesic bottomland woodlands occur in eastern Kansas as described below.

Mesic Bottomland Woodland consists primarily of a tall canopy reaching 70 feet and a well-developed ground cover of sedges, grasses, and herbs (Nelson 2005). Fire limits the establishment of an understory. This woodland is found on terraces along larger streams and river floodplains. Soils are deep and often well-drained. Flooding is shallow and temporary, lasting several weeks during the fall, winter or early spring. The dominant tree is bur oak with co-dominants or associates including pecan, shellbark hickory (*Carya lacinosa*), and white (*Quercus alba*), chinquapin (*Q. muehlenbergia*), and red (*Quercus borealis*) oaks. Poison ivy is found in the shrub layer, while prevalent herbs in the ground layer include switch grass, big bluestem, little bluestem (*Schizachyrium scoparium*), Indian grass (*Sorghastrum* nutans), Virginia wild rye, bur-reed sedge (*Carex sparganoides*) and radiate sedge (*Carex radiata)*, woodland sea oats, and black snakeroot (*Sanicula odorata*). Patches of black willow and/or prairie cordgrass populate low-lying areas.

Community Variation and Subtypes

- This mixed oak floodplain subtype is temporarily flooded woodland found on nearly level to gently sloping soils on floodplains along major rivers and streams in the Osage Cuestas. Soils are deep, somewhat poorly drained, and formed in silty and clayey recent alluvium. It is dominated by bur oak with a big bluestem and switchgrass ground layer. Other species may include pecan, green ash, black willow, and prairie cordgrass.
- The bur oak subtype is temporarily flooded woodland found in the northern half of the Osage Cuestas on floodplains of rivers and streams with gentle to steeps. The soils are silts or loams formed from loess or glacial till. Dominants are bur oak, big bluestem, and porcupine grass. Other associated species include green ash, switch grass, red oak, little bluestem, and Indian grass.

Wet-mesic Bottomland Woodland has an open overstory of medium to tall trees typically dominated by eastern cottonwood and black willow; pecan, green ash, pin oak, and American elm may be co-dominants. Other trees may include box elder and bur oak. The ground layer is species-rich and composed of grasses, sedges, and forbs including big bluestem, prairie cordgrass, and switch grass. Other species in the herbaceous layer are the same as those in wet-mesic and wet prairies. This woodland is found in floodplains near the lower Missouri River and its tributaries in the eastern third of Kansas. Soils are deep, somewhat poorly drained, sandy loam to sand, and formed from alluvium. Flooding reaches several feet and occurs for a month typically in the spring. The water table may be at or near the surface for parts of the year.

Riverine Sand Flats-Sand Bars Sparse Vegetation

This plant community is sparsely vegetated; it occurs along the shorelines, islands, pointbars, and flats of rivers and larger streams statewide in Kansas. Sandbars form when receding floodwaters deposit sand and lesser amounts of clay, silt, cobbles in the channel bed. Soils are often undeveloped due to the ephemeral nature of these sandbars. Drainage depends on the height above the water level. Plant species found in this harsh habitat include seedlings of sycamore and black willow as well as red-root, rusty, and awned umbrella-sedges (*Cyperus erythrorhizos*, *C. odoratus*, and *C. squarrosus*), teal lovegrass, bearded sprangletop, (*Persicaria lapathifolia*), rough cockle bur (*Xanthium strumarium*), spreading yellowcress (*Rorripa sinuata*), yellowseed false pimpernel (*Lindernia dubia*), valley and grand redstems (*Ammannia coccinea* and *A. robusta*), dotted smartweed, and sand dropseed (*Sporobolus cryptandrus*).

Flint Hills Hydrophysiographic Province

The Flint Hills Hydrophysiographic Province encompasses the Flint Hills Ecoregion, which encompasses the largest remaining intact tallgrass prairie in the Great Plains (Figure 1). The region is characterized by rolling hills composed of shale and cherty limestone, rocky soils, and by humid, wet summers. Average annual precipitation ranges from 28 to 35 inches increasing in an easterly direction. The Flint Hills lie near the western edge of the tallgrass prairie ecoregion. The rocky surface of much of the Flint Hills is difficult to plow, except in the floodplains of higher order streams. Consequently, the region has historically supported less cropland agriculture than less rocky ecoregions. The natural tallgrass prairie still exists in most areas and is used for range and pasture land, although it has been impacted by livestock grazing, fire management and anthropogenic fragmentation.

A diversity of plant communities occurred on the floodplains of rivers and streams historically—wet to wet-mesic prairies, herbaceous or emergent wetlands, open water habitat, bottomland forests, riparian woods, and in-stream/in-river mud flats or sand bars. Plant communities historically found in the Flint Hills are described below.

Wet and (Wet-mesic) Prairie

These prairies are restricted to the larger rivers and streams where hydrology (e.g., adequate rainfall and seasonal water tables) is adequate to support these plant communities. They are located in the floodplains of lesser waterways as long as groundwater or runoff is sufficient for this prairie habitat. Species composition is similar to that of these prairies in eastern Kansas being dominated by grasses, sedges, and other graminoids. Moreover, vegetation is rich and diverse.

Emergent Wetlands

As with the wet-mesic and wet prairies, hydrologic conditions in the Flint Hills does not differ dramatically from those of eastern Kansas such that similar types of emergent wetlands (i.e., bulrush-cattail marsh, eastern cattail marsh, and bulrush-spike-rush marsh) found in eastern Kansas are also observed in the Flint Hills. It is safe to assume that the species composition of these emergent wetlands is similar, too.

Open Water Aquatic Habitat

As with the prairie and emergent wetlands, it is safe to assume that open water aquatic habitat and species composition (i.e., pondweed aquatic) in the Flint Hills is similar to that found in the Eastern Hydrophysiographic Province given that rainfall amounts are comparable and hydrology in the rivers and larger streams are also similar.

Bottomland or Floodplain Forests

Flooding and fluctuating water tables occurring along the rivers and larger streams of the Flint Hills is sufficient to support bottomland forest. Sediment carried in the intense flows on these rivers regularly scours the land further shaping the topography and influencing the species composition. And on the smaller watercourses the floodplains support bottomland habitat as a result of sufficient groundwater or runoff.

Riverfront Forest

The cottonwood-black willow riverfront forest occurs in the Flint Hills most likely on the rivers—Kansas, Republican, Smoky Hill, Neosho, Cottonwood, and Walnut—and the larger streams where the flooding is forceful enough to affect the formation of this type of forest. Structure and composition of the riverfront forest is similar to that described in eastern Kansas.

Mesic Bottomland Forest

Much like in eastern Kansas, this riparian community is temporarily flooded and has variable, but rocky soils in places in the Flint Hills. The American elm-hackberry subtype is the most common mesic bottomland in this province. Green ash, chinquapin and bur oaks, and black walnut also may be growing in the canopy and midstory. Rough-leaved dogwood, poison ivy, Virginia wild-rye, and wood nettle is found in the ground cover. Refer to the general description of mesic bottomland in the Eastern Hydrophysiographic Province section for more information.

Wet-mesic Bottomland Forest

Cottonwood and sycamore is the dominant canopy trees in this riparian forest in the Flint Hills. It is a temporarily flooded forest found on mostly level soils on floodplains along the rivers and larger streams in the Flint Hills. Composition of this forest in the Flint Hills is similar to that in eastern Kansas except pecan, pin oak, winter and gray bark grapes, pale dogwood, and touch-me-knots are rare or absent.

Wet Bottomland Forest

Cottonwood and black willow are the dominant trees in this riparian forest given their widespread abundance in Kansas. This forest type is associated with the larger streams and rivers in the Flint Hills likely occurring at old oxbows and swales. Flooding is often seasonal, but may persist through most of the growing season. Composition of the wet bottomland forest is similar to those found in eastern Kansas with dominants including green ash, silver maple, eastern cottonwood, black willow; poison ivy as a common vine, and clear-weed, spotted touch-me-not, and various sedges. A more detailed description of this bottomland forest can be found under riverfront floodplain above.

Bottomland or Floodplain Woodland

Woodlands are highly variable plant communities with open canopy and midstory allowing sunlight to reach the groundcover. Consequently, there is an abundant cover of grasses, sedges, and forbs. A combination of flooding, soil saturation, and fire influenced the development of bottomland woodland over time. Wet-mesic bottomland woodlands occur in the Flint Hills as described below.

Wet-mesic Bottomland Woodland

In the Flint Hills, this floodplain woodland is found on the major rivers and streams. The overstory of riparian community is fairly open with scattered trees including cottonwood and black willow as well as green ash and American elm. Given the open nature of the canopy, the ground layer is rich and diverse composed of grasses, sedges, and forbs including big bluestem, prairie cordgrass, and switch grass.

Riverine Sand Flats-Sand Bars Sparse Vegetation

This plant community is a sparsely vegetated community that occurs along the shorelines, islands, pointbars, and flats of rivers and larger streams statewide in Kansas. Vegetation is sparse and similar to that further east in Kansas. See pages 6 (Riverfront Forests) and 9 (Riverine Sand Flats) above for a more detailed description of this sandbar community.

North Central Hydrophysiographic Province

The North-Central Hydrophysiographic Province is located in the eastern Smoky Hills of Kansas (Figure 1). There are three hill ranges or ecoregions in the Smoky Hills. Dakota sandstone makes up the first hill range (eastern) and is where the study area basin is located. Thin layers of greenhorn limestone alternating with bluish-gray shale makes up the middle hill range (middle; sometimes called the Blue Hills) and comprises some of the drainage area to Milford Lake from the northwest in Nebraska. The third range (western) is the chalk bluffs extending from Kansas to the Rain Water Basins in Nebraska and is formed from outcrops in the Niobrara chalk formation. Average annual precipitation ranges from 24 to 30 inches increasing in an easterly direction.

Historically, it is assumed number and diverse set of plant communities—wet prairies, herbaceous wetlands, shrubby wetlands, open water habitat, bottomland forests, riparian woods, and in-stream/in-river mud flats or sand bars—occurred on the wide floodplains of the larger rivers and less extensive floodplains of the smaller rivers and perennial streams. These plant communities found in the North-Central Hydrophysiographic Province are described below.

Wet Prairie in this hydrophysiographic province is listed by Lauver et al. (1999) as alkali sacaton lowland prairie, and is restricted to slightly to moderately saline flats in the Smoky Hills physiognomic province. It is found on nearly level bottomland and terraces and is temporarily flooded in the spring most of the time with additional moisture provided from runoff from adjacent drainages and the watershed. The groundwater may play less of a role than presumed further east in Kansas. The soils are shallow, moderately well to poorly drained silty clays, formed in alluvium. The plant community is dominated by medium-tall and short grasses, with alkali sacaton (*Sporobolus airoides*) being the most prevalent grass. It often grows with western wheat grass (*Pascopyron smithii*), inland salt grass (*Distichlis spicata*), foxtail barley (*Hordeum jubatum*), inland saltmarsh aster (*Symphyotrichum subulatum*), buffalo grass (*Buchlöe dactyloides*), blue grama (*Bouteloua gracilis*), and clustered field sedge (*Carex praegracilis*). Scattered shrubs such as silver-scale and spear-scale saltbushes (*Atriplex argentea* and *A. subspicata*) may also be present.

Emergent Wetlands or Marshes

Emergent wetlands are dominated by herbaceous vegetation subject to periodic inundation from over-bank flooding or contribution from groundwater or both. Inundation is semi-permanent flooding, with depths up to two or three feet. Soils are typically deep, poorly drained clays, silty clays and in some cases peat and muck often formed in alluvium. These wetlands are found in swales, oxbows, and other depressions along rivers and streams. Composition of vegetation is highly variable in response to water depth, flood duration, and soil and water chemistry. In other words, dramatically different wetland types—freshwater, alkaline, and saline marshes—may be found based on water chemistry. Slight changes in water depths can give rise to a mosaic of vegetation types.

Bulrush-Spike-rush Marsh

The type of freshwater wetland is a semi-permanently flooded wetland on poorly drained clays and silty clays. It is found in basins, oxbows and low lands along streams and creeks statewide. Surface water ranges from one to three feet in depth. Dominants include chair-maker's bulrush, blunt, bald, or creeping spike-rushes. Characteristic species are lesser duckweed (*Lemna minor*), common arrowhead, broad-leaf cattail, and saltmarsh bulrush. Other species that may be present include alkali cordgrass (*Spartina gracilis*), foxtail barley, western wheat grass, and baltic rush (*Juncus balticus*). Scattered trees may be present including cottonwood, peach-leaf willow, sand bar willow, and buckbrush.

Western Cattail Marsh

The second freshwater marsh found in the Smoky Hills is a semi-permanently flooded wetland on poorly drained clays and silty clays. It is found in shallow to deep depressions of oxbows and seepy areas along creeks in the western two-thirds of the state. Surface water ranges from one to three feet in depth. Vegetation is dominated by almost pure stands of broad-leaf cattail with bald and creeping spike-rushes and common arrowhead as associates.

Inland Salt Marsh-Saltmarsh Tuberous-Bulrush-Rocky Mountain Glasswort Saltmarsh

This saltmarsh is semi-permanently flooded or saturated wetland found in swales and depressions of floodplains and their terraces and valley basins in the Smoky Hills and Arkansas River Lowlands. Soils are deep, very poorly drained, and consist of peat, muck, and mineral materials formed in alluvium or loess. It is dependent on the periodic influx of salty water to maintain its soil and water chemistry. Herbaceous plants are dominant, with trees and shrubs rarely present. Dominants include inland salt grass, Rocky Mountain glasswort (*Salicornia rubra*), and saltmarsh tuberous-bulrush (*Bolboschoenus maritmus*). Other common species may include inland saltmarsh aster, foxtail barley, annual sumpweed (*Iva annua*), broom seepweed (*Suaeda calceoliformis*), and Texas dropseed (*Sporobolus texanus*). Few individuals in this community exceed three feet and most are less than two feet. There can be bare ground especially where it is wettest and most saline. Widgeon-grass (*Ruppia cirrhosa*) and sago pondweed (*Stuckenia pectinata*) may be found in pools in the wetter parts of the marsh. The vegetation is denser with few stretches of bare ground on the drier and less saline parts of the wetland.

Chair-Maker's Bulrush-Broom Seepweed Alkaline Marsh

This alkaline marsh is a semi-permanently flooded wetland occurring in depressions in bottomlands along rivers and streams and along the margins of moderately to strongly alkaline lakes in basins or valleys in the Smoky Hills and Arkansas River Lowlands. These marshes often have limited surface outlet and poor subsurface drainage due to poorly drained clays and loams. Hydrology is mostly supplied through precipitation and runoff. Vegetation is dominated by medium to tall graminoids tolerant of strong alkaline conditions, and may include common chair-maker's bulrush and broom seepweed. Other species present in this alkaline marsh include plains coreopsis, hard-stem and soft-stem bulrushes, Pennsylvania and pink smartweeds (*Persicaria pensylvanica* and *P. bicornis*), broad-leaf cattail, and long-barb arrowhead (*Sagittaria longiloba*).

Open Water Aquatic Habitat

Open water aquatic habitat is permanently flooded wetland on poorly drained clays and sands in interdunal swales and depressions along streams in the Smoky Hills, Arkansas River lowlands, and the Wellington-McPherson Lowlands. Surface water depths are up to three feet. Vegetation varies from sparse to dense with submersed rooted and floating plants. Species composition varies with substrate, water depth, water chemistry, and turbidity. Dominants include water-thread, long-leaf, and sago pondweeds (*Potamogeton foliosus*, *P. nodosus*, and *Stuckenia pectinata*), naiad (*Najas quadalupensis*), and horned pondweed (*Zannichellia palustris*). Common hornwort (*Ceratophyllum demersum*) and duckweed (*Lemna* spp.) can be locally abundant. Other species include broad-leaf cattail, common arrowhead, soft-stem and green (*Scirpus atrovirens*) bulrushes, and bald and creeping spike-rushes.

Scrub-shrub Wetland

These wetlands are found in a variety of habitats including backwater channels, floodplain swales, sandbars, islands, and shorelines of streams and rivers in the Smoky Hills. Soils are poorly developed and composed of sand, clay, silt, or gravel found in alluvium. Inundation occurs temporarily from over-bank flooding or contribution from groundwater or both.

The scrub-shrub wetland is characterized by thick stands of sandbar willow (*Salix exigua*) and a moderate to dense cover of graminoids including prairie cordgrass, big bluestem, switch grass, fescue, pest, and woolly sedges (*Carex brevior*, *C. gravida*, and *C. pellita*), blunt, creeping, and bald spike-rushes, and Dudley's (*Juncus dudleyi*) and Torrey's rushes, chair-maker's bulrush, western wheat grass, and prairie wedgescale (*Sphenopholis obtusata*). Forbs include rough cockle bur, nodding and bearded beggar-ticks, great blue lobelia (*Lobelia siphilitica*), common water horehound, winged loosestrife, and water, Pennsylvania, and pink smartweeds. Other woody vegetation sometimes present includes cottonwood, peach-leaf willow, and false indigo (*Amorpha fruticosa*).

Bottomland or Floodplain Forests

These bottomland forests were restricted to the larger rivers and streams where flooding and fluctuating water tables was adequate to support these forest types. Sediment carried in the intense flows on these rivers regularly scours the land further shaping the topography and influencing the species composition. They occur in the floodplains of smaller waterways as long as groundwater or runoff is sufficient for this bottomland habitat. Species composition is assumed to be similar too.

Riverfront Forests

The cottonwood-black willow riverfront forest occurs in the Smoky Hills along the Kansas, Saline, Republican, and Smoky Hill rivers and their larger tributaries. Structure of the riverfront forest is similar to that described in eastern Kansas. Composition varies given the decreasing rainfall and changing topography. Less prevalent in riverfront forests of the Smoky Hills include black willow (being replaced by peach-leaf willow), silky wild-rye, nodding beggar-ticks, pale dogwood, wood nettle, panicled aster, and winter, gray bark, and raccoon grapes.

Mesic Bottomland Forest

Much like in eastern Kansas, this riparian community is temporarily flooded and has variable, but rocky soils in places in the Smoky Hills. The American elm-hackberry subtype is the common mesic bottomland in this province. Green ash, black walnut, hackberry, and bur oaks also could be growing in the canopy and midstory. Rough-leaved dogwood, poison ivy, plains muhly (*Muhlenbergia cuspidata*), Virginia wild-rye, occurs in the ground cover. Plant species that drop out from the east include paw paw, basswood, wood nettle, nodding fescue, woodland sea oats, and western buckeye. Refer to the general description of mesic bottomland in the Eastern Hydrophysiographic Province section for more information.

Wet-mesic Bottomland Forest

Cottonwood and sycamore are the dominant canopy trees in this riparian forest in the Smoky Hills. It is a temporarily flooded forest found on mostly level soils on floodplains along the rivers and larger streams in the Smoky Hills. The species composition is generally similar to that in the Flint Hills.

Wet Bottomland Forest

Cottonwood and peach-leaf willow are the dominant trees in this riparian forest given their widespread abundance in Kansas. The forest is associated with the larger streams and rivers in the Smoky Hills, and being found at old oxbows and swales. Flooding is often seasonal, but may persist throughout the growing season. Composition of the wet bottomland forest is generally similar to those found in the Flint Hills and eastern Kansas with dominants including green ash, silver maple, eastern cottonwood, peach-leaf willow, poison ivy as a vine, and clearweed, spotted touch-me-not, and various sedges. A more detailed description of this bottomland forest can be found under riverfront floodplain above.

Bottomland or Floodplain Woodland

Woodlands are highly variable plant communities with open canopy and midstory allowing sunlight to reach the groundcover. Consequently, there is a diversity of grasses, sedges, and forbs. A combination of flooding, soil saturation, and fire influenced the development of bottomland woodland over time.

Wet-Mesic Bottomland Woodland

This woodland is found in nearly level floodplains along the major rivers and streams in the Smoky Hills and Arkansas River Lowlands. Soils are deep, loams, silts, and sands on somewhat poorly to well-drained formed in sandy, calcareous silty or loamy recent alluvium. Flooding is temporary, fluctuating with the levels of the adjacent rivers or streams.

This woodland has an overstory of medium to tall trees typically dominated by eastern cottonwood, with peach-leaf willow often as a co-dominant. The shrub/sapling layer is conspicuous especially along the watercourse, and consists mainly of cottonwood, sandbar willow, and peach-leaf willow. The ground layer comprises grasses and sedges in undisturbed sites including woolly sedge, western wheat grass, Virginia wild-rye, and prairie cordgrass. Smooth horsetail (*Equisetum laevigatum*) and wild licorice (*Glycyrrhiza* *lepidota*) are common. Widely distributed forbs and grasses include western ragweed (*Ambrosia psilostachya*), western sagewort (*Artemisia campestris*), marsh muhly (*Muhlenbergia racemosa*), Louisiana sagewort (*Artemisia ludoviciana*), prairie sandreed (*Calmovilfa longifolia*), mat sandbur (*Cenchrus longispinus*), thymeleaf sandmat (*Chamaesyce serpyllifolia*), curlycup gumweed (*Grindelia squarrosa*), prairie sunflower (*Helianthus petiolaris*), hairy false goldensaster (*Heterotheca villosa*), lanceleaf frogfruit *(Phyla lanceolata*), and sand dropseed.

Riverine Sand Flats-Sand Bars Sparse Vegetation

This plant community is a sparsely vegetated community that occurs along the shorelines, islands, pointbars, and flats of rivers and larger streams statewide in Kansas. Vegetation is sparse and similar to that further east in Kansas. See pages 6 (Riverfront Forests) and 9 (Riverine Sand Flats) above for a more detailed description of this sandbar community.

South Central Hydrophysiographic Province

The South-Central Hydrophysiographic Province straddles the Great Bend Sand Prairie region to the west and the Wellington-McPherson Lowland region to the east (Figure 1). The Great Bend Sand Prairie comprises undulating to rolling sand plains. A mantle of windblown sand, sandy outwash, and dunes supports a potential natural vegetation of sand prairie bunchgrass. Average annual precipitation in this province ranges from 24 to 30 inches per year, increasing in an easterly direction. The flat lowland topography of the Wellington-McPherson Lowland distinguishes this region from the sand hills to the west and northwest, the undulating hill ranges of the Smoky Hills to the north, and the rolling chert and limestone hills of the Flint Hills to the east.

Historically, larger rivers with wide, expansive floodplains may have numerous plant communities including wet prairies, emergent wetlands, scrub-shrub wetlands, open water habitat, bottomland forests, riparian woods, upland forests, and in-stream/in-river mud flats or sand bars. These plant communities are composed of numerous plant species as described below.

Wet Prairies

Wet prairie in this hydrophysiographic province is listed by Lauver et al. (1999) as sandhills wet prairie, which is found on nearly level terrain along streams and rivers and in wet interdunal valleys, terraces, and floodplains in the Arkansas River Lowlands. Soils are poorly drained sands and sandy loams with high organic content (often muck and peat) and are formed in sand or alluvium. The wet prairie is often temporarily flooded early in the season and may have a water table within three feet of the surface during most years. Wet prairie is densely vegetated mostly by graminoids that are one and one-half to five feet tall. Prairie cordgrass is the most common, but blue joint grass (*Calamagrostis canadensis*), wooly and broom (*Carex scoparia*) sedges, bald, creeping, and blunt spike-rushes, Torrey's rush, switch grass are also common. Forbs are scattered or locally abundant and may include swamp milkweed, field mint (*Mentha arvensis*), spotted water-hemlock (*Cicuta maculata*), American water horehound, common goldstar (*Hypoxis hirsuta*), and blue skullcap (*Scutellaria lateriflora*). Scattered patches of shrubs include false indigo, sandbar willow, and rough-leaved dogwood.

Emergent Wetlands

As described in the previous sections, emergent wetlands are composed of herbaceous plants adapted to varying hydrology, soils, and water chemistry. As in the North Central Hydrophysiographic Province, the water in emergent wetlands may be fresh, saline, or alkaline, whose source may be over-bank flooding, groundwater or both. Wetland plant communities in the Arkansas River Lowlands include bulrush-spike-rush marsh, salt marsh, alkaline marsh, and western cattail marsh. Species composition of these four wetland types is similar to that found in the Smoky Hills.

Open Water Aquatic Habitat

Open water aquatic habitat is permanently flooded wetland on poorly drained clays and sands in interdunal swales and depressions along streams in the Arkansas River Lowlands and Wellington-McPherson Lowlands. Surface water depths are up to three feet. Vegetation varies from sparse to dense with submersed rooted and floating plants. Species composition varies with substrate, water depth, water chemistry, and turbidity. Dominants include water-thread, long-leaf, and sago pondweeds, naiad, and horned pondweed. Common hornwort and duckweed can be locally abundant. Other species include broad-leaf cattail, common arrowhead, various bulrushes, and spike-rushes.

Bottomland or Floodplain Forests

These bottomland forests were restricted to the larger rivers and streams where flooding and fluctuating water tables was adequate to support these forest types. Sediment carried in the intense flows on these rivers regularly scours the land further shaping the topography and influencing the species composition. They occur in the floodplains of smaller waterways as long as groundwater or runoff was sufficient for this bottomland habitat. Species composition is assumed to be similar too.

Mesic Bottomland Forest

Much like in eastern Kansas, this riparian community is temporarily flooded and has variable, but rocky soils in places in the Arkansas River Lowlands and Wellington-McPherson Lowlands. The American elm-hackberry subtype is the common mesic bottomland in this hydrophysiographic province. Green ash, black walnut, and chinquapin and bur oaks also may be growing in the canopy and midstory. Rough-leaved dogwood, poison ivy, Virginia wild-rye, tall bellflower, and wood nettle occurs in the ground cover. Refer to the general description of mesic bottomland in the Eastern Hydrophysiographic Province section for more information.

Wet-mesic Bottomland Forest

Cottonwood and sycamore are the dominant canopy trees in this riparian forest in the Arkansas River lowlands. It is a temporarily flooded forest found on mostly level soils on floodplains along the rivers and larger streams in the uplands of this province. Composition of this forest in the Arkansas River Lowlands is similar to that in eastern Kansas except pecan, pin oak, winter and gray bark grapes, pale dogwood, and touch-me-knots are rare or absent.

Wet Bottomland Forest

Cottonwood and black willow are the dominant trees in this riparian. It is associated with the larger streams and rivers in the Arkansas River lowlands occurring at old oxbows and swales. Flooding is seasonal and may persist throughout the growing season. Species composition is similar to that of more eastern Kansas with dominants including green ash, silver maple, eastern cottonwood, black willow, poison ivy, clearweed, and various sedges occurring in the ground layer. A more detailed description of this bottomland forest can be found under riverfront floodplain above.

Bottomland or Floodplain Woodland

Woodlands are highly variable plant communities with open canopy and midstory allowing sunlight to reach the groundcover. Consequently, there is a dense and diverse cover of grasses, sedges, and forbs. A combination of flooding, soil saturation, and fire influenced the development of bottomland woodland over time. Wet-mesic bottomland woodlands occur in the Arkansas River Lowlands as described below.

Wet-Mesic Bottomland Woodland

This woodland is found in nearly level floodplains along the major rivers and streams in the Arkansas River Lowlands. Soils are deep, somewhat poorly to well-drained, and loams, silts, and sands formed in sandy, calcareous silty or loamy recent alluvium. Flooding is temporary, fluctuating with the levels of the adjacent rivers or streams.

The wet-mesic bottomland woodland has an open overstory of medium to tall trees typically dominated by eastern cottonwood, with peach-leaf willow often as a co-dominant. The shrub/sapling layer is conspicuous especially along watercourses, and consists mainly of cottonwood, sandbar willow, and peach-leaf willow. The ground layer consists of grasses and sedges in undisturbed sites including woolly sedge, western wheat grass, Virginia wild-rye, and prairie cordgrass. Smooth horsetail and wild licorice are common. Widely distributed forbs and grasses include western ragweed, western sagewort, marsh muhly, Louisiana sagewort, prairie sandreed, mat sandbur, thymeleaf sandmat, curlycup gumweed, prairie sunflower, hairy false goldensaster, lanceleaf frogfruit, and sand dropseed.

Riverine Sand Flats-Sand Bars Sparse Vegetation

This plant community is a sparsely vegetated community that occurs along the shorelines, islands, pointbars, and flats of rivers and larger streams statewide in Kansas. Vegetation is sparse and similar to that further east in Kansas. See pages 6 (Riverfront Forests) and 9 (Riverine Sand Flats) above for a more detailed description of this sandbar community.

Final Considerations & Recommendations

Although we cannot be sure of the historic plant communities (PNC) occurring in the floodplains of Kansas, we can discern with some confidence the likely composition of many of these communities based on pre-settlement environmental conditions, paleobotanical data, botanical data accumulated during European settlement, medicinal plant use of Native Americans, and current floristic data. In addition, KARS has mapped approximate locations of historic forests based on public land data of the 1850s and 1860s (see previous discussion in report—Historic Riparian Forest), but little field work has been done to confirm whether these forests are still present and in what condition they are (e.g., intact, third or fourth growth, or adventive woods). One exception was the work by Kindscher et al. (2009), who searched for historic forests based on public land surveys, topography, and other factors in Linn and Anderson counties, Kansas. Twenty-four (24) high quality forests, a number of which were riparian in nature, were found during the study. Continuing this effort by Kindscher in riparian forests in one or more of the four hydro-physiographic provinces would be of great value. The work would confirm the locations of historic riparian forests in the study area, update our data on potential high quality forests, and possibly provide us a better understanding of the dynamics of riparian areas and forests over time and through seral-stage succession, as they vary from upstream to downstream and how they respond to hydrological, climatic and anthropongenic disturbance.

Also, refer to Recommendations in previous section of this report as pertains to further development of riparian planting guides by hydrophysiographic province and identification of the PNC and its capability given limiting factors as well as proper functioning condition of riparian areas and evaluation of historical potential remnant forests.

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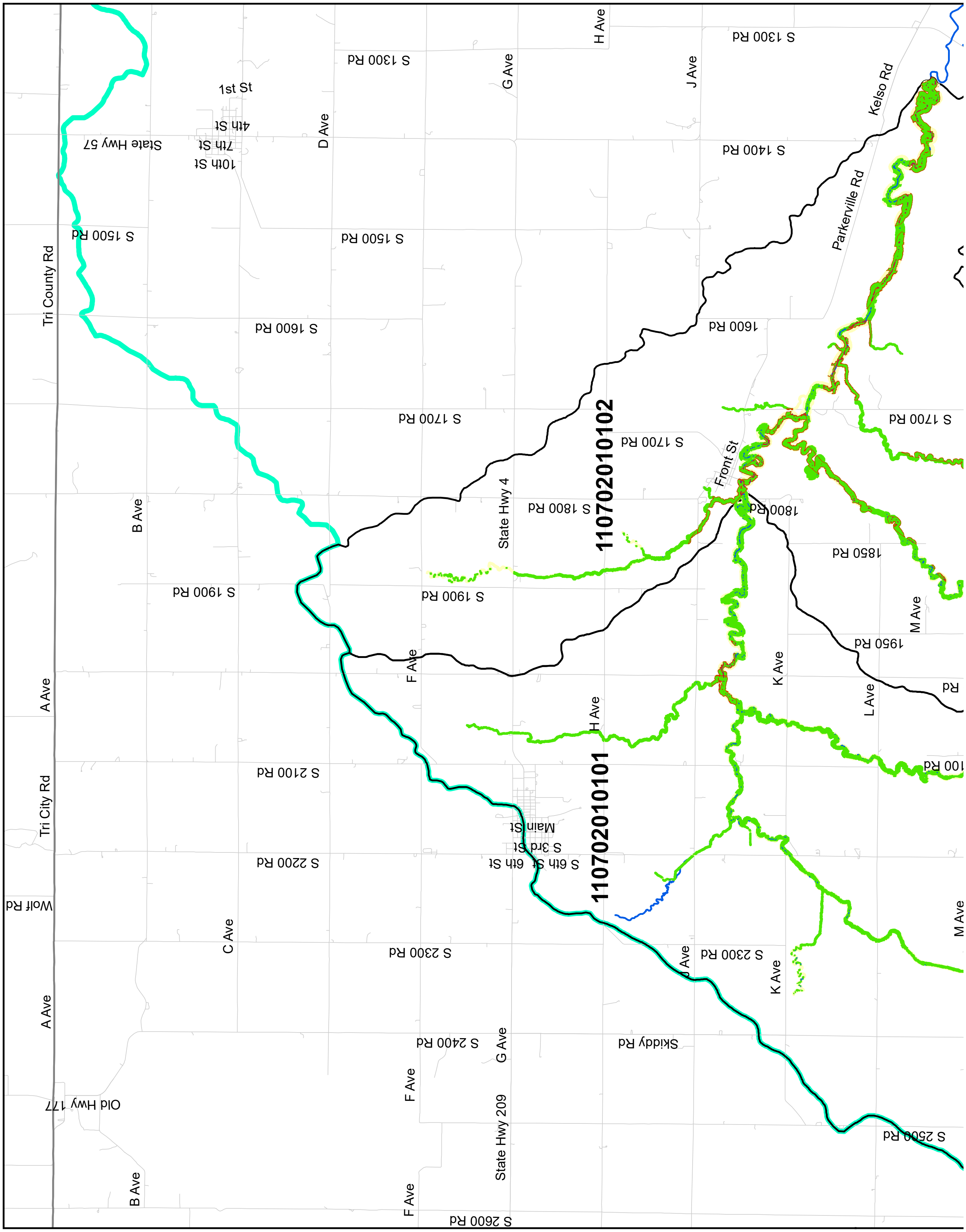
Appendices

- Appendix A: Remote Riparian Assessment Maps for All RCPP Study Areas
- Appendix B: Twin Lakes Riparian Assessment
- Appendix C: Riparian Condition Class and Potential Historical Remnant Forest by Hydrophysiographic Province and Adjacent to Lakes
- Appendix D: Riparian Species List by Hydrophysiographic Province and Riparian Community Type

Appendix A: Remote Riparian Assessment Maps for All RCPP Study Areas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Tri City Rd
Wolf Rd
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4th St
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10th St
Main St
S 3rd St
S 6th St
6th St
Front St
Kelso Rd
Parkerville Rd
Skiddy Rd
A Ave
B Ave
C Ave
D Ave
F Ave
G Ave
H Ave
J Ave
K Ave
L Ave
M Ave
S 1300 Rd
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S 1500 Rd
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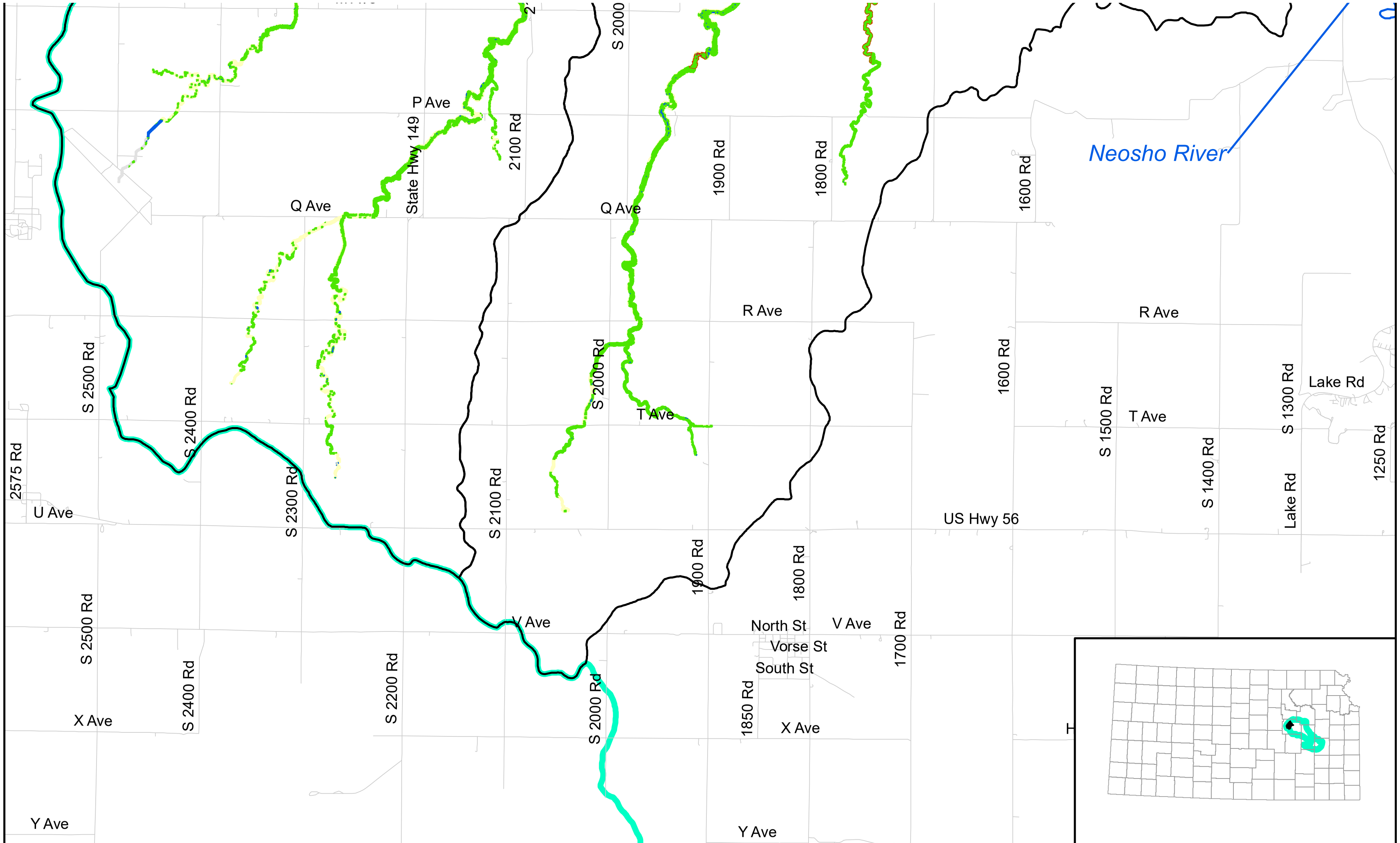
S 2600 Rd



Riparian Forest Assssessment

HUC-12 = 110702010101 & 110702010102

Twin Lakes Study Area

NRCS-RCPP Agreement

March 2018

Projection: Albers Equal Area Conic USGS

Sources:

EPA National Hydrography Dataset

NRCS HUC-8 & HUC-12 Boundaries

TIGER 2014 County Boundaries and Roads

Riparian Forest Class

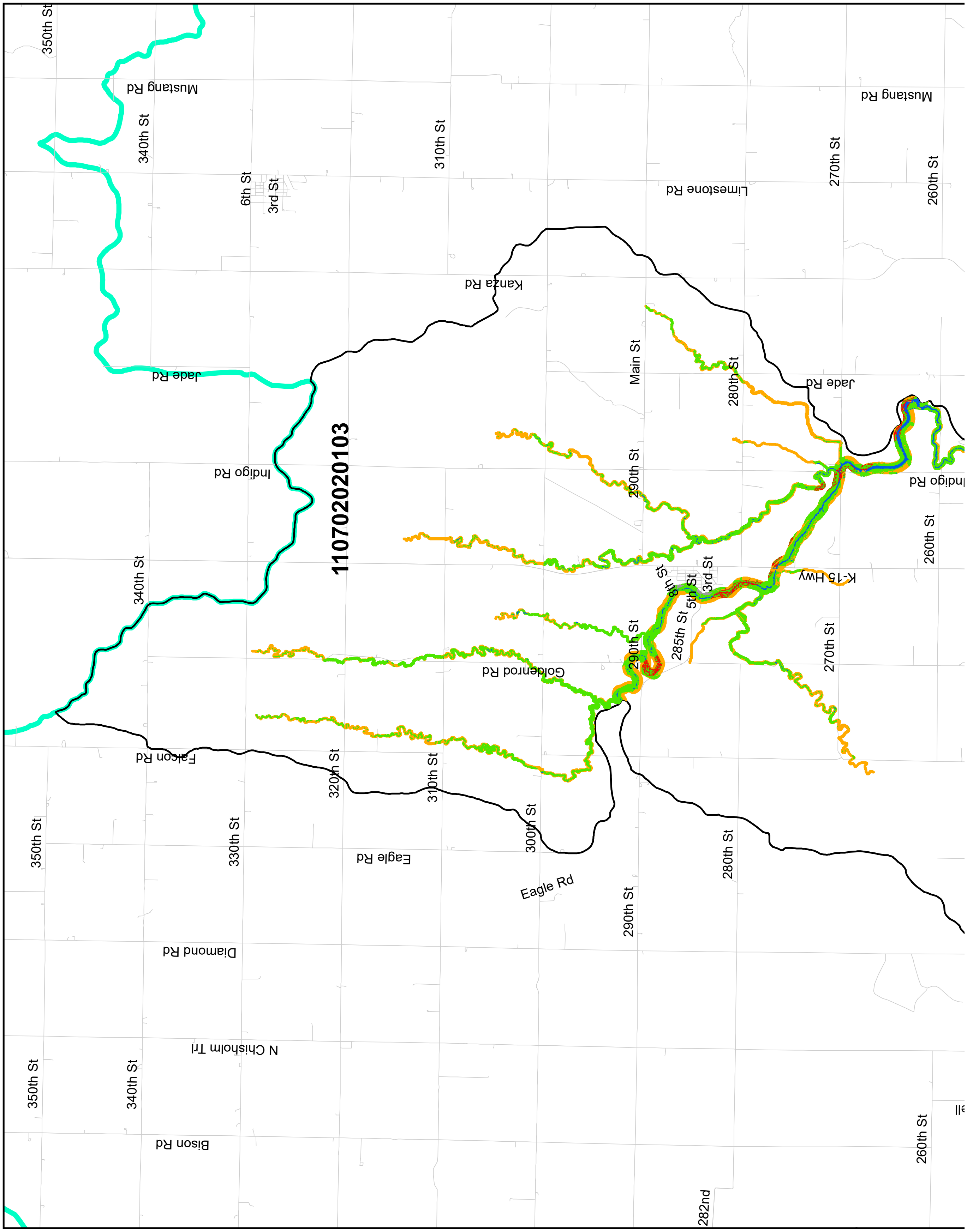
- Conservation
- Developed
- Establishment
- Management
- Water
- Potential Historical Remnant Forest

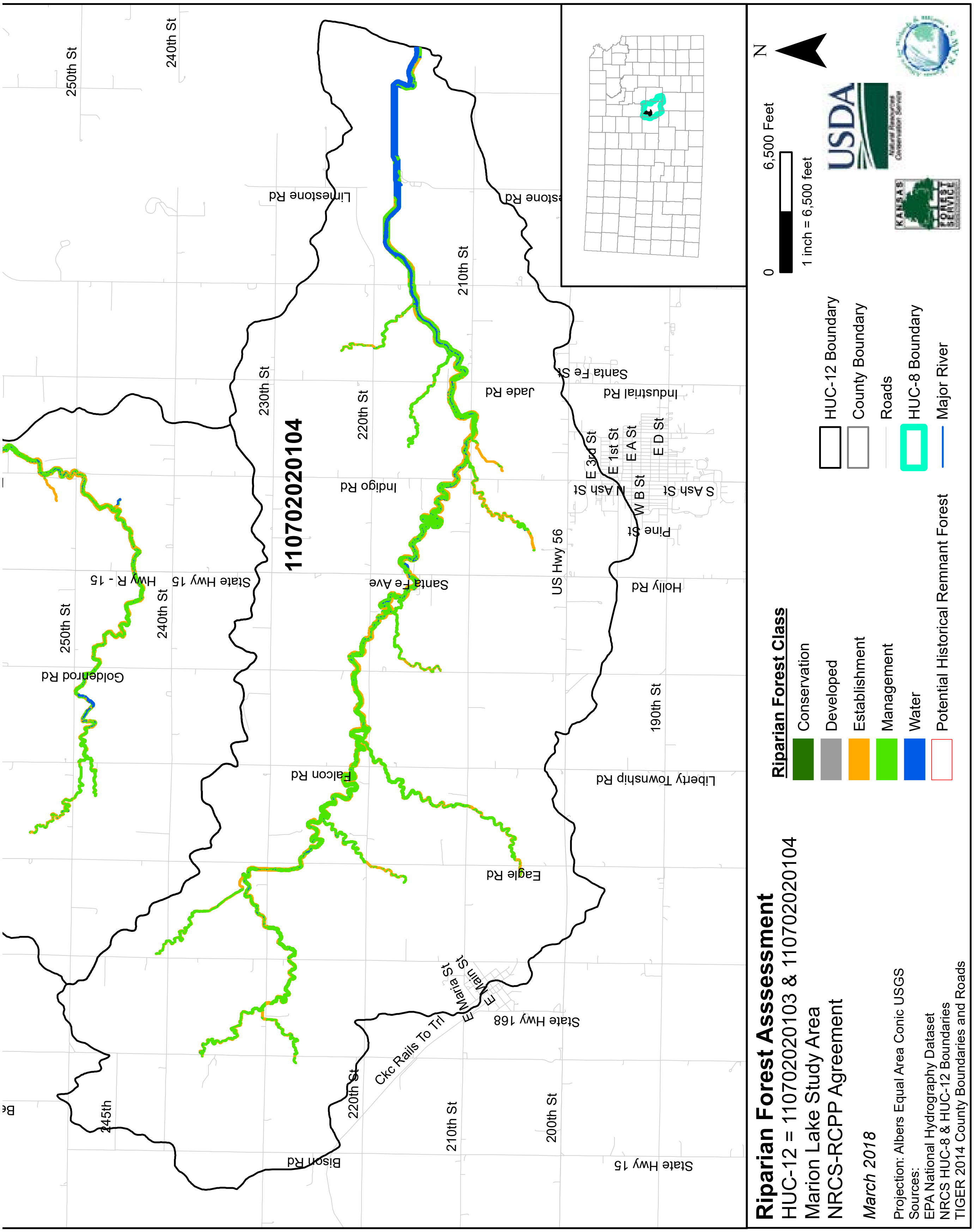
- HUC-12 Boundary
- County Boundary
- Roads
- HUC-8 Boundary
- Major River

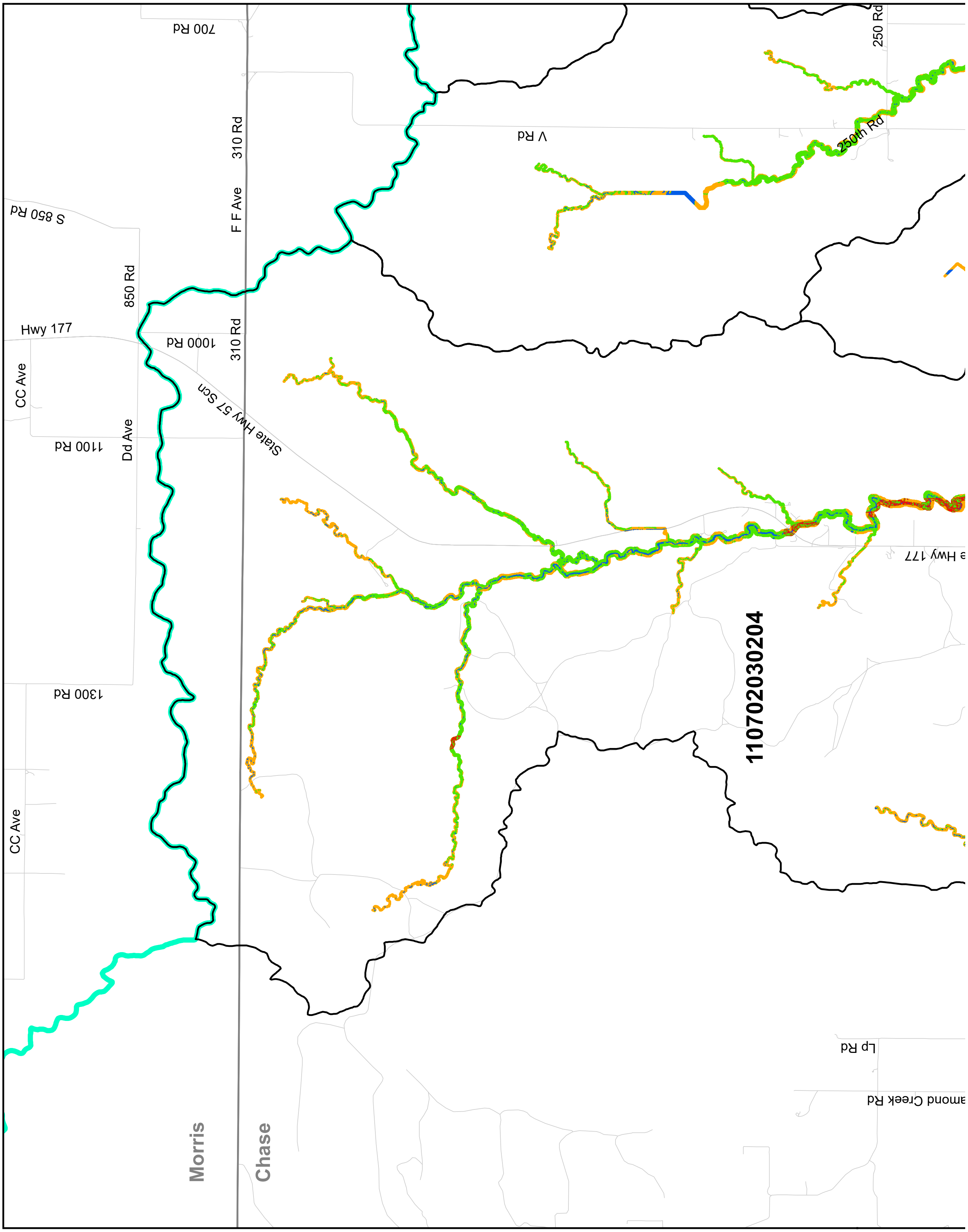
0 7,000 Feet

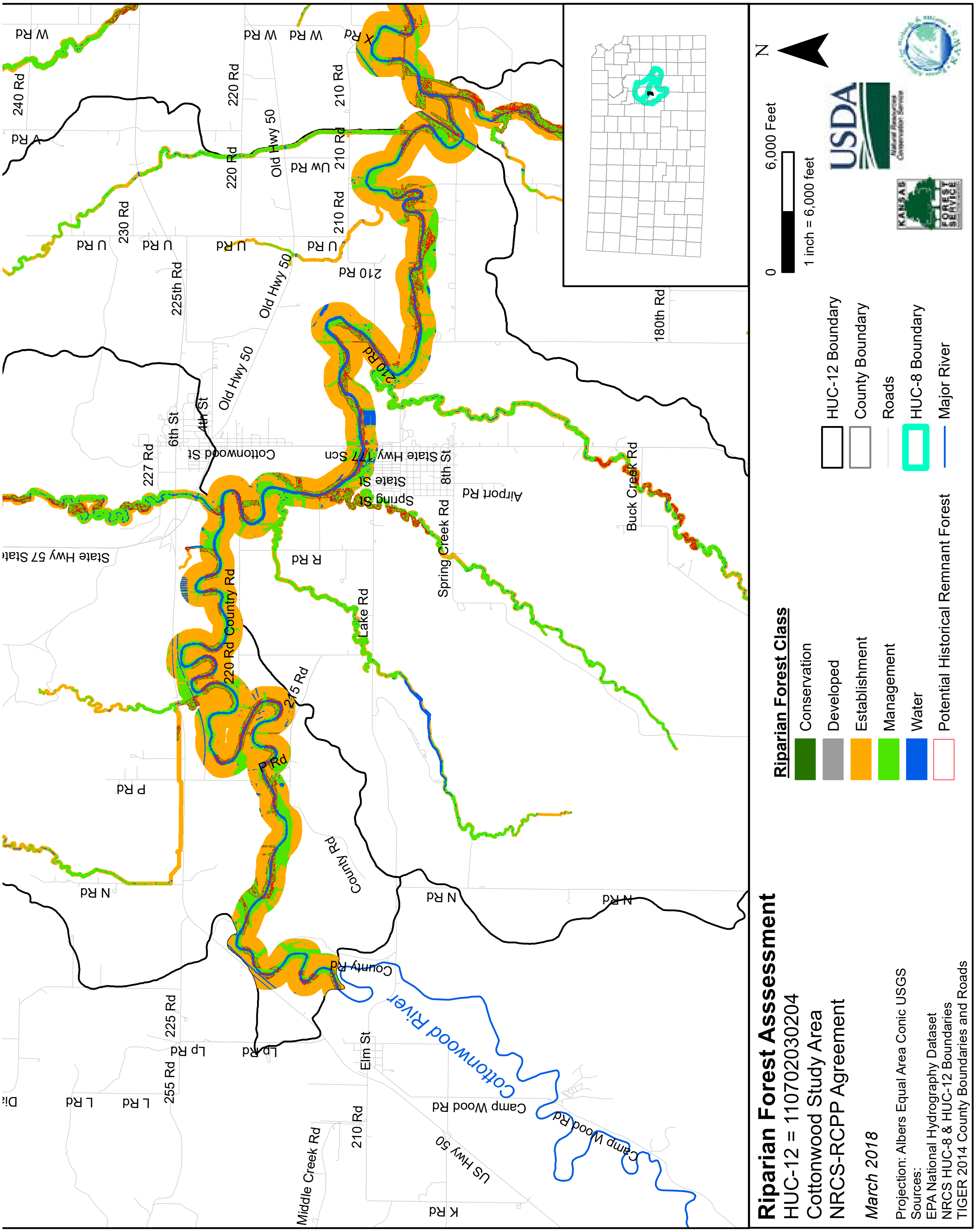
1 inch = 7,000 feet

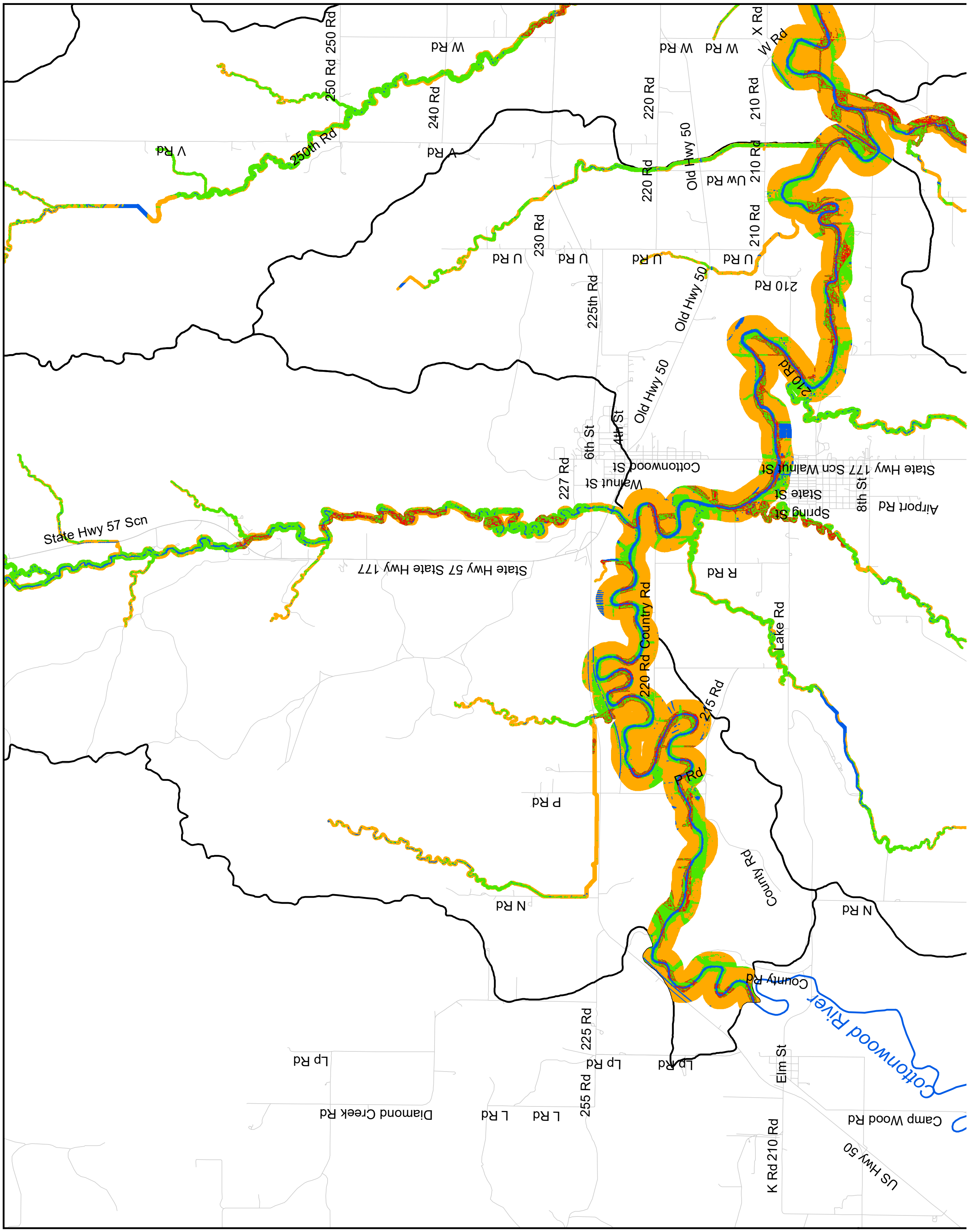
N


110702020103
Mustang Rd
Limestone Rd
Kanza Rd
Jade Rd
Indigo Rd
K-15 Hwy
Goldenrod Rd
Falcon Rd
Eagle Rd
Diamond Rd
N Chisholm Trl
Bison Rd
Main St
350th St
340th St
330th St
320th St
310th St
300th St
290th St
285th St
280th St
270th St
260th St
282nd
6th St
5th St
3rd St

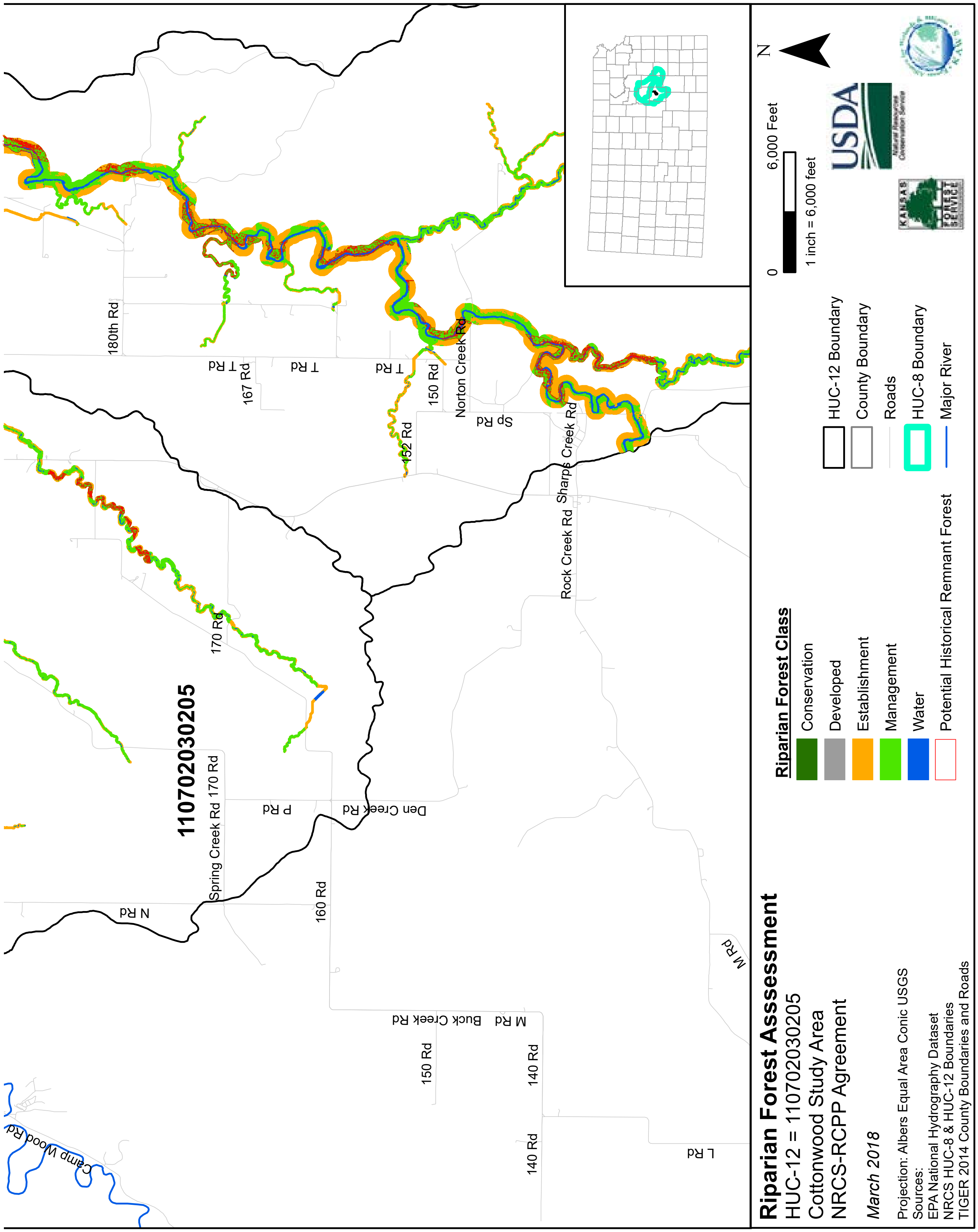

Riparian Forest Asssessment
HUC-12 = 110702020103 & 110702020104
Marion Lake Study Area
NRCS-RCPP Agreement
March 2018
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads
Riparian Forest Class
Conservation
Developed
Establishment
Management
Water
Potential Historical Remnant Forest
HUC-12 Boundary
County Boundary
Roads
HUC-8 Boundary
Major River
0
6,500 Feet
1 inch = 6,500 feet
N
USDA
110702020104
250th St
240th St
Limestone Rd
230th St
220th St
210th St
Jade Rd
Santa Fe St
Industrial Rd
Indigo Rd
E 3rd St
E 1st St
E A St
E D St
N Ash St
W B St
S Ash St
Pine St
US Hwy 56
Holly Rd
Santa Fe Ave
State Hwy 15
Hwy R - 15
Goldenrod Rd
190th St
Falcon Rd
Liberty Township Rd
Eagle Rd
E Maria St
E Main St
State Hwy 168
Ckc Rails To Trl
245th
200th St
Bison Rd


700 Rd
310 Rd
F F Ave
V Rd
250 Rd
250th Rd
S 850 Rd
850 Rd
Hwy 177
1000 Rd
310 Rd
CC Ave
State Hwy 57 Scn
1100 Rd
Dd Ave
1300 Rd
CC Ave
110702030204
Lp Rd
Morris
Chase

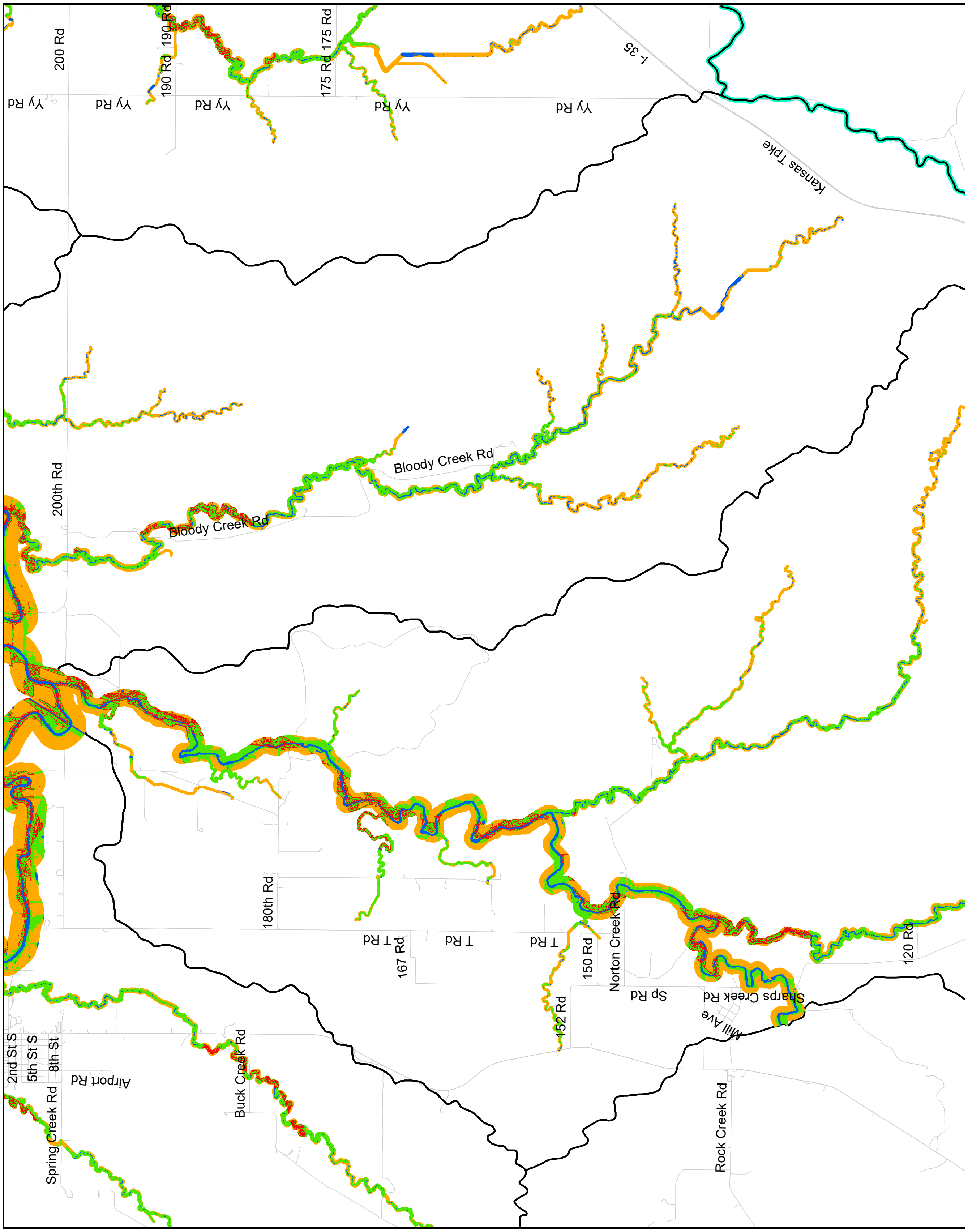

Riparian Forest Asssessment
HUC-12 = 110702030204
Cottonwood Study Area
NRCS-RCPP Agreement
March 2018
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads
Riparian Forest Class
Conservation
Developed
Establishment
Management
Water
Potential Historical Remnant Forest
HUC-12 Boundary
County Boundary
Roads
HUC-8 Boundary
Major River
0
6,000 Feet
1 inch = 6,000 feet
N
USDA
Cottonwood River

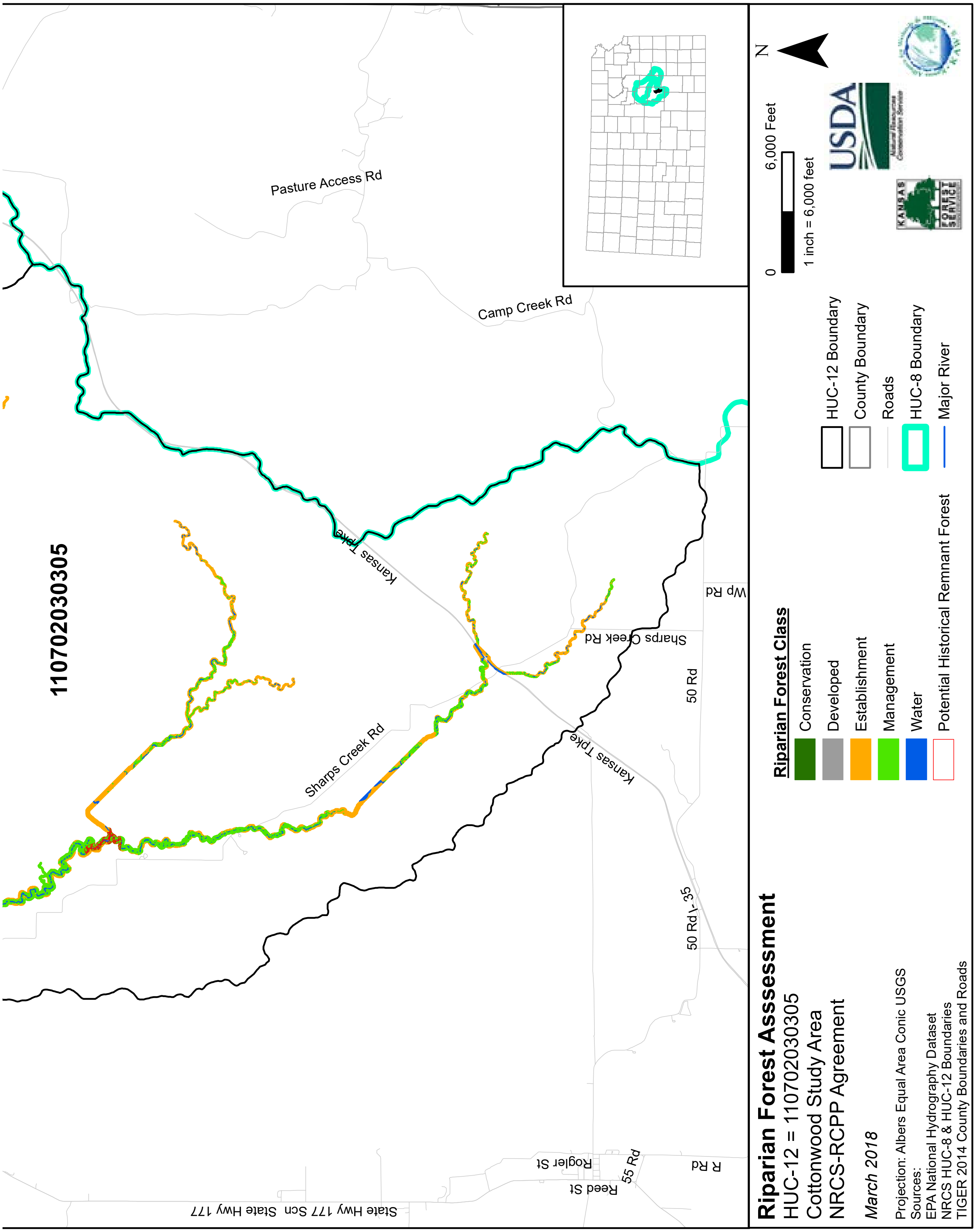


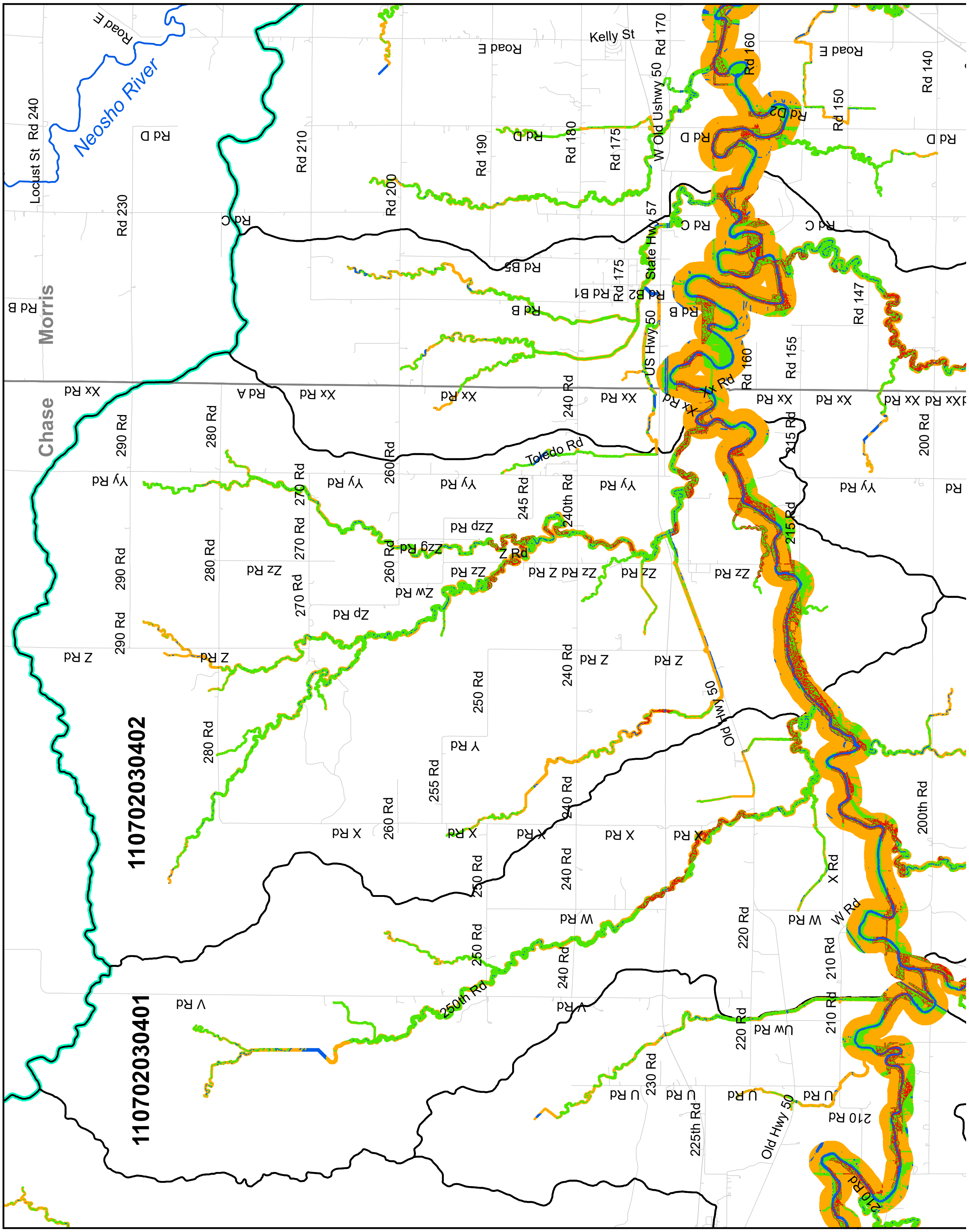
Cottonwood River
State Hwy 57 Scn
State Hwy 57 State Hwy 177
State Hwy 177 Scn Walnut St
Old Hwy 50
US Hwy 50
220 Rd Country Rd
Lake Rd
County Rd
Airport Rd
Camp Wood Rd
Diamond Creek Rd
250th Rd
250 Rd
240 Rd
230 Rd
225th Rd
227 Rd
225 Rd
255 Rd
220 Rd
210 Rd
215 Rd
K Rd 210 Rd
X Rd
W Rd
V Rd
U Rd
Uw Rd
R Rd
P Rd
N Rd
Lp Rd
L Rd
6th St
4th St
8th St
Cottonwood St
Walnut St
State St
Spring St
Elm St

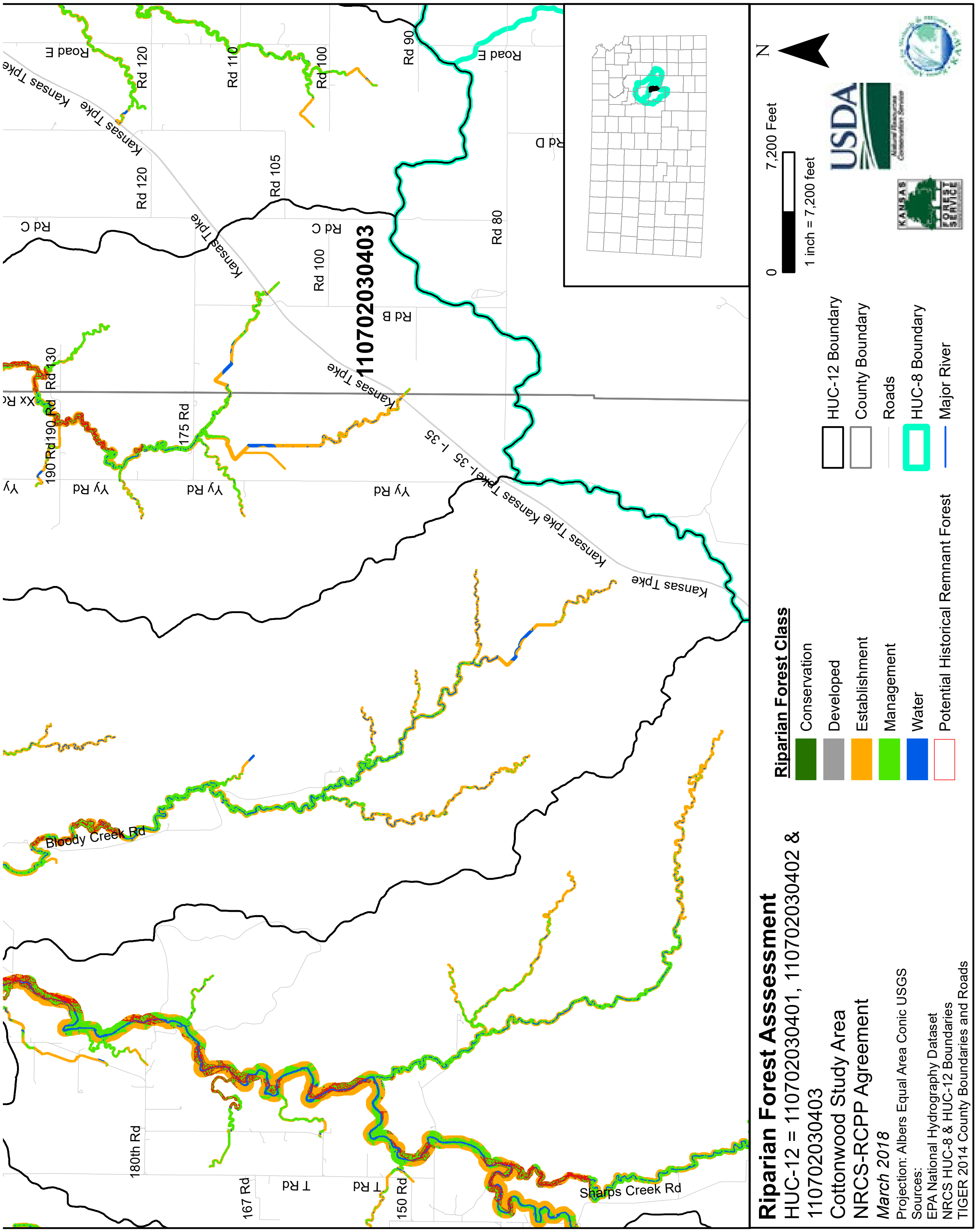


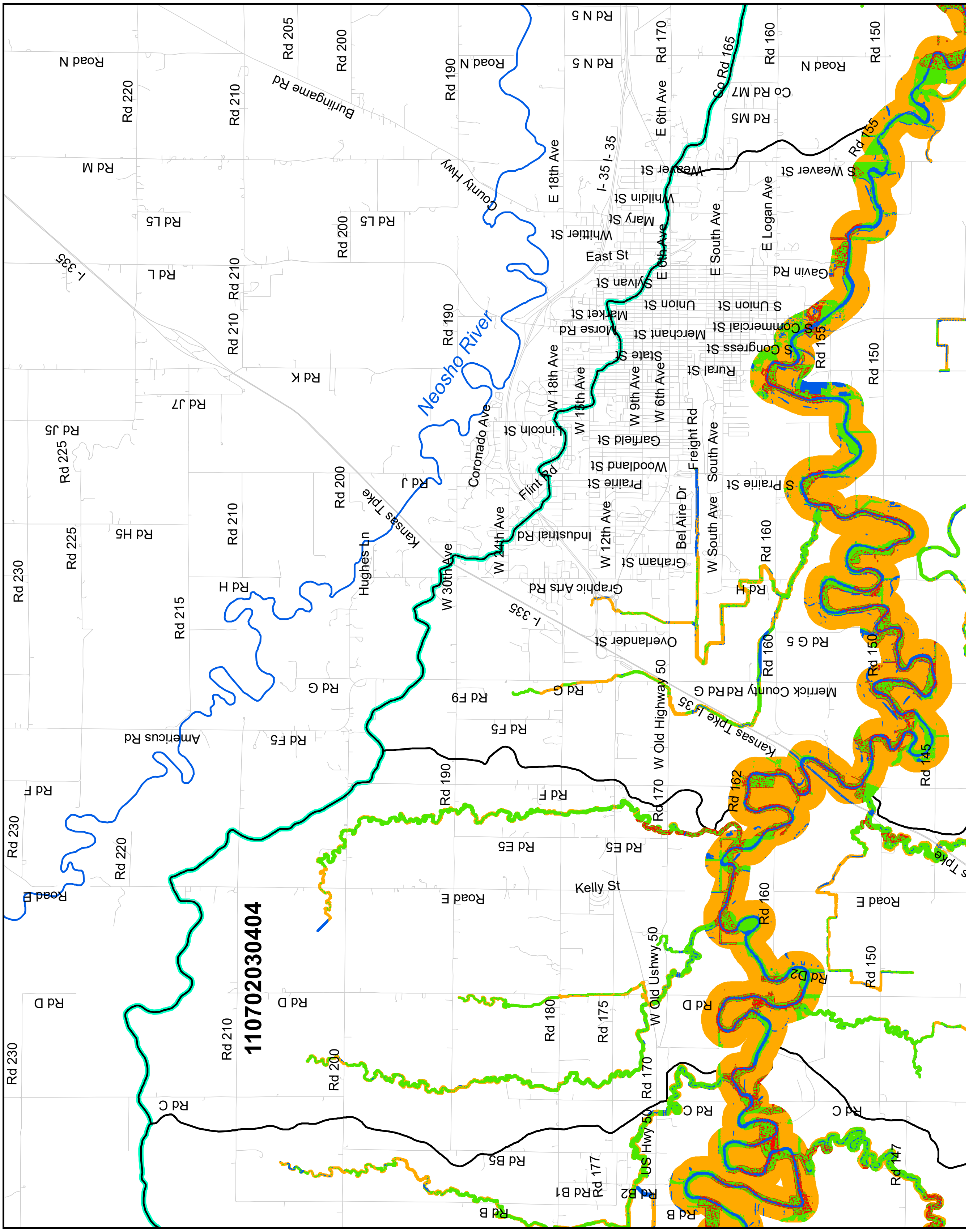
Riparian Forest Asssessment
HUC-12 = 110702030205
Cottonwood Study Area
NRCS-RCPP Agreement
March 2018
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads
Riparian Forest Class
Conservation
Developed
Establishment
Management
Water
Potential Historical Remnant Forest
HUC-12 Boundary
County Boundary
Roads
HUC-8 Boundary
Major River
0
6,000 Feet
1 inch = 6,000 feet
N
USDA
110702030205
180th Rd
T Rd
167 Rd
150 Rd
Norton Creek Rd
152 Rd
Sp Rd
Sharps Creek Rd
Rock Creek Rd
170 Rd
Spring Creek Rd 170 Rd
P Rd
Den Creek Rd
N Rd
160 Rd
M Rd
Buck Creek Rd
150 Rd
140 Rd
Camp Wood Rd
L Rd

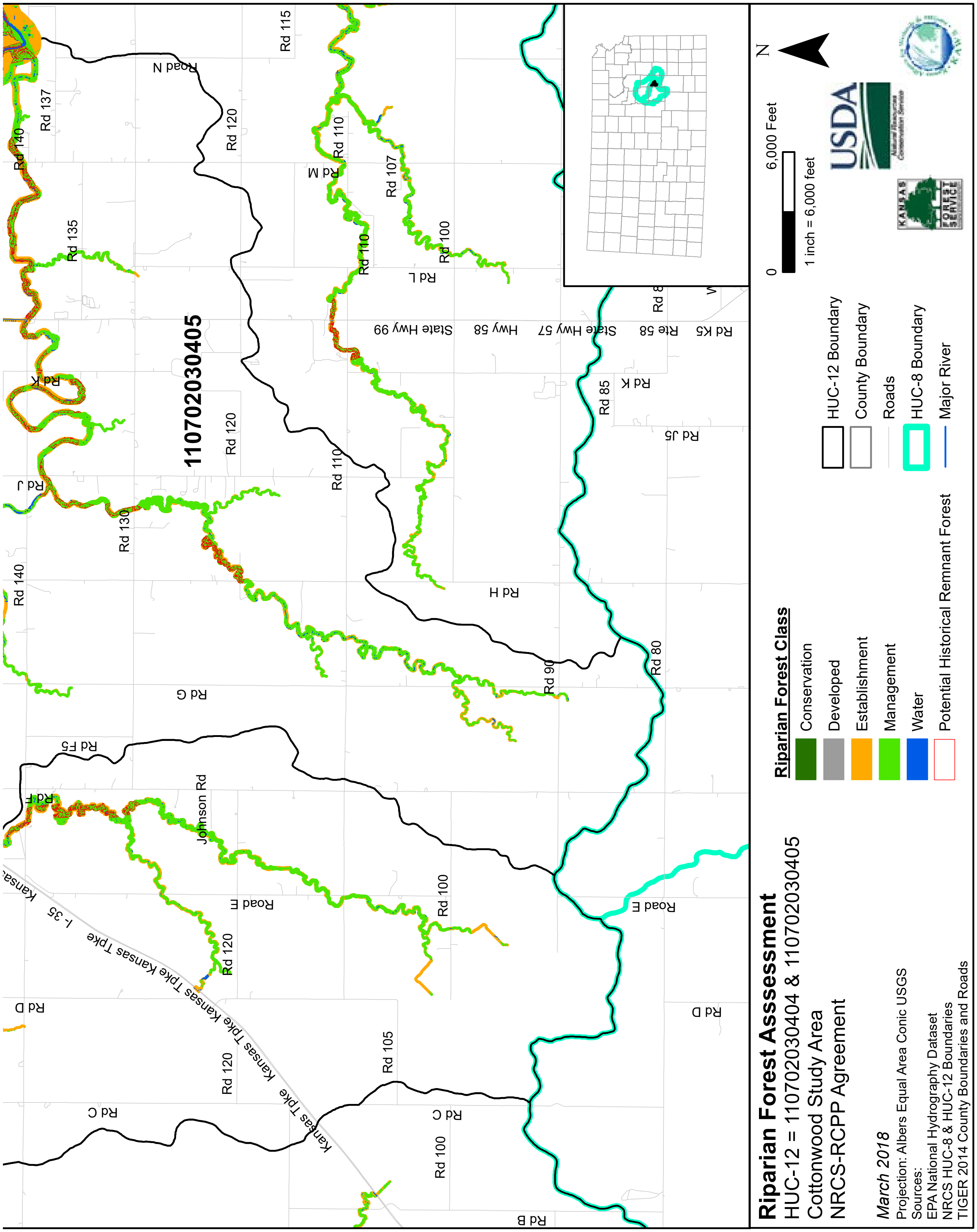

200 Rd
190 Rd
175 Rd
Yy Rd
I-35
Kansas Tpke
200th Rd
Bloody Creek Rd
180th Rd
T Rd
167 Rd
152 Rd
150 Rd
Norton Creek Rd
Sp Rd
Sharps Creek Rd
Mill Ave
Rock Creek Rd
120 Rd
2nd St S
5th St S
8th St
Airport Rd
Buck Creek Rd
Spring Creek Rd

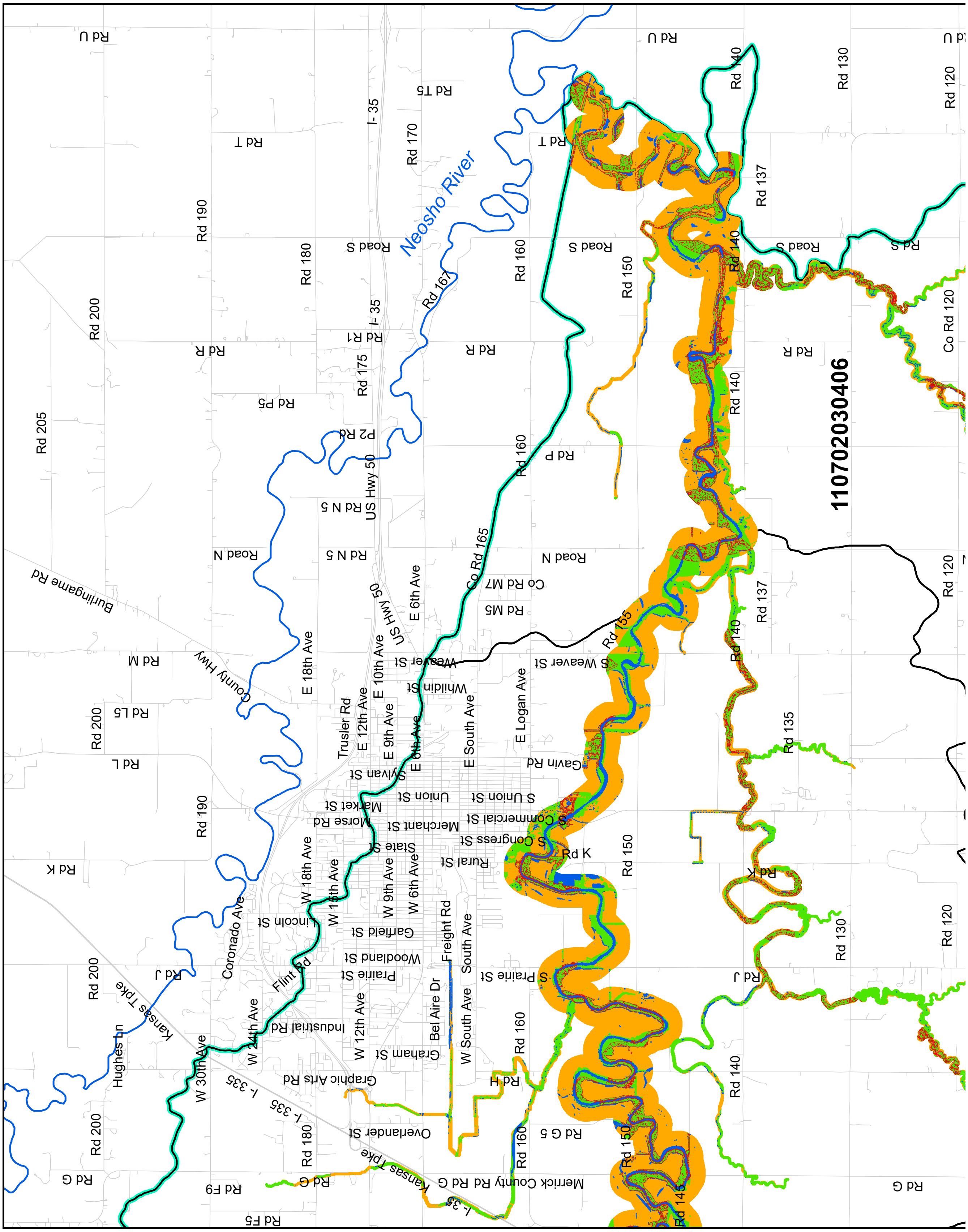

110702030305
Pasture Access Rd
Camp Creek Rd
Kansas Tpke
Sharps Creek Rd
Wp Rd
50 Rd
50 Rd
I- 35
Rogler St
Reed St
55 Rd
R Rd
State Hwy 177 Scn
State Hwy 177
Riparian Forest Assessment
HUC-12 = 110702030305
Cottonwood Study Area
NRCS-RCPP Agreement
March 2018
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads
Riparian Forest Class
Conservation
Developed
Establishment
Management
Water
Potential Historical Remnant Forest
HUC-12 Boundary
County Boundary
Roads
HUC-8 Boundary
Major River
0
6,000 Feet
1 inch = 6,000 feet
N
USDA

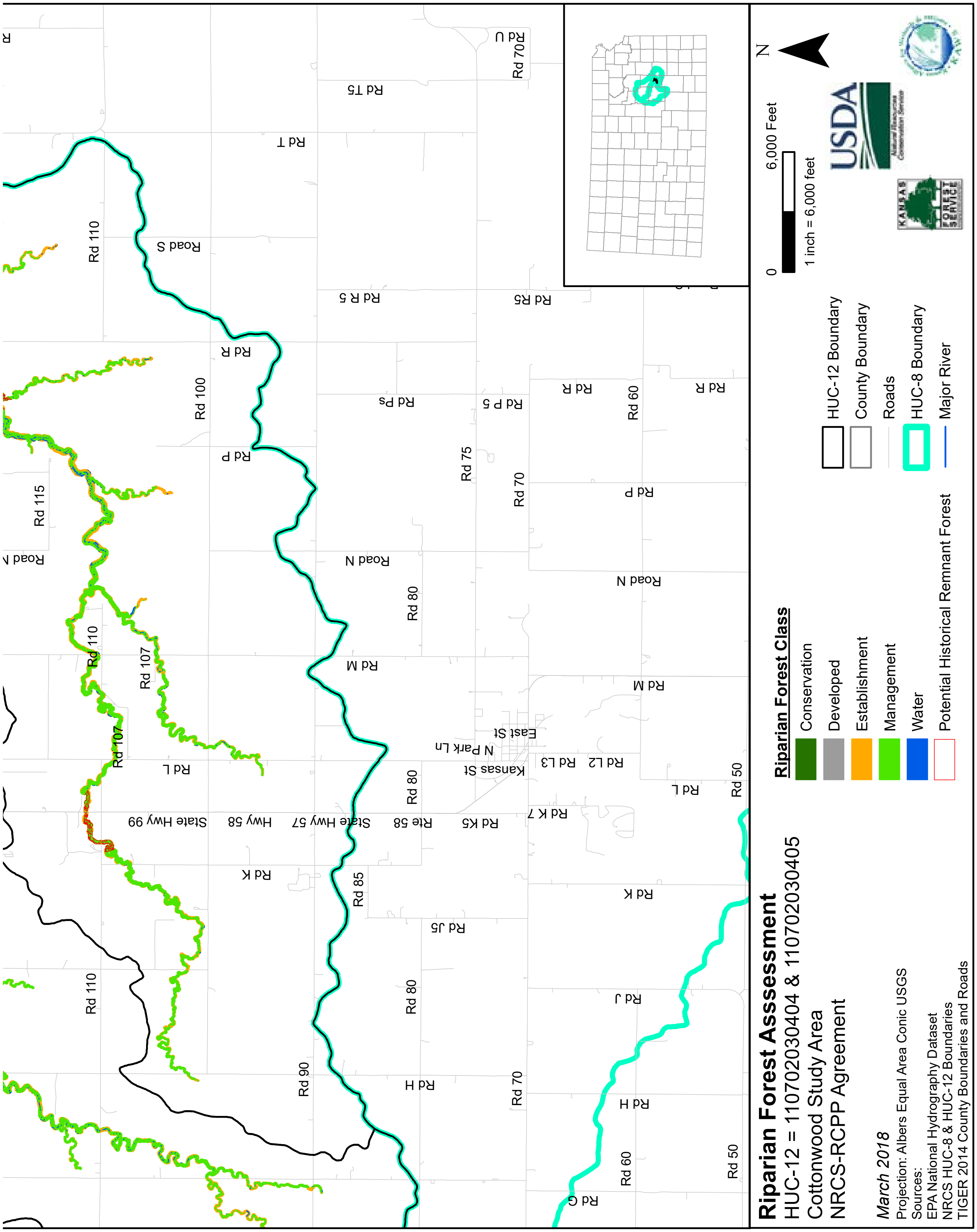

Neosho River
Morris
Chase
110702030402
110702030401
Locust St
Rd 240
Rd 230
Rd 210
Rd 200
Rd 190
Rd 180
Rd 175
Rd 170
Rd 160
Rd 155
Rd 150
Rd 147
Rd 140
Kelly St
Road E
Rd D
Rd D2
Rd C
Rd B
Rd B1
Rd B2
Rd B5
Rd A
W Old Ushwy 50
State Hwy 57
US Hwy 50
Xx Rd
Toledo Rd
Yy Rd
Zzp Rd
Zzg Rd
Zz Rd
Zw Rd
Zp Rd
Z Rd
Y Rd
X Rd
W Rd
V Rd
Uw Rd
U Rd
290 Rd
280 Rd
270 Rd
260 Rd
255 Rd
250 Rd
250th Rd
245 Rd
240 Rd
240th Rd
230 Rd
225th Rd
220 Rd
215 Rd
210 Rd
200 Rd
200th Rd
Old Hwy 50


Riparian Forest Asssessment
HUC-12 = 110702030401, 110702030402 &
110702030403
Cottonwood Study Area
NRCS-RCPP Agreement
March 2018
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Bounaries
TIGER 2014 County Boundaries and Roads
Riparian Forest Class
Conservation
Developed
Establishment
Management
Water
Potential Historical Remnant Forest
HUC-12 Boundary
County Boundary
Roads
HUC-8 Boundary
Major River
0
7,200 Feet
1 inch = 7,200 feet
N
USDA
110702030403
Kansas Tpke
I-35
Bloody Creek Rd
Sharps Creek Rd
Rd 120
Rd 110
Rd 100
Rd 90
Rd 105
Rd 80
Rd 130
175 Rd
190 Rd
180th Rd
167 Rd
150 Rd
Road E
Rd D
Rd C
Rd B
Yy Rd
Xx Rd
T Rd

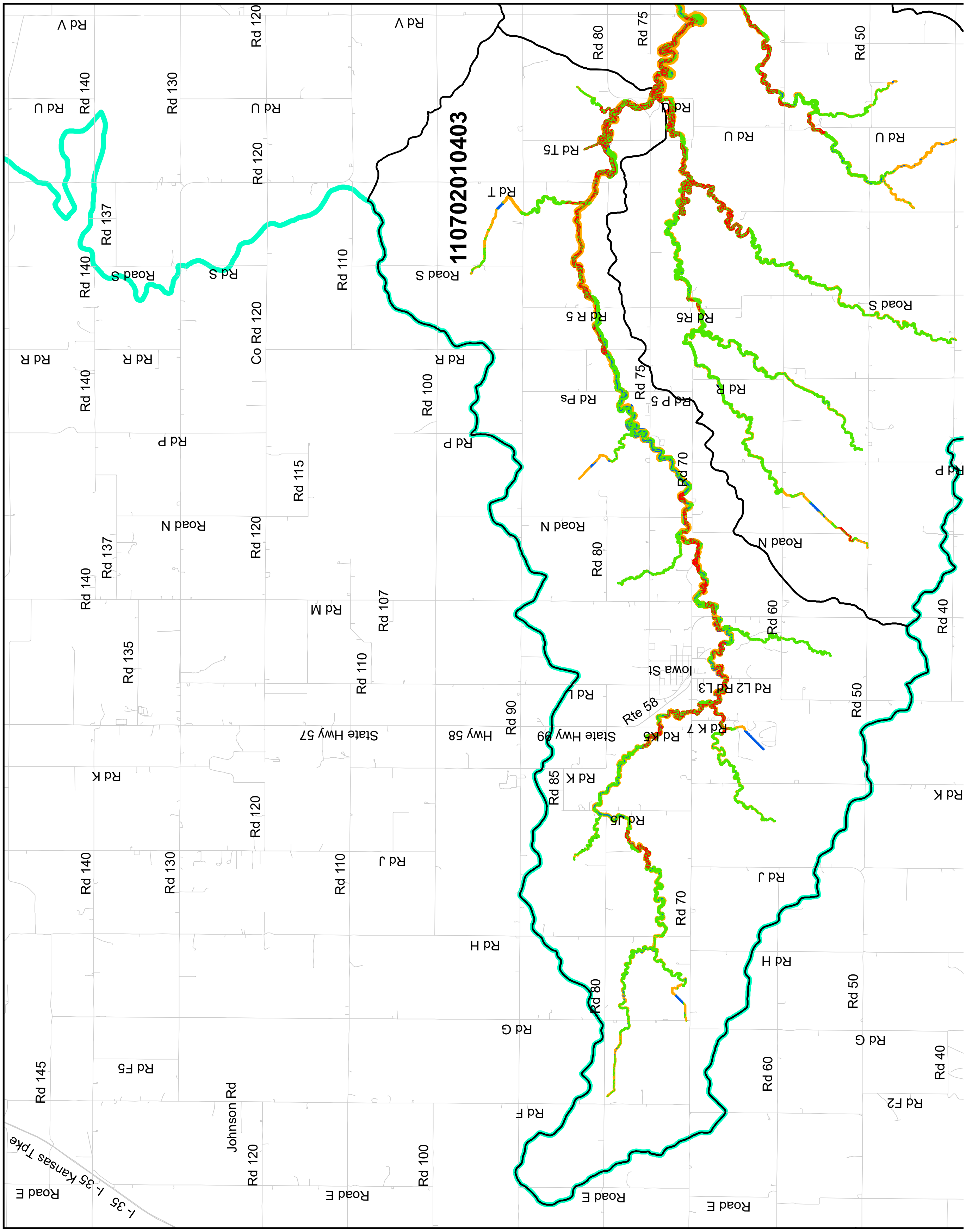

110702030404
Neosho River
Kansas Tpke
I- 335
I- 35 I- 35
Burlingame Rd
County Hwy
W Old Highway 50
W Old Ushwy 50
US Hwy 50
Merrick County Rd
Americus Rd
Kelly St
Graphic Arts Rd
Industrial Rd
Overlander St
Coronado Ave
Hughes Ln
Flint Rd
Freight Rd
Bel Aire Dr
E 18th Ave
W 18th Ave
W 15th Ave
W 12th Ave
W 9th Ave
W 6th Ave
E 6th Ave
W 24th Ave
W 30th Ave
E South Ave
W South Ave
South Ave
E Logan Ave
Weaver St
S Weaver St
Whittier St
Mary St
Whildin St
East St
Sylvan St
Union St
S Union St
Market St
Morse Rd
Merchant St
S Commercial St
State St
S Congress St
Rural St
Lincoln St
Garfield St
Woodland St
Prairie St
S Prairie St
Graham St
Gavin Rd
Co Rd 165
Co Rd M7
Road N
Road E
Rd 230
Rd 225
Rd 220
Rd 215
Rd 210
Rd 205
Rd 200
Rd 190
Rd 180
Rd 177
Rd 175
Rd 170
Rd 162
Rd 160
Rd 155
Rd 150
Rd 147
Rd 145
Rd N 5
Rd M5
Rd M
Rd L5
Rd L
Rd K
Rd J7
Rd J5
Rd J
Rd H5
Rd H
Rd G 5
Rd G
Rd F9
Rd F5
Rd F
Rd E5
Rd D
Rd D2
Rd C
Rd B5
Rd B1
Rd B2
Rd B

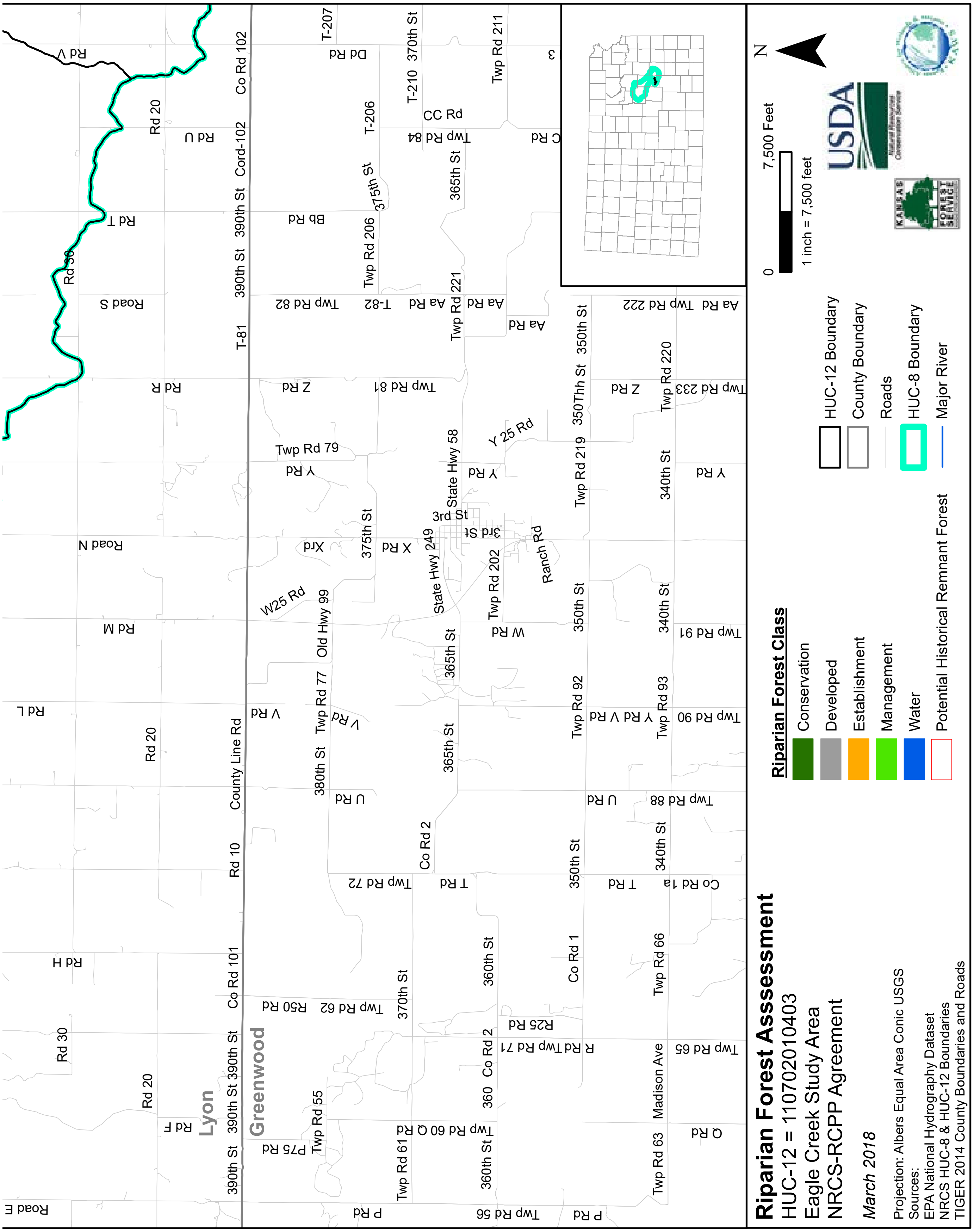

Riparian Forest Asssessment
HUC-12 = 110702030404 & 110702030405
Cottonwood Study Area
NRCS-RCPP Agreement
March 2018
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads
Riparian Forest Class
Conservation
Developed
Establishment
Management
Water
Potential Historical Remnant Forest
HUC-12 Boundary
County Boundary
Roads
HUC-8 Boundary
Major River
0
6,000 Feet
1 inch = 6,000 feet
N
USDA
110702030405
Kansas Tpke
I-35
Rd 140
Rd 137
Rd 135
Rd 130
Rd 120
Rd 115
Rd 110
Rd 107
Rd 105
Rd 100
Rd 90
Rd 85
Rd 80
Road N
Rd M
Rd L
Rd K
Rd J
Rd J5
Rd H
Rd G
Rd F5
Rd F
Road E
Rd D
Rd C
Rd B
Johnson Rd
State Hwy 99
Hwy 58
State Hwy 57
Rte 58
Rd K5

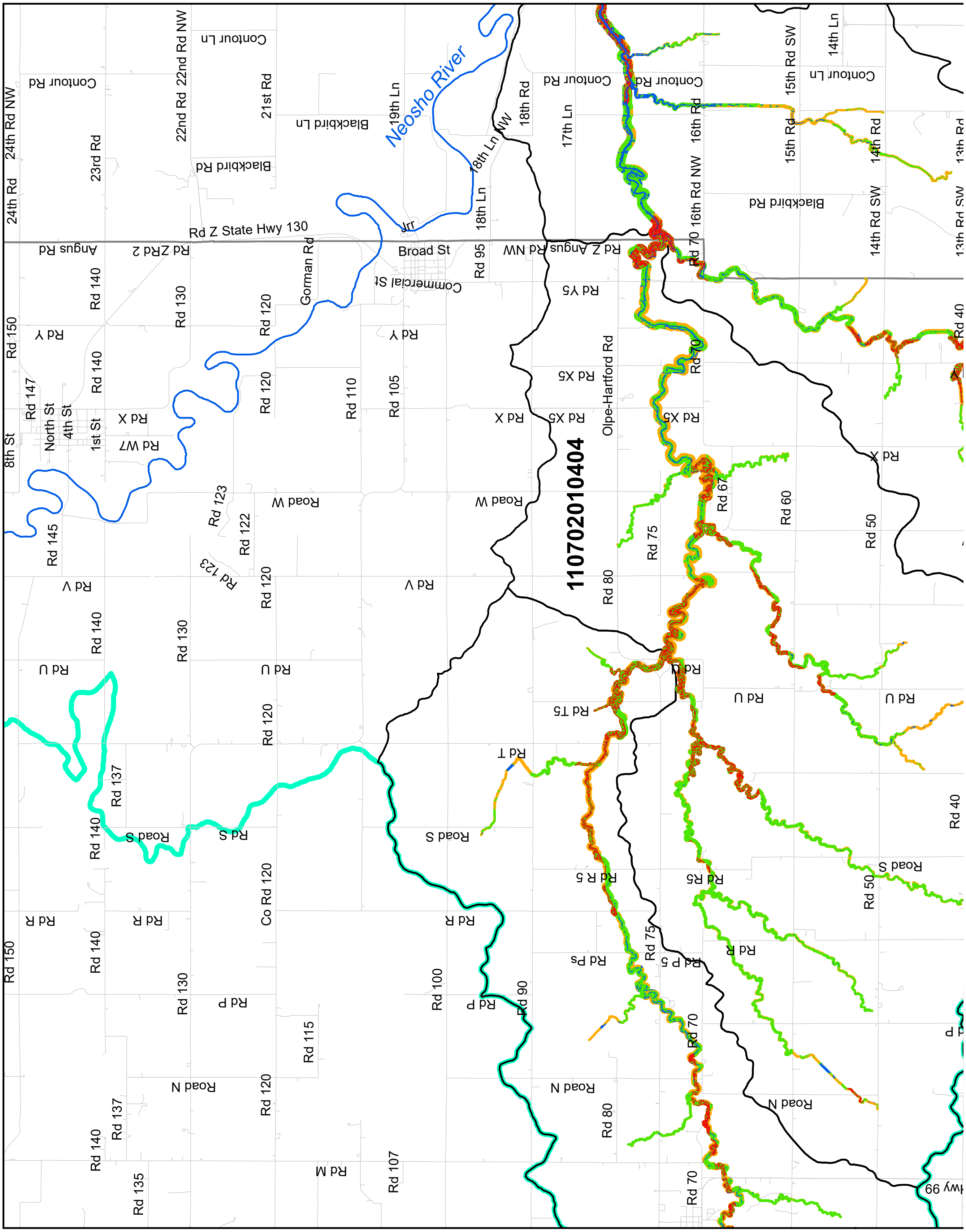

Neosho River
110702030406
I- 35
US Hwy 50
Co Rd 165
Burlingame Rd
County Hwy
Kansas Tpke
I- 335
Merrick County Rd
Rd 205
Rd 200
Rd 190
Rd 180
Rd 175
Rd 170
Rd 167
Rd 160
Rd 155
Rd 150
Rd 145
Rd 140
Rd 137
Rd 135
Rd 130
Rd 120
Co Rd 120
Rd U
Rd T5
Rd T
Road S
Rd R1
Rd R
Rd P5
P2 Rd
Rd P
Rd N 5
Road N
Co Rd M7
Rd M5
Rd M
Rd L5
Rd L
Rd K
Rd J
Rd H
Rd G 5
Rd G
Rd F9
Rd F5
E 18th Ave
E 12th Ave
E 10th Ave
E 9th Ave
E 6th Ave
Trusler Rd
Weaver St
S Weaver St
Whildin St
E South Ave
E Logan Ave
Gavin Rd
Sylvan St
Union St
S Union St
Market St
Morse Rd
Merchant St
S Commercial St
State St
S Congress St
Rural St
W 18th Ave
W 15th Ave
W 9th Ave
W 6th Ave
Freight Rd
Lincoln St
Garfield St
Woodland St
Prairie St
S Prairie St
Coronado Ave
Flint Rd
South Ave
W South Ave
Bel Aire Dr
W 12th Ave
W 24th Ave
W 30th Ave
Hughes Ln
Industrial Rd
Graham St
Graphic Arts Rd
Overlander St

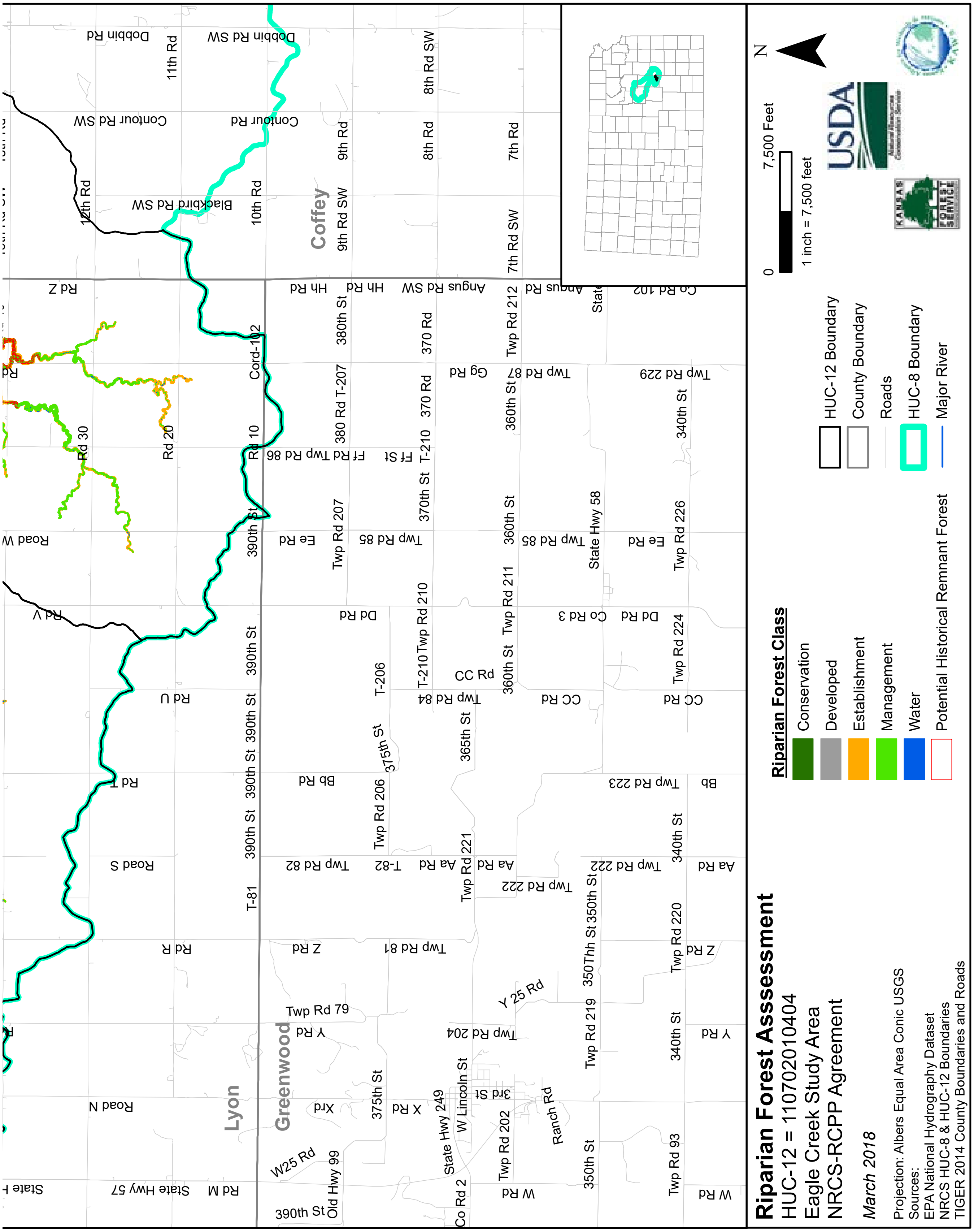


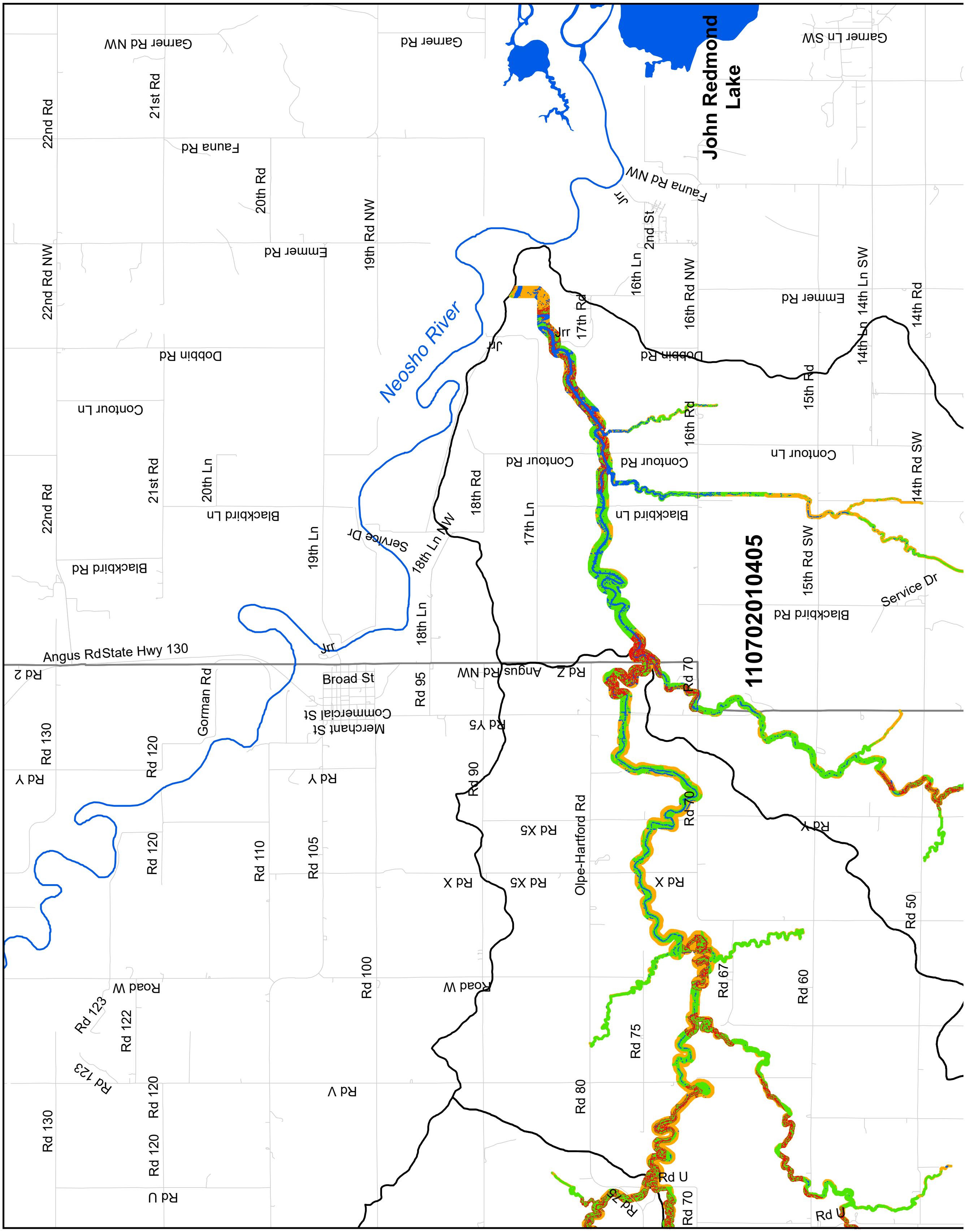
Riparian Forest Assessment
HUC-12 = 110702030404 & 110702030405
Cottonwood Study Area
NRCS-RCPP Agreement
March 2018
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads
Riparian Forest Class
Conservation
Developed
Establishment
Management
Water
Potential Historical Remnant Forest
HUC-12 Boundary
County Boundary
Roads
HUC-8 Boundary
Major River
0
6,000 Feet
1 inch = 6,000 feet
N

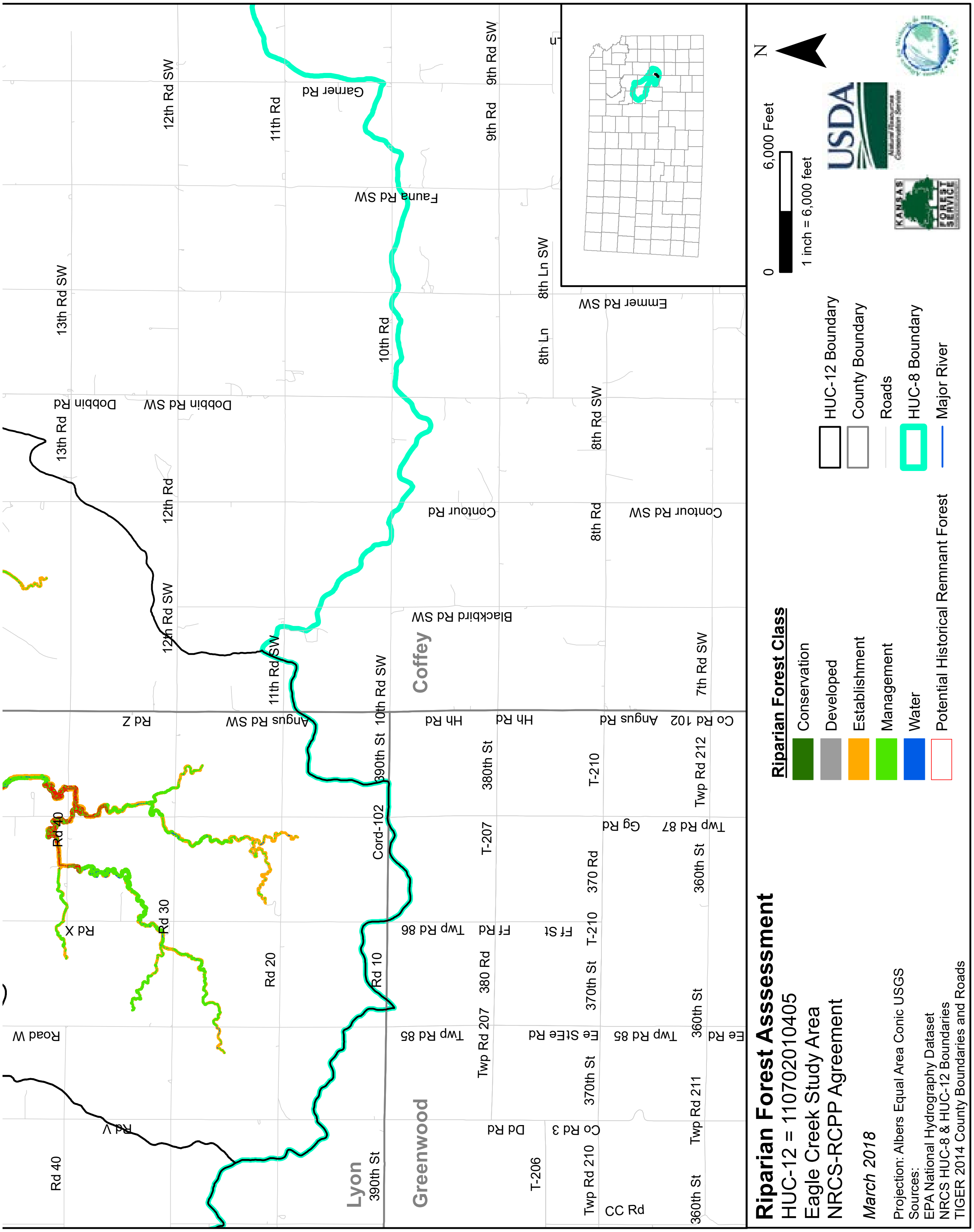

110702010403
Rd V
Rd U
Rd T
Rd T5
Road S
Rd S
Rd R
Rd R 5
Rd R5
Rd Ps
Rd P 5
Rd P
Road N
Rd M
Iowa St
Rd L
Rd L2
Rd L3
Rte 58
State Hwy 57
Hwy 58
State Hwy 99
Rd K
Rd K5
Rd K 7
Rd J5
Rd J
Rd H
Rd G
Rd F
Rd F2
Rd F5
Road E
Rd 40
Rd 50
Rd 60
Rd 70
Rd 75
Rd 80
Rd 85
Rd 90
Rd 100
Rd 107
Rd 110
Rd 115
Rd 120
Co Rd 120
Rd 130
Rd 135
Rd 137
Rd 140
Rd 145
Johnson Rd
I-35
I-35 Kansas Tpke

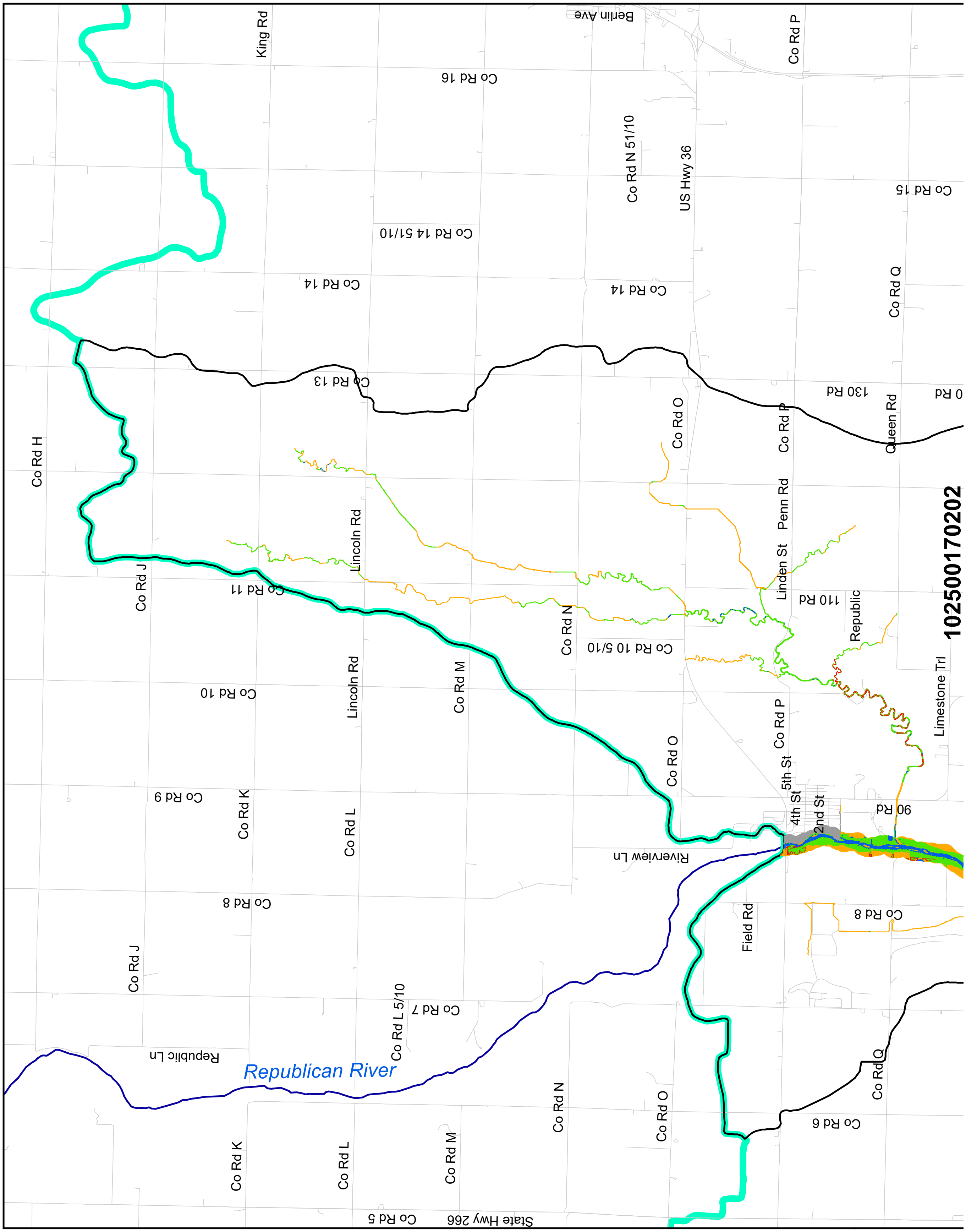

Riparian Forest Asssessment
HUC-12 = 110702010403
Eagle Creek Study Area
NRCS-RCPP Agreement
March 2018
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads
Riparian Forest Class
Conservation
Developed
Establishment
Management
Water
Potential Historical Remnant Forest
HUC-12 Boundary
County Boundary
Roads
HUC-8 Boundary
Major River
0
7,500 Feet
1 inch = 7,500 feet
N
USDA
Lyon
Greenwood

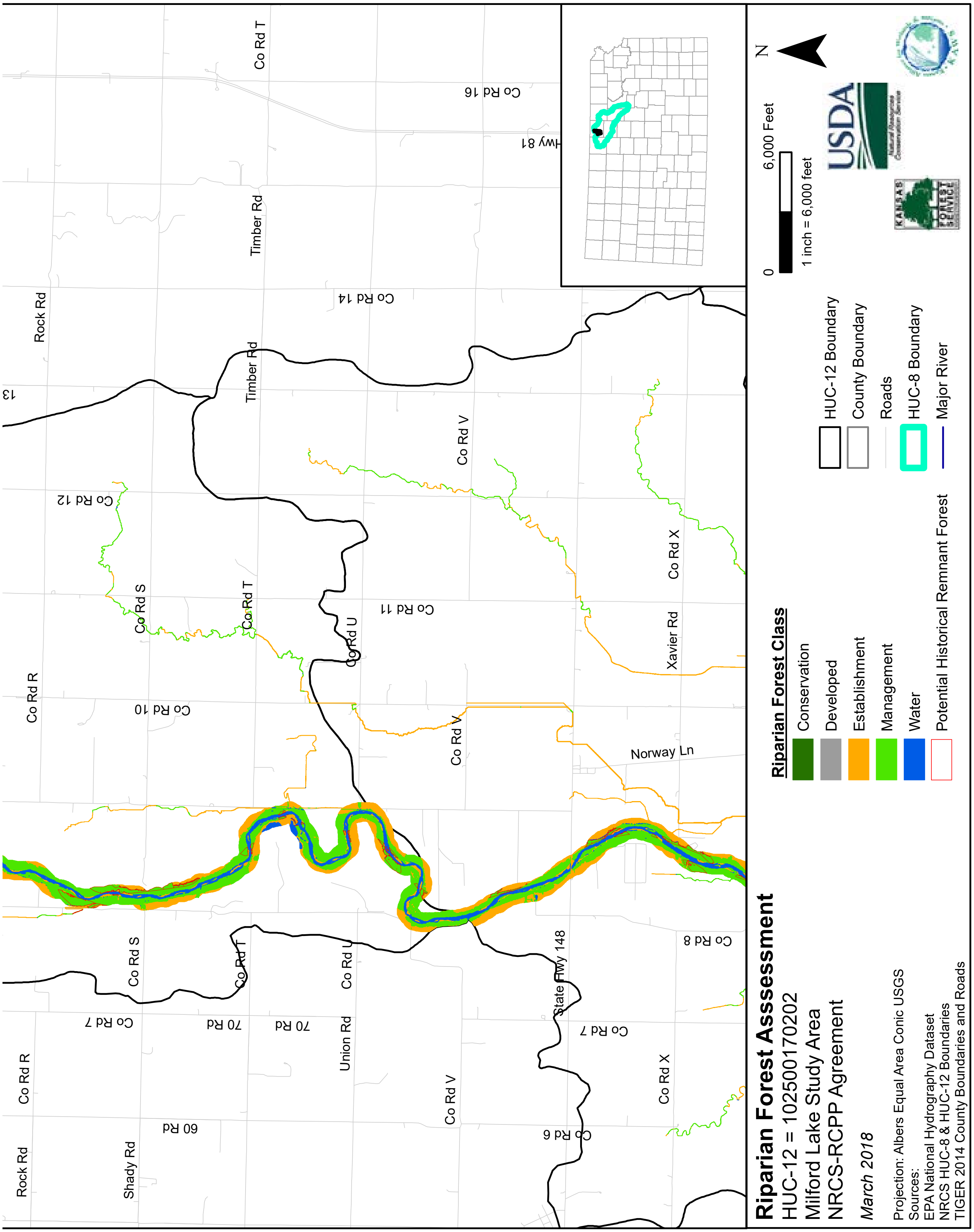

110702010404
Neosho River
Rd Z State Hwy 130
Broad St
Commercial St
Olpe-Hartford Rd
Contour Rd
Contour Ln
Blackbird Rd
Blackbird Ln
Angus Rd
Rd Z Angus Rd NW
Gorman Rd
24th Rd NW
24th Rd
23rd Rd
22nd Rd
22nd Rd NW
21st Rd
19th Ln
18th Ln NW
18th Ln
18th Rd
17th Ln
16th Rd
16th Rd NW
15th Rd SW
15th Rd
14th Ln
14th Rd
14th Rd SW
North St
4th St
1st St
8th St
Road W
Road S
Road N
Rd 150
Rd 147
Rd 145
Rd 140
Rd 137
Rd 135
Rd 130
Rd 123
Rd 122
Rd 120
Co Rd 120
Rd 115
Rd 110
Rd 107
Rd 105
Rd 100
Rd 95
Rd 90
Rd 80
Rd 75
Rd 70
Rd 67
Rd 60
Rd 50
Rd 40
Rd Y
Rd Y5
Rd X
Rd X5
Rd W7
Rd V
Rd U
Rd T
Rd T5
Rd R
Rd R5
Rd P
Rd P5
Rd M
Hwy 99

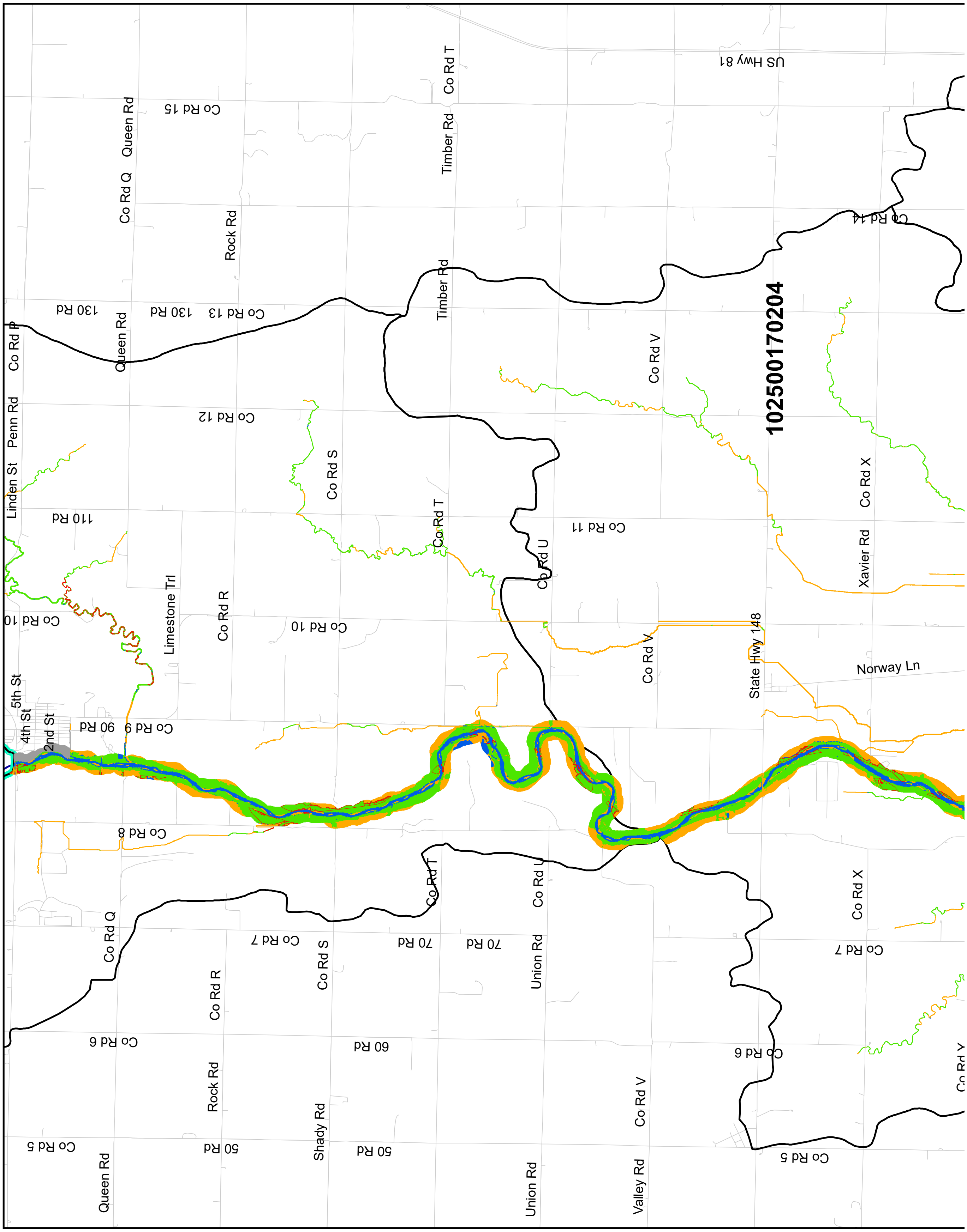

Riparian Forest Assessment
HUC-12 = 110702010404
Eagle Creek Study Area
NRCS-RCPP Agreement
March 2018
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads
Riparian Forest Class
Conservation
Developed
Establishment
Management
Water
Potential Historical Remnant Forest
HUC-12 Boundary
County Boundary
Roads
HUC-8 Boundary
Major River
0
7,500 Feet
1 inch = 7,500 feet
N
USDA
Lyon
Greenwood
Coffey


John Redmond Lake
Neosho River
110702010405
Angus Rd State Hwy 130
Olpe-Hartford Rd
Broad St
Commercial St
Merchant St
Garner Rd NW
Garner Rd
Garner Ln SW
Fauna Rd
Fauna Rd NW
Emmer Rd
Dobbin Rd
Contour Ln
Contour Rd
Blackbird Ln
Blackbird Rd
Service Dr
Angus Rd NW
22nd Rd
22nd Rd NW
21st Rd
20th Rd
20th Ln
19th Rd NW
19th Ln
18th Ln NW
18th Rd
18th Ln
17th Rd
17th Ln
16th Ln
16th Rd NW
16th Rd
15th Rd
15th Rd SW
14th Ln SW
14th Ln
14th Rd
14th Rd SW
2nd St
Rd 2
Rd Z
Rd Y
Rd Y5
Rd X
Rd X5
Road W
Rd V
Rd U
Rd 50
Rd 60
Rd 67
Rd 70
Rd 75
Rd 80
Rd 90
Rd 95
Rd 100
Rd 105
Rd 110
Rd 120
Rd 122
Rd 123
Rd 130
Gorman Rd


Riparian Forest Asssessment
HUC-12 = 110702010405
Eagle Creek Study Area
NRCS-RCPP Agreement
March 2018
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads
Riparian Forest Class
Conservation
Developed
Establishment
Management
Water
Potential Historical Remnant Forest
HUC-12 Boundary
County Boundary
Roads
HUC-8 Boundary
Major River
0
6,000 Feet
1 inch = 6,000 feet
N
Lyon
Greenwood
Coffey


102500170202
Republican River
Republic
Co Rd H
Co Rd J
Co Rd K
Co Rd L
Co Rd M
Co Rd N
Co Rd O
Co Rd P
Co Rd Q
Co Rd 5
Co Rd 6
Co Rd 7
Co Rd 8
Co Rd 9
Co Rd 10
Co Rd 11
Co Rd 13
Co Rd 14
Co Rd 15
Co Rd 16
Co Rd 10 5/10
Co Rd 14 51/10
Co Rd N 51/10
Co Rd L 5/10
King Rd
Berlin Ave
US Hwy 36
State Hwy 266
Lincoln Rd
Penn Rd
Linden St
Queen Rd
Limestone Trl
Field Rd
Riverview Ln
Republic Ln
5th St
4th St
2nd St
90 Rd
110 Rd
130 Rd
0 Rd


Riparian Forest Assessment
HUC-12 = 102500170202
Milford Lake Study Area
NRCS-RCPP Agreement
March 2018
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads
Riparian Forest Class
Conservation
Developed
Establishment
Management
Water
Potential Historical Remnant Forest
HUC-12 Boundary
County Boundary
Roads
HUC-8 Boundary
Major River
0
6,000 Feet
1 inch = 6,000 feet
N
Rock Rd
Co Rd R
Shady Rd
Co Rd S
Co Rd T
Union Rd
Co Rd U
Co Rd V
Co Rd X
Timber Rd
Xavier Rd
Norway Ln
State Hwy 148
Hwy 81
60 Rd
70 Rd
Co Rd 6
Co Rd 7
Co Rd 8
Co Rd 10
Co Rd 11
Co Rd 12
Co Rd 14
Co Rd 16
13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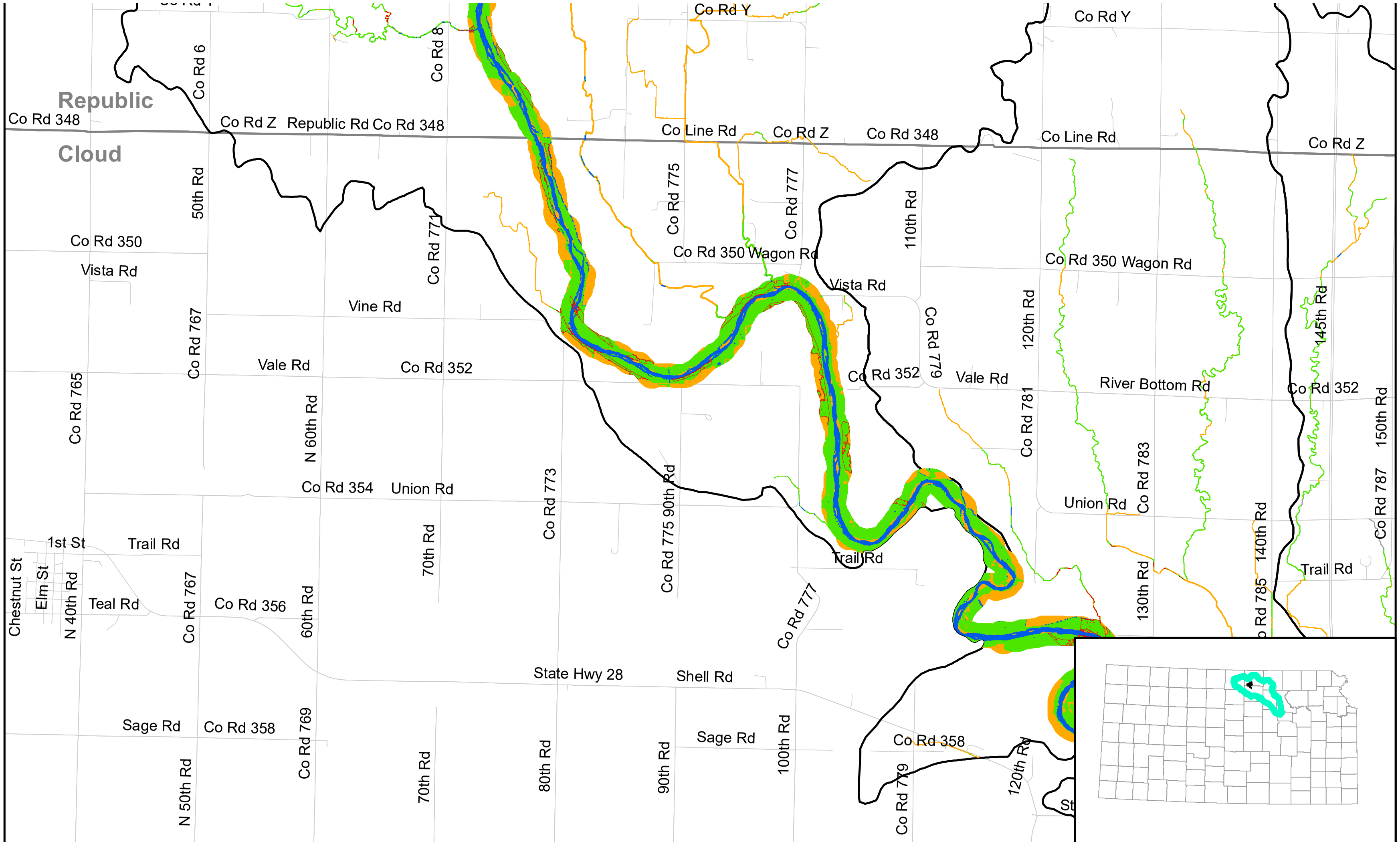
US Hwy 81
Co Rd 15
Co Rd 14
Co Rd 13
130 Rd
Co Rd 12
110 Rd
Co Rd 11
Co Rd 10
Co Rd 9
90 Rd
Co Rd 8
Co Rd 7
70 Rd
Co Rd 6
60 Rd
Co Rd 5
50 Rd
Co Rd P
Co Rd Q
Co Rd R
Co Rd S
Co Rd T
Co Rd U
Co Rd V
Co Rd X
Queen Rd
Rock Rd
Timber Rd
Penn Rd
Linden St
Limestone Trl
5th St
4th St
2nd St
State Hwy 148
Norway Ln
Xavier Rd
Shady Rd
Union Rd
Valley Rd



Riparian Forest Asssessment
HUC-12 = 102500170204
Milford Lake Study Area
NRCS-RCPP Agreement

March 2018

Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads

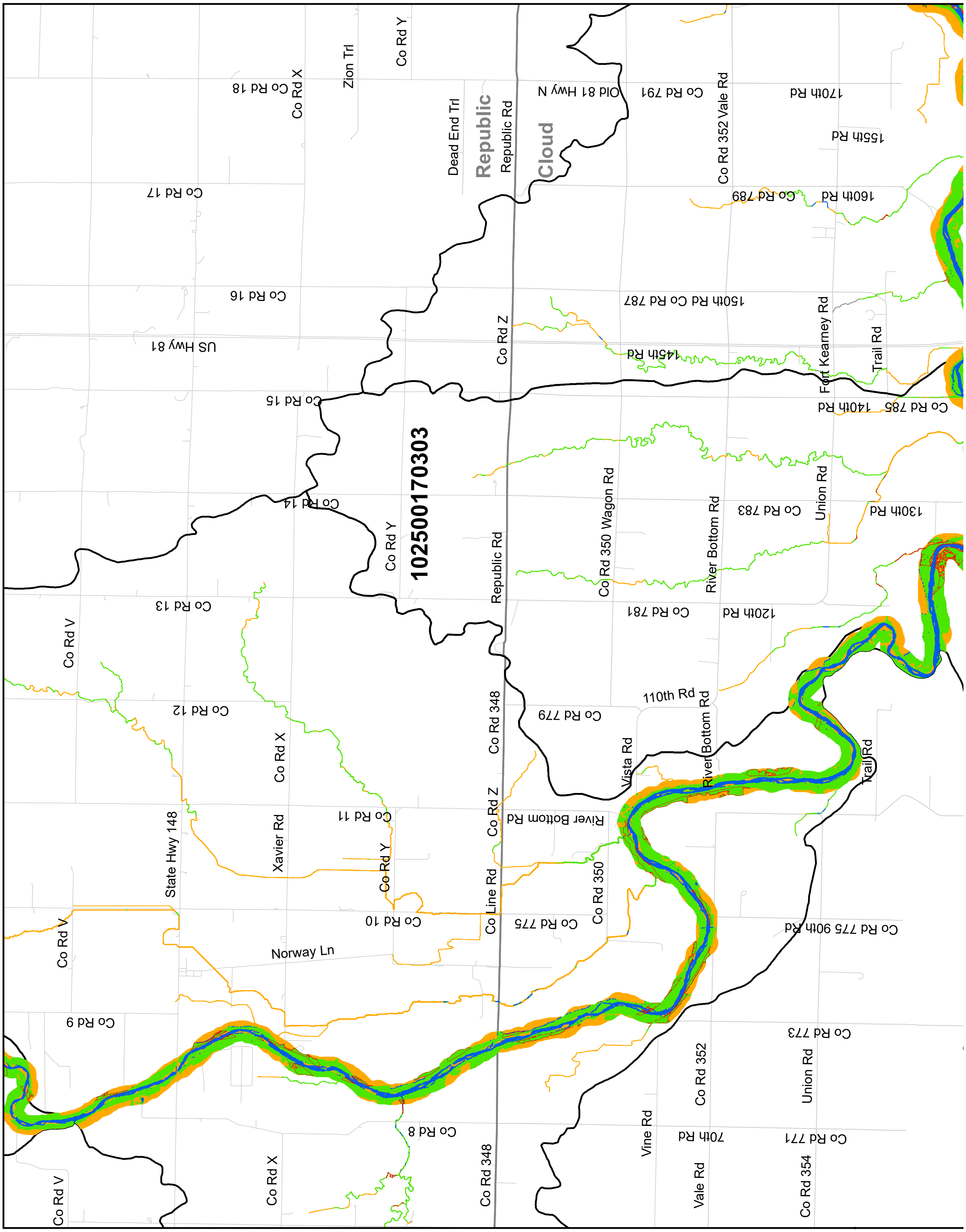
Riparian Forest Class
Conservation
Developed
Establishment
Management
Water
Potential Historical Remnant Forest

HUC-12 Boundary
County Boundary
Roads
HUC-8 Boundary
Major River

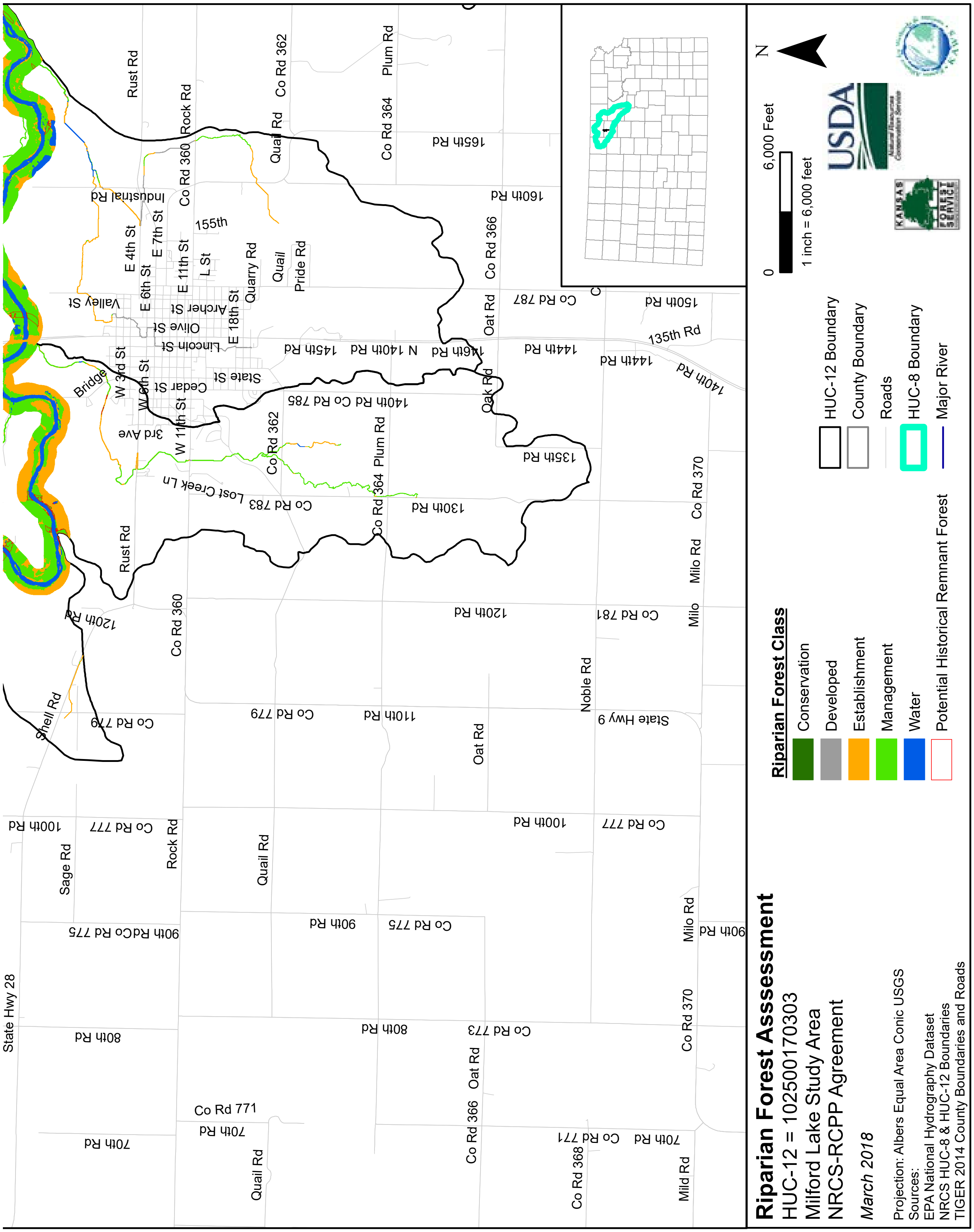
0 6,000 Feet
1 inch = 6,000 feet

N

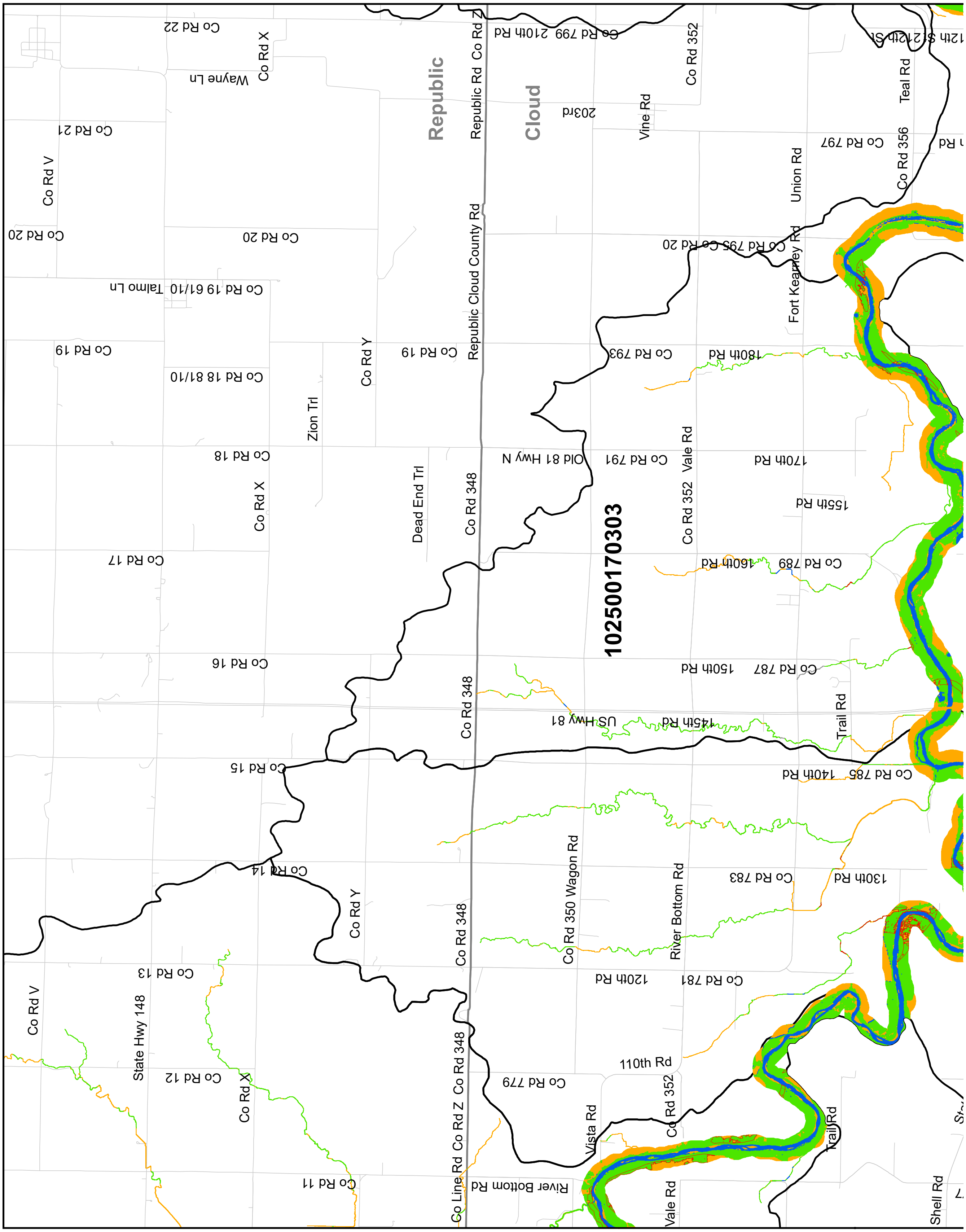
USDA
Natural Resources Conservation Service



1025001703033
Republic
Cloud
Co Rd X
Co Rd 18
Zion Trl
Co Rd Y
Dead End Trl
Republic Rd
Old 81 Hwy N
Co Rd 791
Co Rd 352 Vale Rd
170th Rd
155th Rd
Co Rd 17
Co Rd 789
160th Rd
Co Rd 16
150th Rd Co Rd 787
Co Rd Z
US Hwy 81
145th Rd
Fort Kearney Rd
Trail Rd
Co Rd 15
Co Rd 785
140th Rd
Co Rd 14
Co Rd Y
Co Rd 350 Wagon Rd
River Bottom Rd
Co Rd 783
Union Rd
130th Rd
Republic Rd
Co Rd 13
Co Rd 781
120th Rd
Co Rd V
Co Rd 12
Co Rd 348
Co Rd 779
110th Rd
Co Rd X
Vista Rd
River Bottom Rd
Trail Rd
State Hwy 148
Xavier Rd
Co Rd 11
Co Rd Z
River Bottom Rd
Co Rd Y
Line Rd
Co Rd 350
Co Rd V
Co Rd 10
Co Rd 775
Co Rd 775 90th Rd
Norway Ln
Co Rd 9
Co Rd 773
Co Rd 352
Union Rd
Co Rd 8
Vine Rd
70th Rd
Co Rd 771
Co Rd V
Co Rd X
Co Rd 348
Vale Rd
Co Rd 354



Riparian Forest Assessment
HUC-12 = 102500170303
Milford Lake Study Area
NRCS-RCPP Agreement
March 2018
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads
Riparian Forest Class
Conservation
Developed
Establishment
Management
Water
Potential Historical Remnant Forest
HUC-12 Boundary
County Boundary
Roads
HUC-8 Boundary
Major River
0
6,000 Feet
1 inch = 6,000 feet
N
USDA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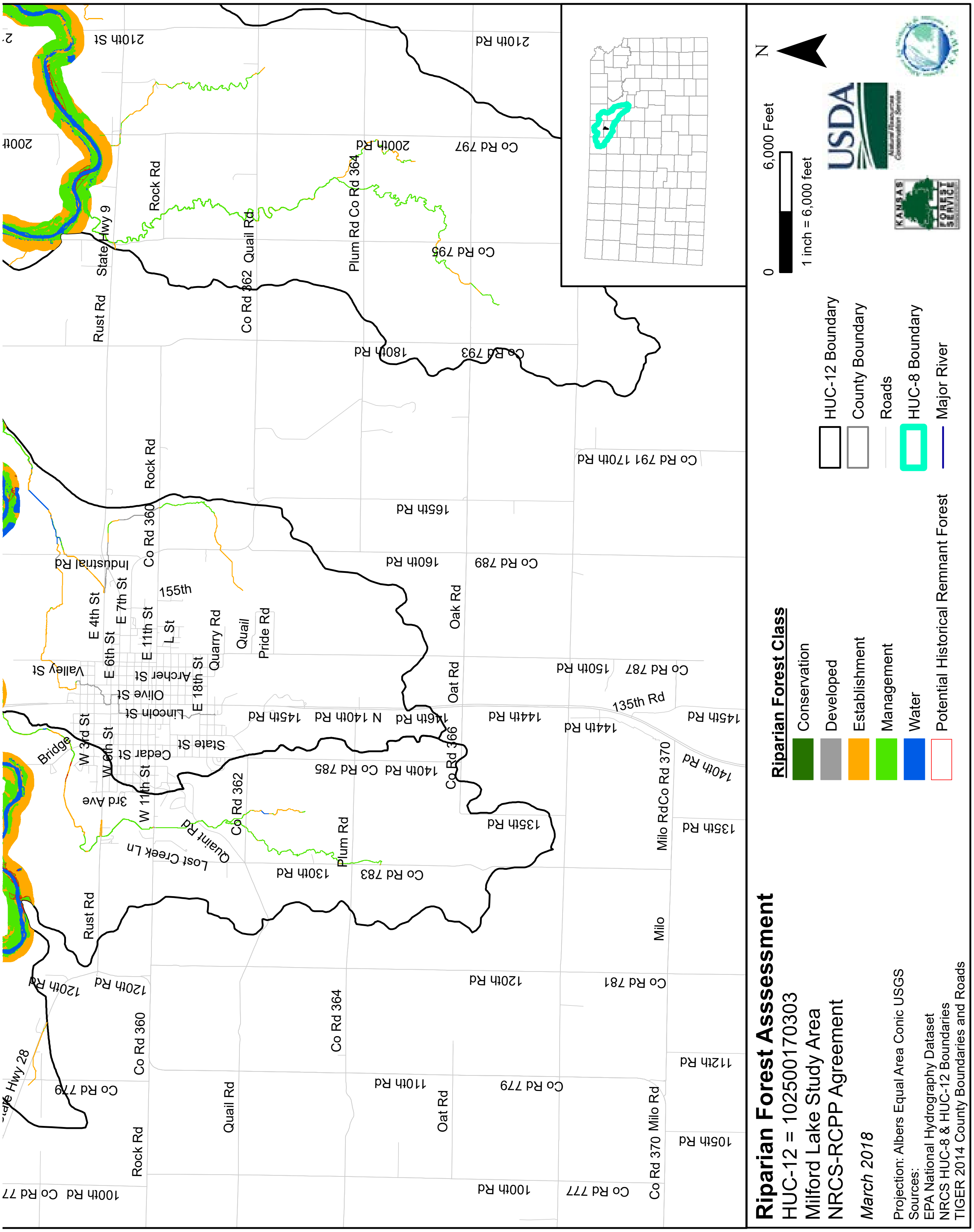
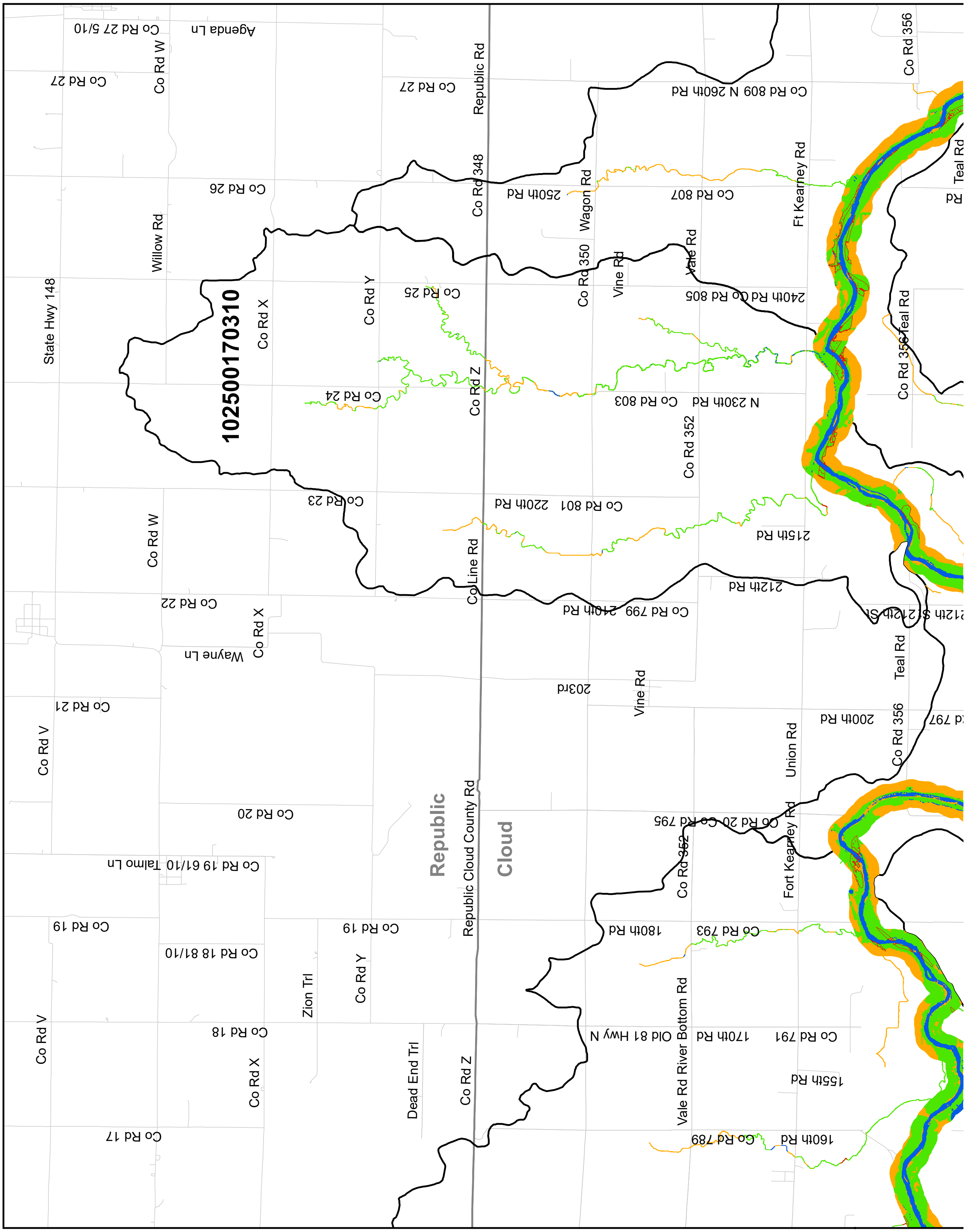
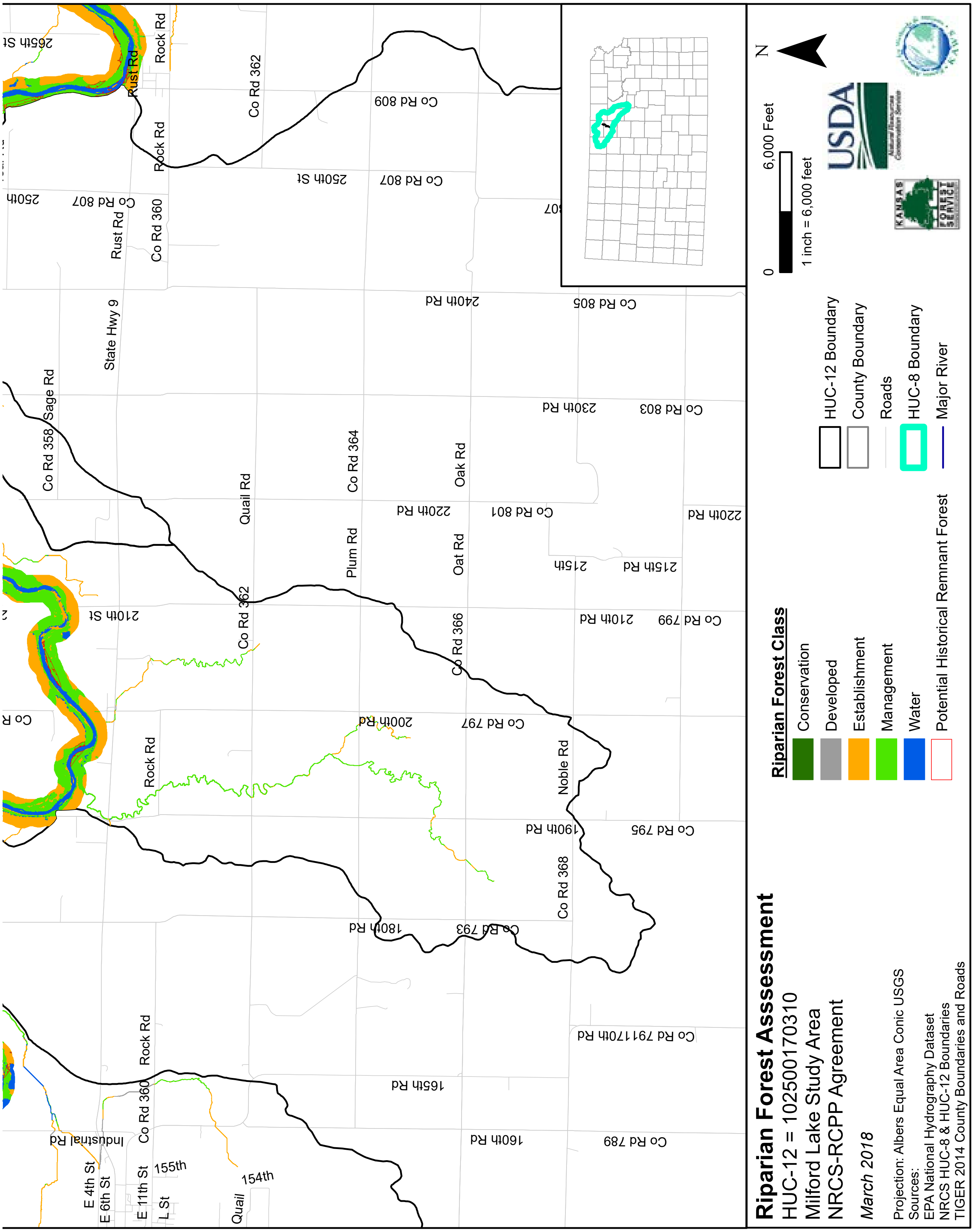
Cloud
102500170303
Co Rd 22
Co Rd X
Wayne Ln
Co Rd 21
Co Rd V
Co Rd 20
Co Rd 19 61/10
Talmo Ln
Co Rd 19
Co Rd 18 81/10
Co Rd Y
Zion Trl
Co Rd 18
Dead End Trl
Co Rd 348
Co Rd 17
Co Rd 16
Co Rd 15
Co Rd 14
Co Rd 13
State Hwy 148
Co Rd 12
Co Rd 11
Co Line Rd
Co Rd Z
River Bottom Rd
Republic Rd
Republic Cloud County Rd
210th Rd
Co Rd 799
Co Rd 352
203rd
Vine Rd
12th St
Teal Rd
Co Rd 797
Co Rd 356
Union Rd
Co Rd 795
Fort Kearney Rd
Co Rd 793
180th Rd
Old 81 Hwy N
Co Rd 791
Vale Rd
170th Rd
155th Rd
160th Rd
Co Rd 789
150th Rd
Co Rd 787
US Hwy 81
145th Rd
Trail Rd
Co Rd 785
140th Rd
Co Rd 350 Wagon Rd
Co Rd 783
130th Rd
120th Rd
Co Rd 781
110th Rd
Co Rd 779
Vista Rd
Shell Rd



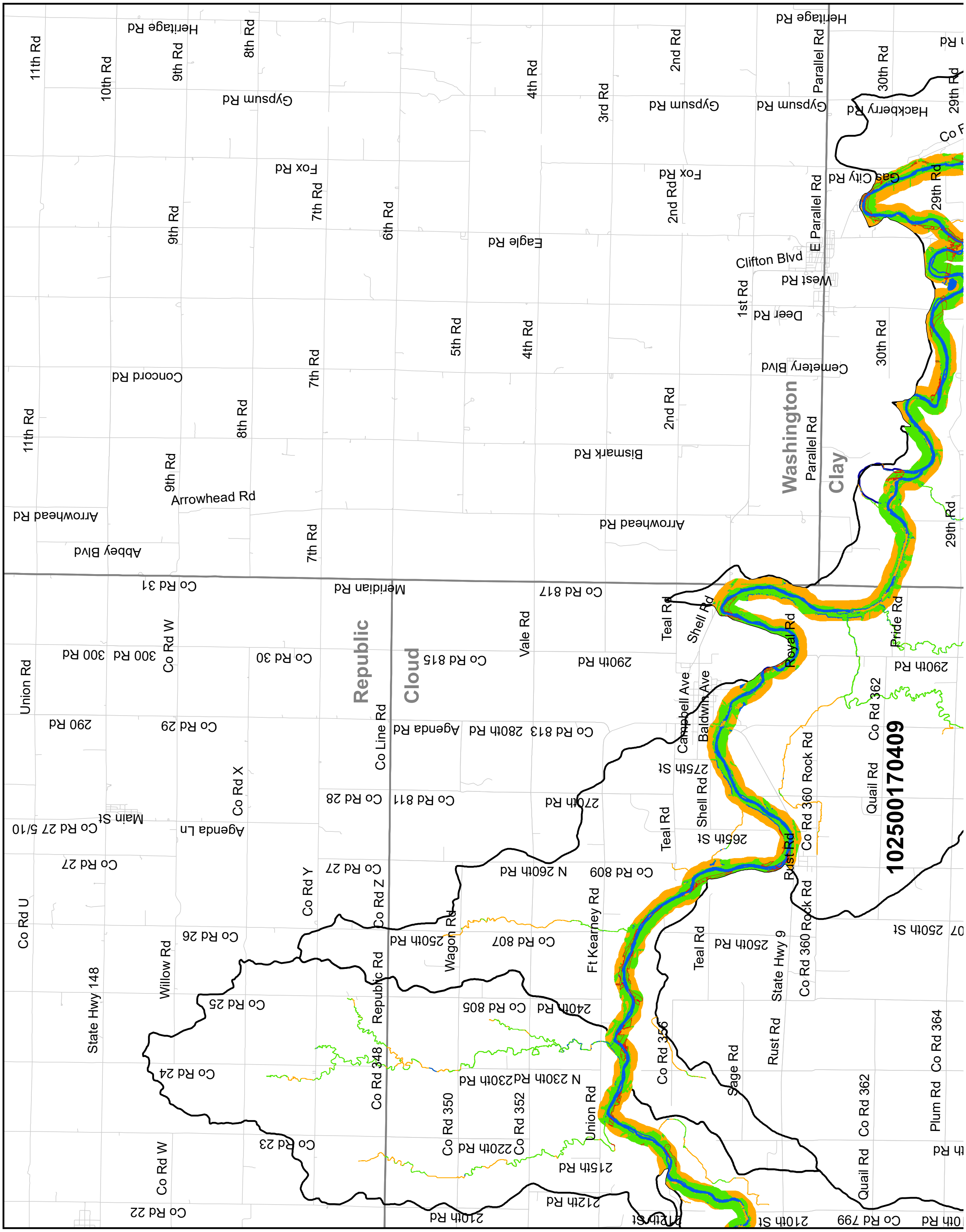
Riparian Forest Assessment
HUC-12 = 102500170303
Milford Lake Study Area
NRCS-RCPP Agreement
March 2018
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads
Riparian Forest Class
Conservation
Developed
Establishment
Management
Water
Potential Historical Remnant Forest
HUC-12 Boundary
County Boundary
Roads
HUC-8 Boundary
Major River
0
6,000 Feet
1 inch = 6,000 feet
N
Rust Rd
State Hwy 9
Rock Rd
Co Rd 362
Quail Rd
Plum Rd
Co Rd 364
Co Rd 360
Industrial Rd
E 4th St
E 7th St
E 6th St
E 11th St
155th
L St
Quarry Rd
Quail
Pride Rd
Oak Rd
Oat Rd
Valley St
Olive St
Archer St
E 18th St
Lincoln St
Cedar St
State St
W 3rd St
W 6th St
W 11th St
3rd Ave
Bridge
Lost Creek Ln
Quaint Rd
Co Rd 366
Milo Rd
Co Rd 370
Milo
135th Rd
210th St
210th Rd
200th Rd
Co Rd 797
Co Rd 795
180th Rd
Co Rd 793
Co Rd 791
170th Rd
165th Rd
160th Rd
Co Rd 789
150th Rd
Co Rd 787
145th Rd
N 140th Rd
146th Rd
144th Rd
140th Rd
Co Rd 785
130th Rd
Co Rd 783
120th Rd
Co Rd 781
112th Rd
110th Rd
Co Rd 779
105th Rd
100th Rd
Co Rd 777
State Hwy 28

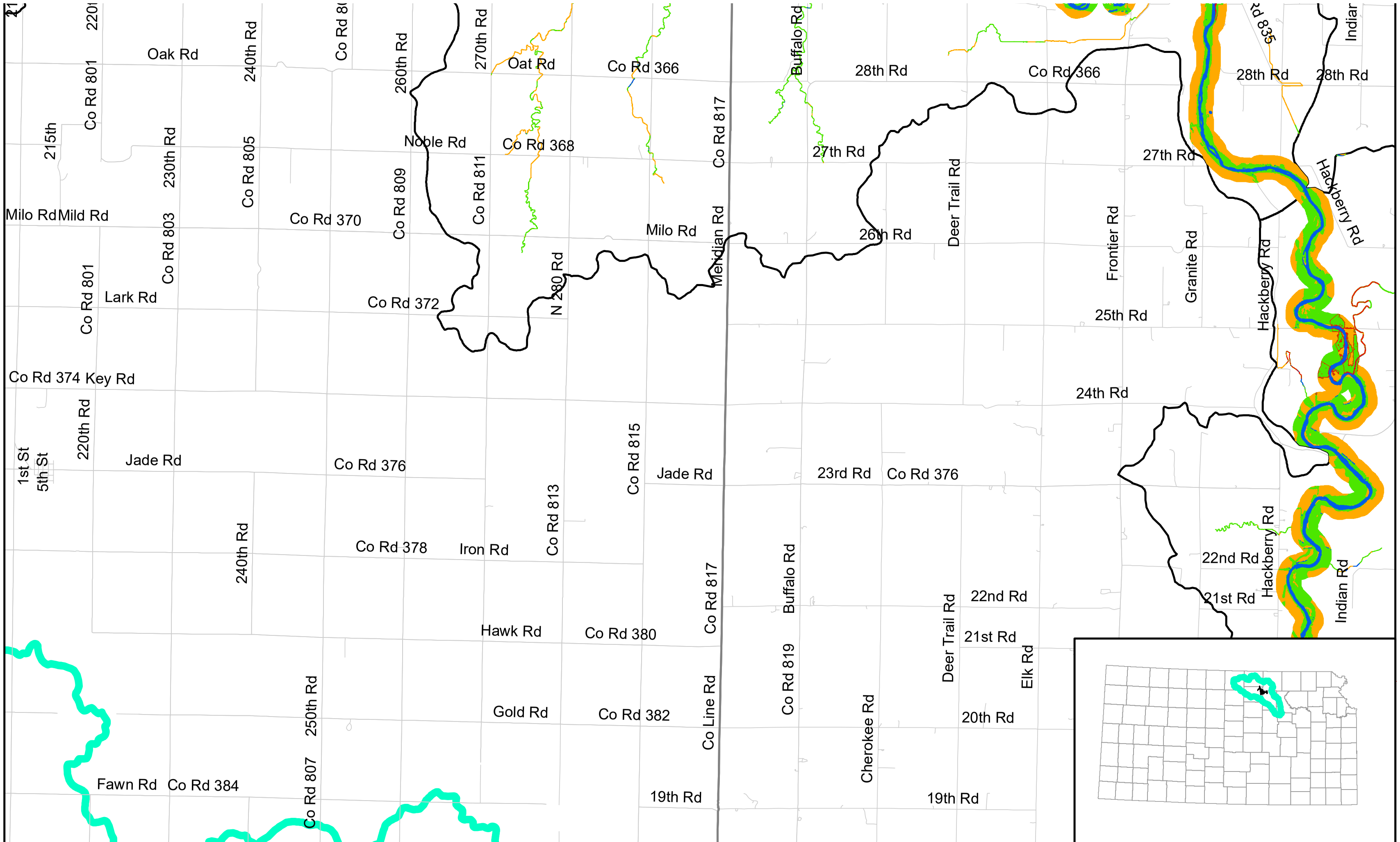


102500170310
Republic
Cloud
Republic Cloud County Rd
Republic Rd
State Hwy 148
Co Rd 27 5/10
Agenda Ln
Co Rd 27
Co Rd W
Co Rd 809 N 260th Rd
Co Rd 356
Co Rd 26
Willow Rd
Co Rd 348
250th Rd
Wagon Rd
Co Rd 807
Ft Kearney Rd
Teal Rd
Co Rd X
Co Rd Y
Co Rd 25
Co Rd 350
Vine Rd
Vale Rd
240th Rd Co Rd 805
Co Rd 24
Co Rd Z
Co Rd 803
N 230th Rd
Co Rd 352
Co Rd 23
220th Rd
Co Rd 801
215th Rd
Co Line Rd
212th Rd
Co Rd 22
Co Rd 799
210th Rd
Wayne Ln
Co Rd 21
203rd
200th Rd
Co Rd V
Union Rd
Co Rd 20
Co Rd 795
Fort Kearney Rd
Co Rd 19 61/10
Talmo Ln
Co Rd 19
180th Rd
Co Rd 793
Co Rd 18 81/10
Zion Trl
Co Rd 18
Old 81 Hwy N
Vale Rd River Bottom Rd
170th Rd
Co Rd 791
155th Rd
Dead End Trl
Co Rd 17
Co Rd 789
160th Rd



Riparian Forest Asssessment
HUC-12 = 102500170310
Milford Lake Study Area
NRCS-RCPP Agreement
March 2018
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads
Riparian Forest Class
Conservation
Developed
Establishment
Management
Water
Potential Historical Remnant Forest
HUC-12 Boundary
County Boundary
Roads
HUC-8 Boundary
Major River
N
0
6,000 Feet
1 inch = 6,000 feet
USDA
Rock Rd
Rust Rd
Co Rd 362
Co Rd 809
Co Rd 807
250th St
Co Rd 360
State Hwy 9
240th Rd
Co Rd 805
Sage Rd
Co Rd 358
230th Rd
Co Rd 803
Quail Rd
Co Rd 364
Oak Rd
220th Rd
Co Rd 801
Plum Rd
Oat Rd
215th
215th Rd
210th St
210th Rd
Co Rd 799
Co Rd 366
200th Rd
Co Rd 797
Noble Rd
190th Rd
Co Rd 795
Co Rd 368
180th Rd
Co Rd 793
170th Rd
Co Rd 791
165th Rd
160th Rd
Co Rd 789
Industrial Rd
E 4th St
E 6th St
E 11th St
L St
155th
154th
Quail


Republic
Cloud
Washington
Clay
102500170409
Heritage Rd
11th Rd
10th Rd
9th Rd
8th Rd
Gypsum Rd
4th Rd
3rd Rd
2nd Rd
Parallel Rd
30th Rd
29th Rd
Hackberry Rd
Fox Rd
7th Rd
6th Rd
Gas City Rd
Eagle Rd
Clifton Blvd
E Parallel Rd
West Rd
1st Rd
Deer Rd
5th Rd
Concord Rd
Cemetery Blvd
Bismark Rd
Arrowhead Rd
Abbey Blvd
Co Rd 31
Meridian Rd
Co Rd 817
Teal Rd
Shell Rd
Pride Rd
Union Rd
300 Rd
Co Rd W
Co Rd 30
Co Rd 815
Vale Rd
290th Rd
Royal Rd
Campbell Ave
Baldwin Ave
290 Rd
Co Rd 29
Co Line Rd
Agenda Rd
280th Rd
Co Rd 813
Co Rd 362
Co Rd X
275th St
Rock Rd
Quail Rd
Co Rd 28
Co Rd 811
270th Rd
Main St
Co Rd 27 5/10
Agenda Ln
Co Rd 360
265th St
Co Rd 27
Co Rd Y
N 260th Rd
Co Rd 809
Rust Rd
Co Rd U
Co Rd Z
Wagon Rd
Ft Kearney Rd
Co Rd 26
250th Rd
Co Rd 807
State Hwy 9
250th St
State Hwy 148
Willow Rd
Republic Rd
Co Rd 25
Co Rd 805
240th Rd
Co Rd 356
Sage Rd
Co Rd 364
Co Rd 24
Co Rd 348
N 230th Rd
230th Rd
Co Rd 350
Co Rd 352
Union Rd
Plum Rd
Co Rd 23
220th Rd
215th Rd
Co Rd 22
212th Rd
210th Rd
212th St
210th St
Co Rd 799



Riparian Forest Asssessment
HUC-12 = 102500170409
Milford Lake Study Area
NRCS-RCPP Agreement

March 2018

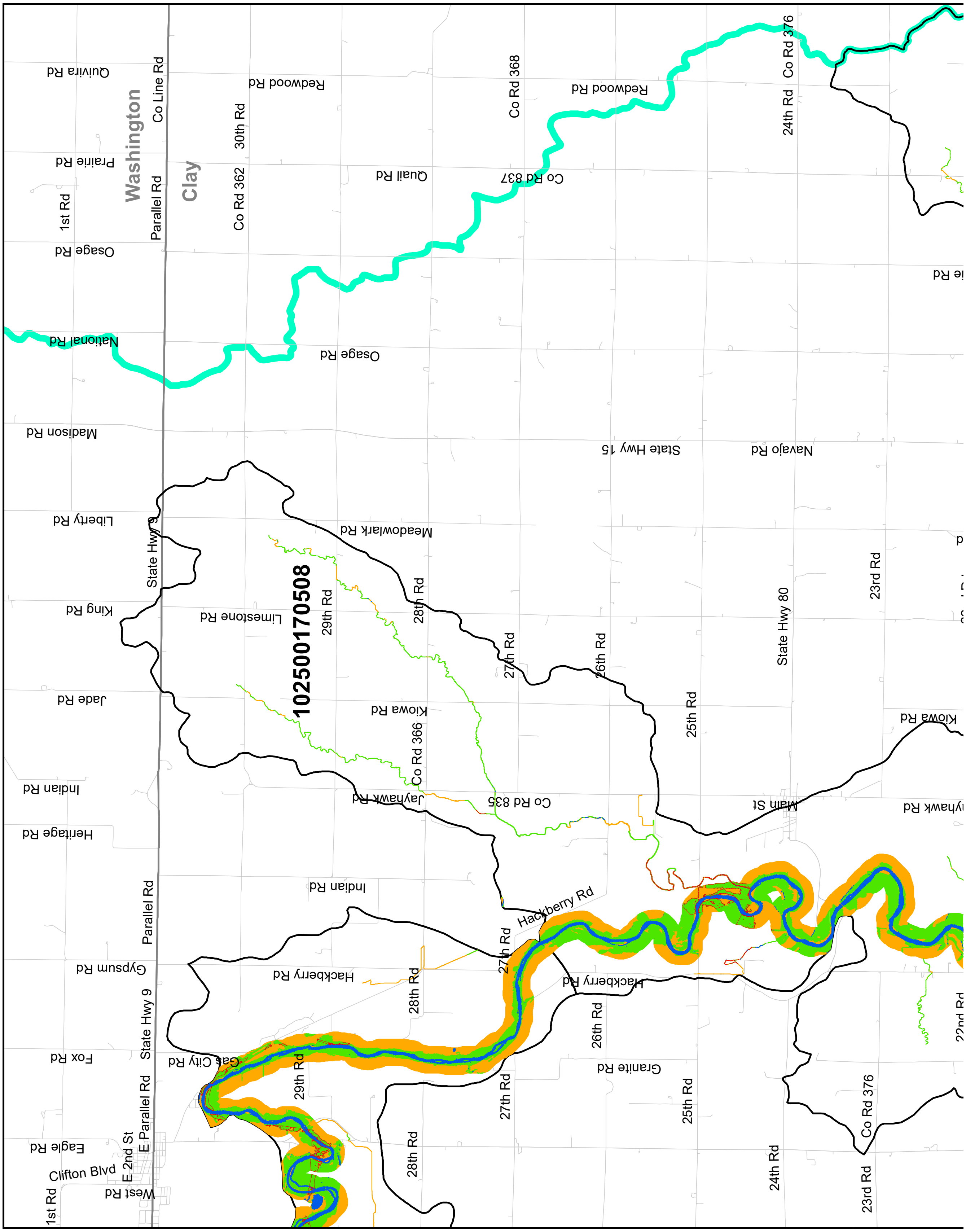
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads

Riparian Forest Class
- Conservation
- Developed
- Establishment
- Management
- Water
- Potential Historical Remnant Forest

- HUC-12 Boundary
- County Boundary
- Roads
- HUC-8 Boundary
- Major River

0 9,000 Feet
1 inch = 9,000 feet

N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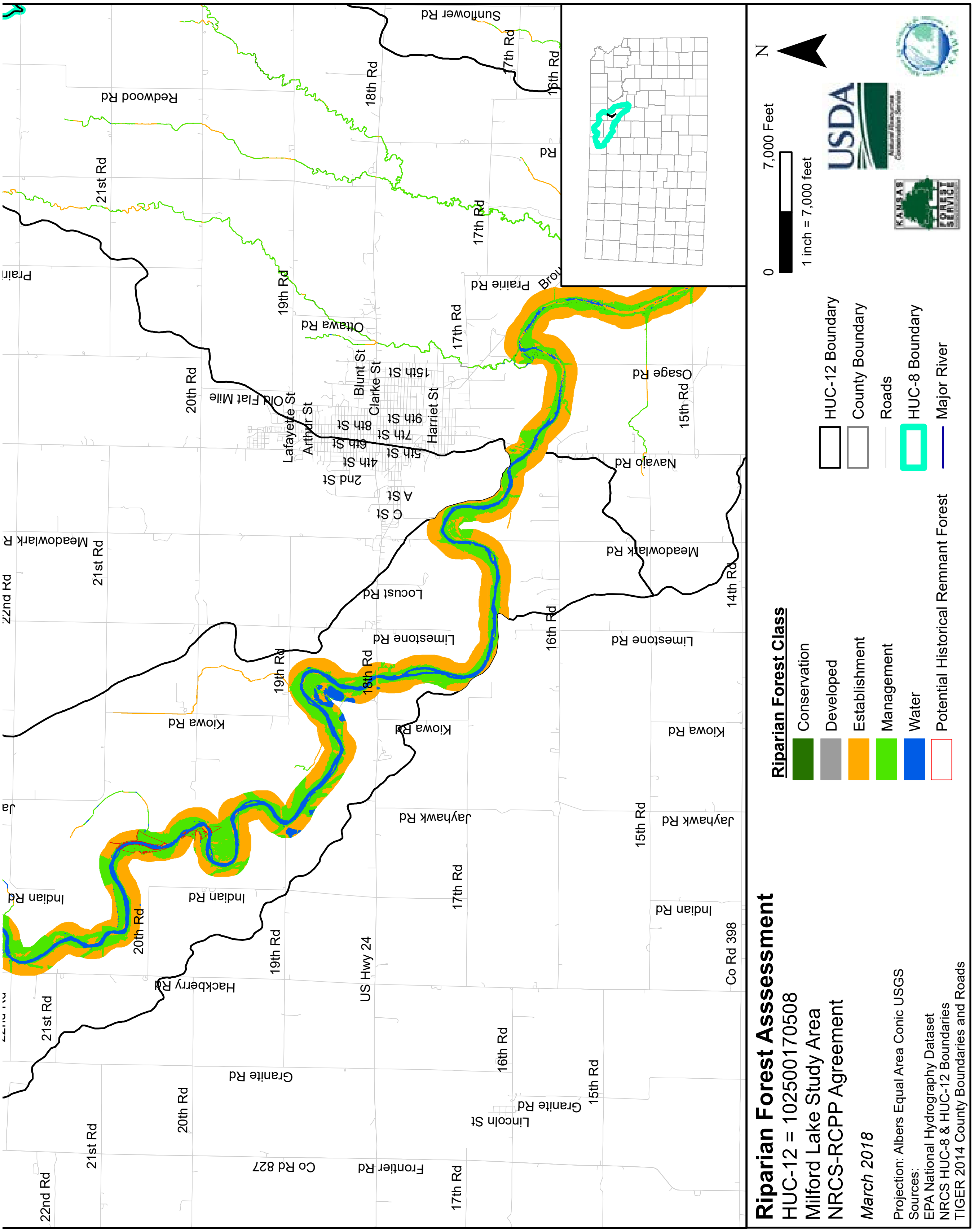
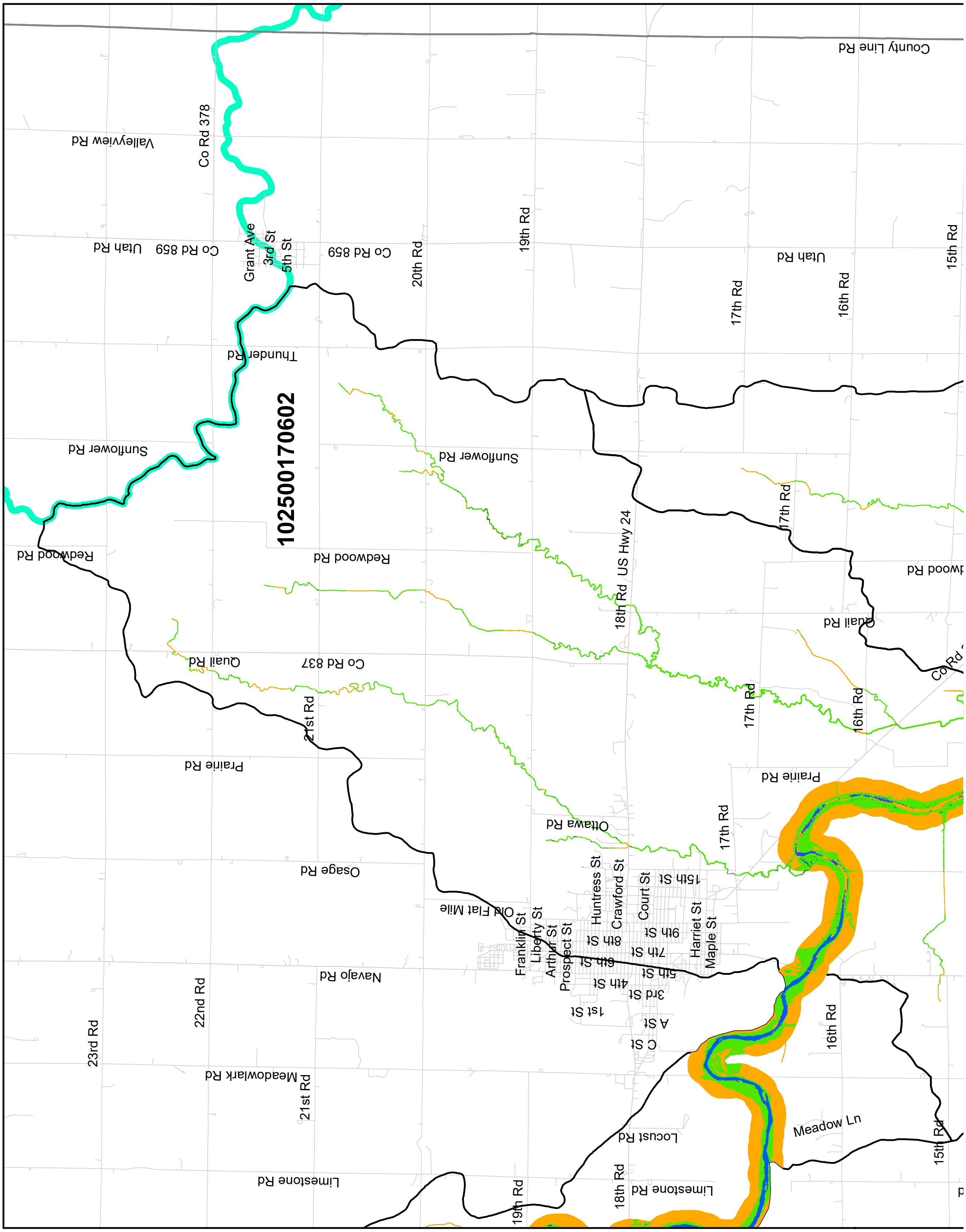
Co Line Rd
Washington
Clay
Redwood Rd
30th Rd
Co Rd 368
Redwood Rd
24th Rd
Co Rd 376
Prairie Rd
Parallel Rd
1st Rd
Co Rd 362
Quail Rd
Co Rd 837
Osage Rd
National Rd
Osage Rd
Madison Rd
State Hwy 15
Navajo Rd
Liberty Rd
Meadowlark Rd
State Hwy 9
102500170508
King Rd
Limestone Rd
29th Rd
28th Rd
27th Rd
26th Rd
State Hwy 80
23rd Rd
Jade Rd
Kiowa Rd
25th Rd
Kiowa Rd
Co Rd 366
Indian Rd
Jayhawk Rd
Co Rd 835
Main St
Heritage Rd
Indian Rd
Parallel Rd
Hackberry Rd
Gypsum Rd
Hackberry Rd
28th Rd
27th Rd
Hackberry Rd
State Hwy 9
26th Rd
Fox Rd
Gas City Rd
29th Rd
Granite Rd
E Parallel Rd
27th Rd
25th Rd
Co Rd 376
Eagle Rd
E 2nd St
28th Rd
24th Rd
Clifton Blvd
West Rd
1st Rd
23rd Rd


Riparian Forest Asssessment
HUC-12 = 102500170508
Milford Lake Study Area
NRCS-RCPP Agreement
March 2018
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads
Riparian Forest Class
Conservation
Developed
Establishment
Management
Water
Potential Historical Remnant Forest
HUC-12 Boundary
County Boundary
Roads
HUC-8 Boundary
Major River
0
7,000 Feet
1 inch = 7,000 feet
N
USDA
Kiowa Rd
Jayhawk Rd
Indian Rd
Hackberry Rd
Granite Rd
Limestone Rd
Locust Rd
Meadowlark Rd
Navajo Rd
Osage Rd
Ottawa Rd
Prairie Rd
Redwood Rd
Sunflower Rd
Frontier Rd
Co Rd 827
Co Rd 398
Lincoln St
US Hwy 24
Old Flat Mile
Lafayette St
Arthur St
Blunt St
Clarke St
Harriet St
15th St
9th St
8th St
7th St
6th St
5th St
4th St
2nd St
A St
C St
22nd Rd
21st Rd
20th Rd
19th Rd
18th Rd
17th Rd
16th Rd
15th Rd
14th Rd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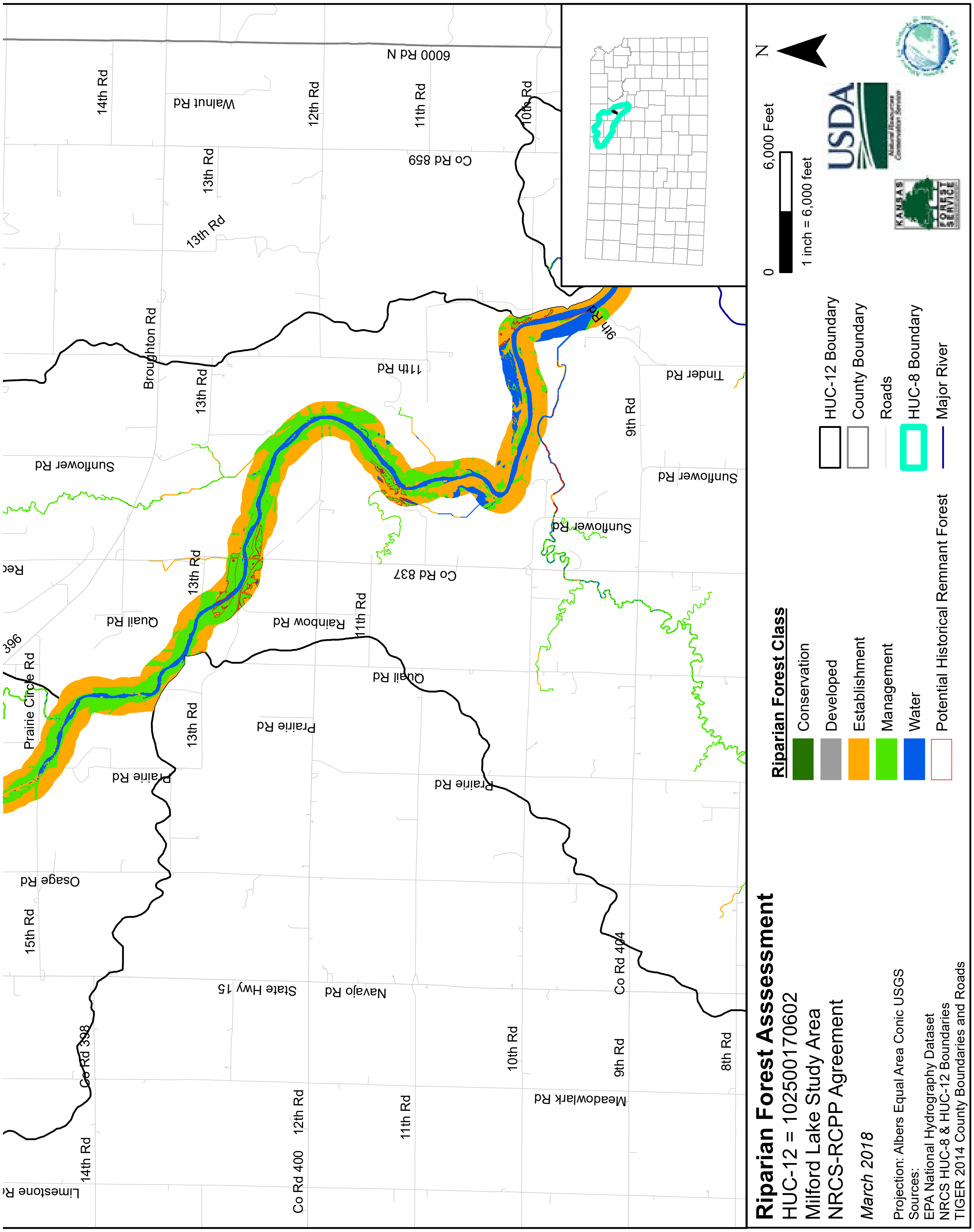
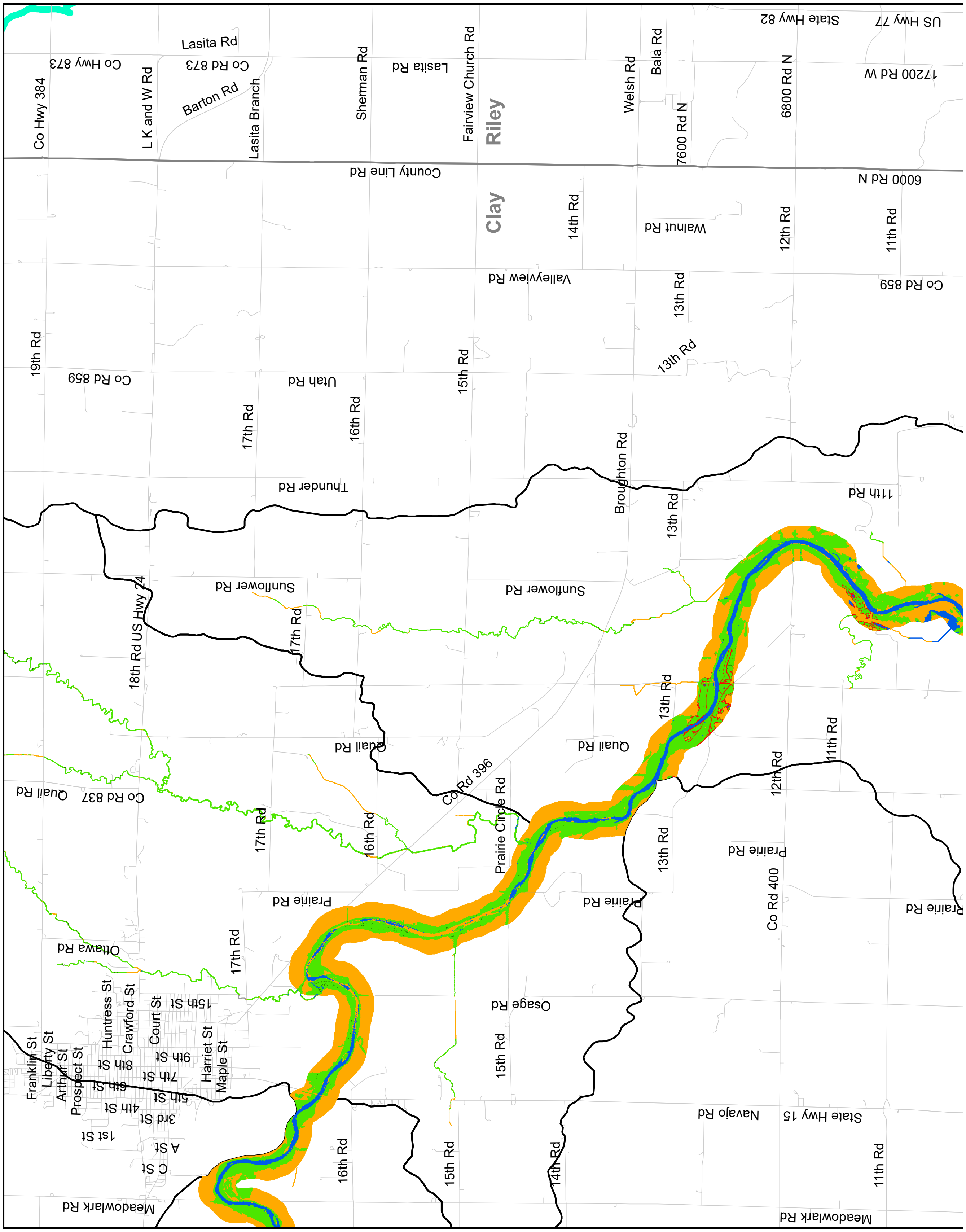
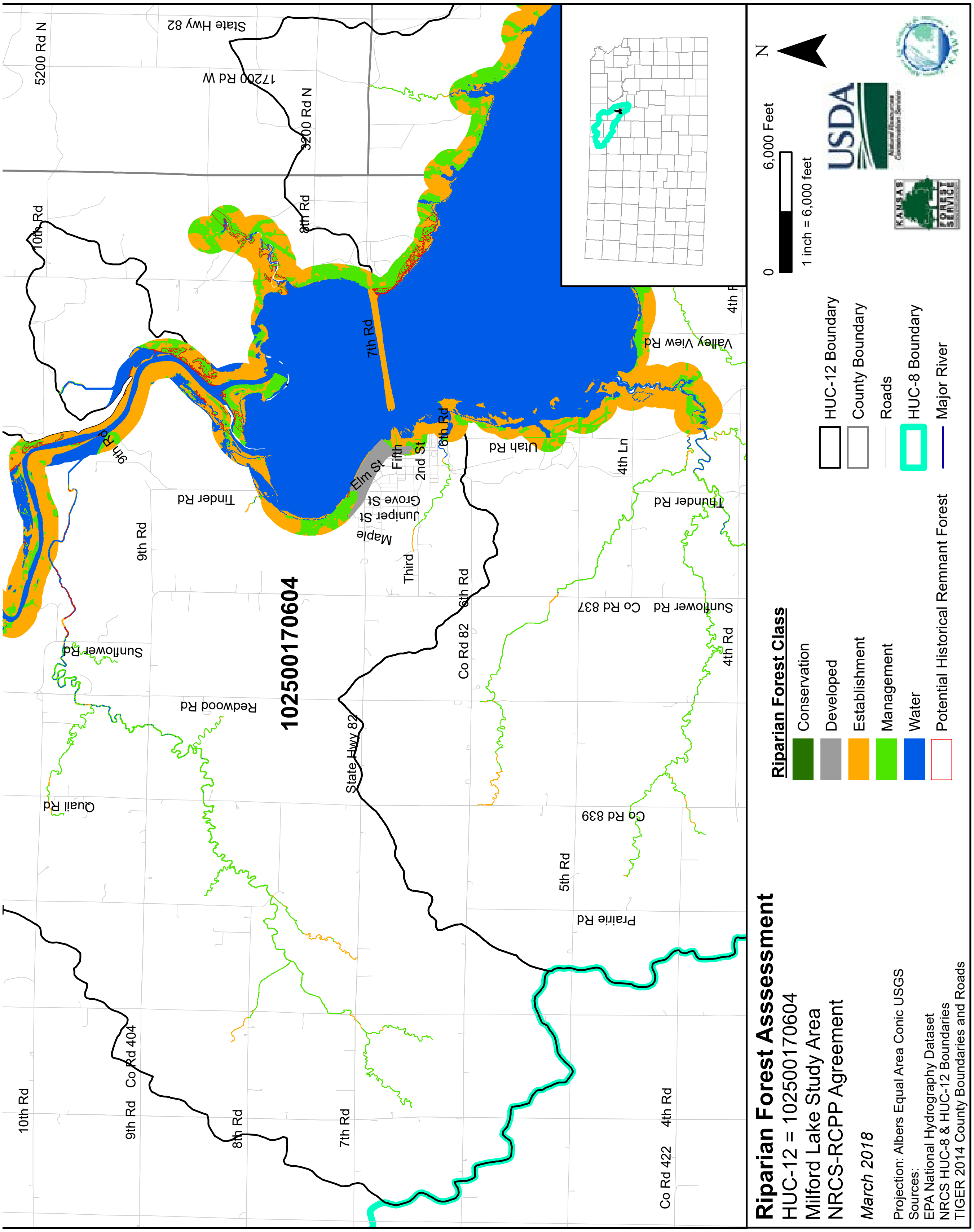
County Line Rd
Valleyview Rd
Co Rd 378
Utah Rd
Co Rd 859
Grant Ave
3rd St
5th St
20th Rd
19th Rd
17th Rd
16th Rd
15th Rd
Thunder Rd
Sunflower Rd
Redwood Rd
US Hwy 24
18th Rd
Quail Rd
Co Rd 837
21st Rd
Prairie Rd
Ottawa Rd
Osage Rd
Old Flat Mile
Franklin St
Liberty St
Arthur St
Prospect St
Huntress St
Crawford St
Court St
15th St
8th St
9th St
7th St
6th St
5th St
4th St
3rd St
1st St
A St
C St
Harriet St
Maple St
Navajo Rd
23rd Rd
22nd Rd
Meadowlark Rd
Meadow Ln
Locust Rd
Limestone Rd


Riparian Forest Asssessment
HUC-12 = 102500170602
Milford Lake Study Area
NRCS-RCPP Agreement
March 2018
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads
Riparian Forest Class
Conservation
Developed
Establishment
Management
Water
Potential Historical Remnant Forest
HUC-12 Boundary
County Boundary
Roads
HUC-8 Boundary
Major River
0
6,000 Feet
1 inch = 6,000 feet
N
USDA



Riley
Clay
Co Hwy 384
Co Hwy 873
Lasita Rd
Co Rd 873
L K and W Rd
Barton Rd
Lasita Branch
Sherman Rd
Lasita Rd
Fairview Church Rd
Welsh Rd
Bala Rd
7600 Rd N
6800 Rd N
State Hwy 82
US Hwy 77
17200 Rd W
County Line Rd
6000 Rd N
14th Rd
Walnut Rd
12th Rd
11th Rd
Valleyview Rd
13th Rd
Co Rd 859
19th Rd
Co Rd 859
Utah Rd
15th Rd
13th Rd
17th Rd
16th Rd
Broughton Rd
Thunder Rd
13th Rd
11th Rd
Sunflower Rd
Sunflower Rd
18th Rd US Hwy 24
17th Rd
13th Rd
Quail Rd
Quail Rd
11th Rd
12th Rd
Co Rd 396
Quail Rd
Co Rd 837
Prairie Circle Rd
17th Rd
16th Rd
13th Rd
Prairie Rd
Prairie Rd
Prairie Rd
Co Rd 400
Prairie Rd
Ottawa Rd
17th Rd
Huntress St
Crawford St
Court St
15th St
Osage Rd
Franklin St
Liberty St
Arthur St
Prospect St
8th St
9th St
Harriet St
Maple St
6th St
7th St
5th St
4th St
3rd St
1st St
A St
C St
15th Rd
Navajo Rd
State Hwy 15
16th Rd
15th Rd
14th Rd
11th Rd
Meadowlark Rd
Meadowlark Rd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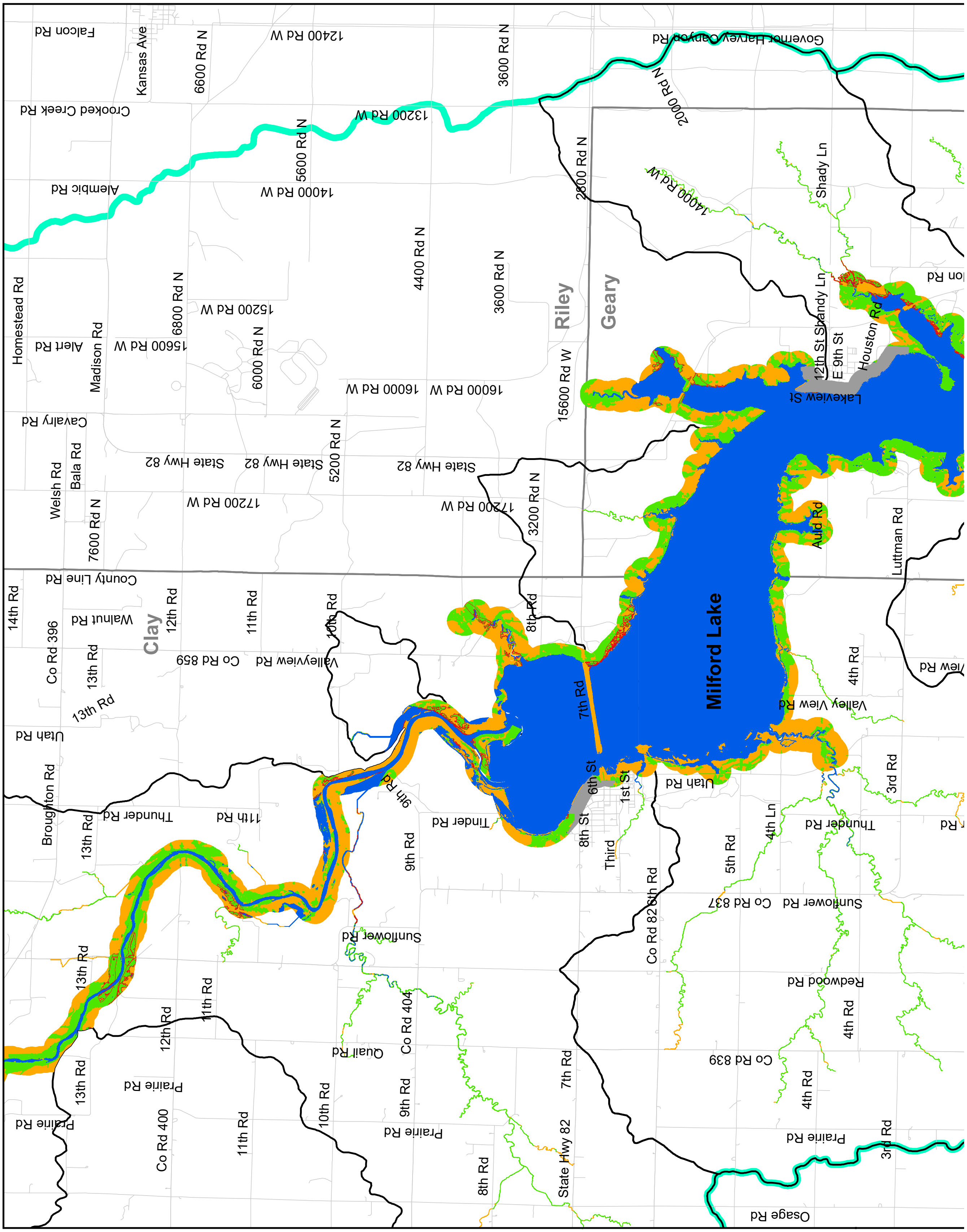
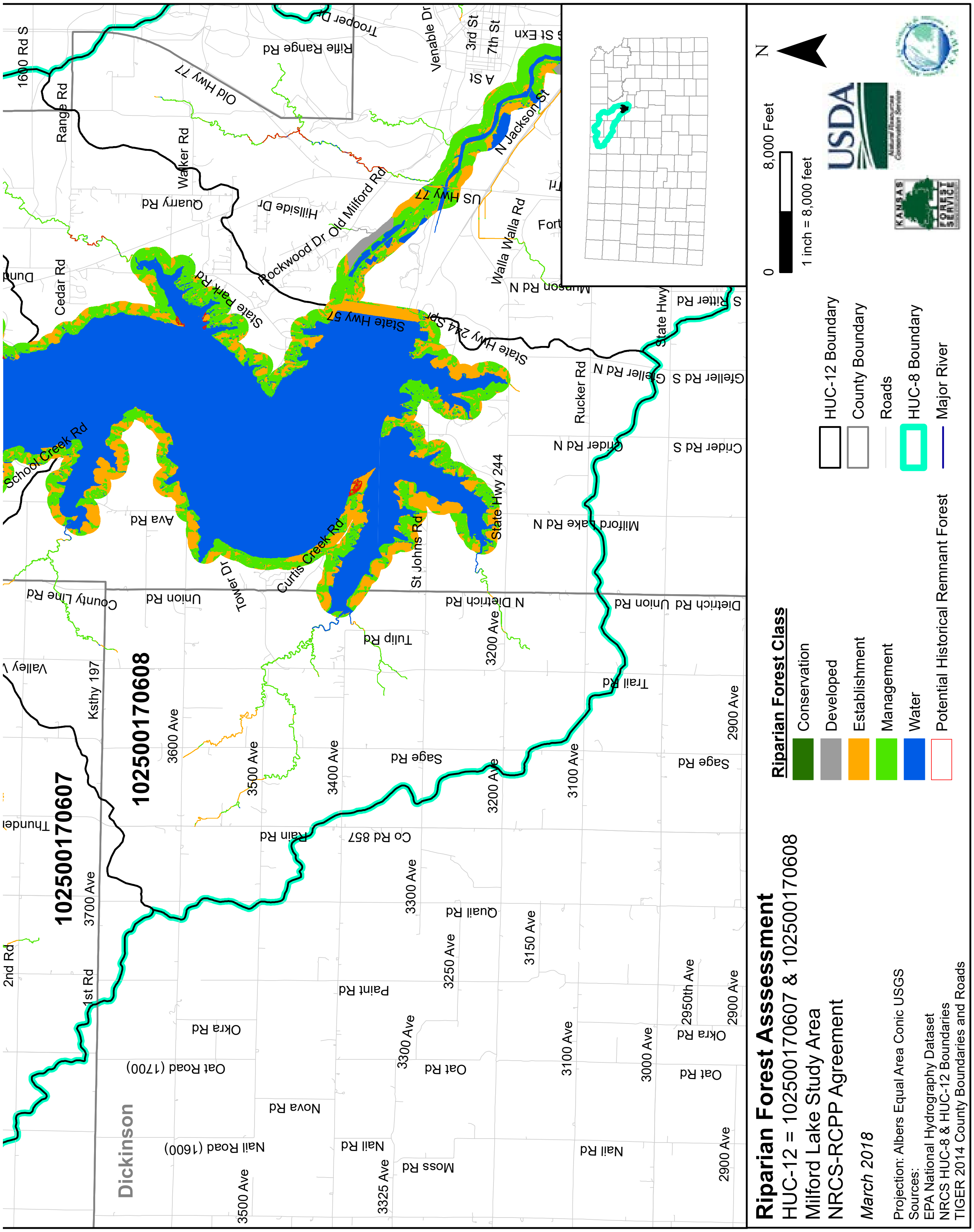
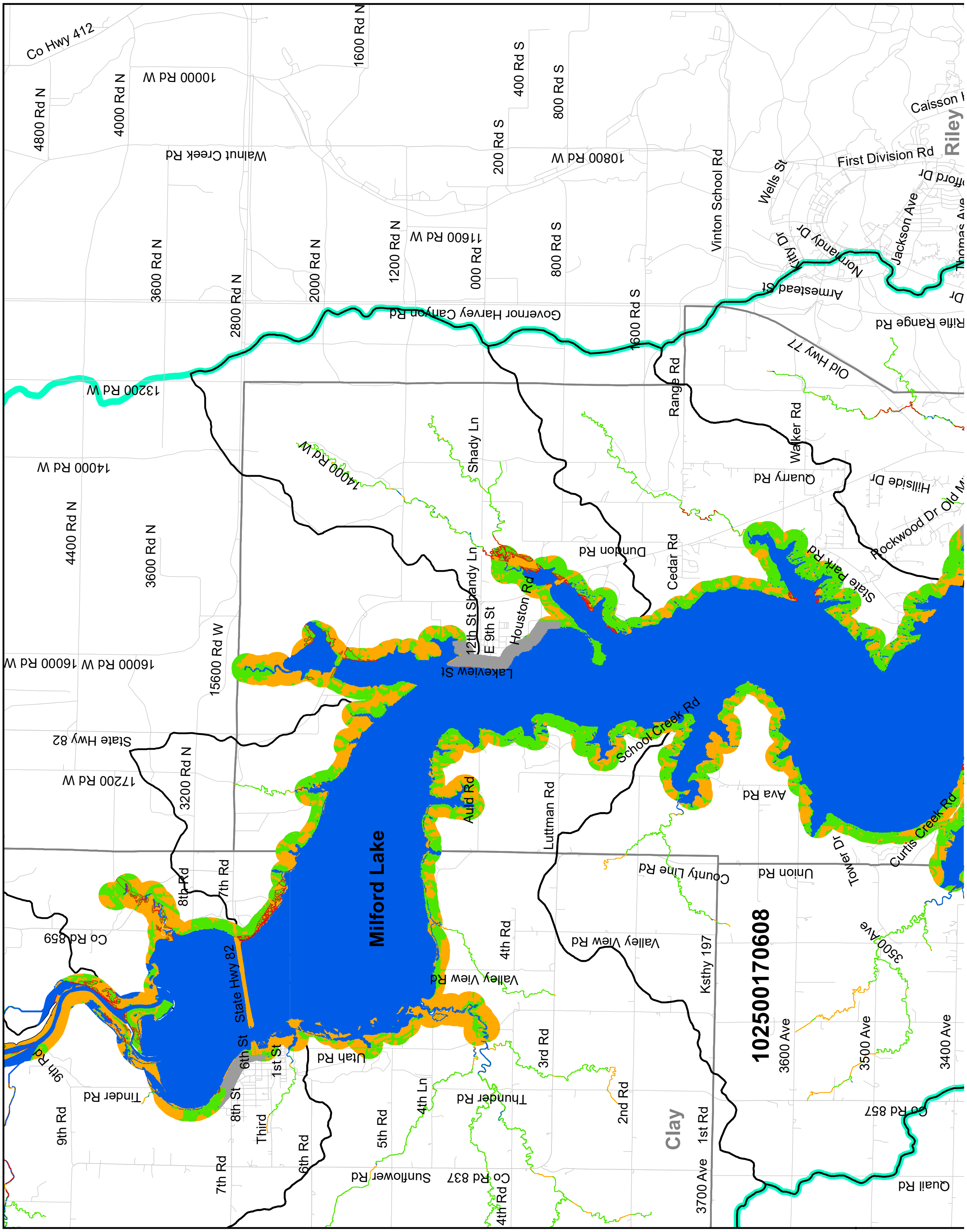
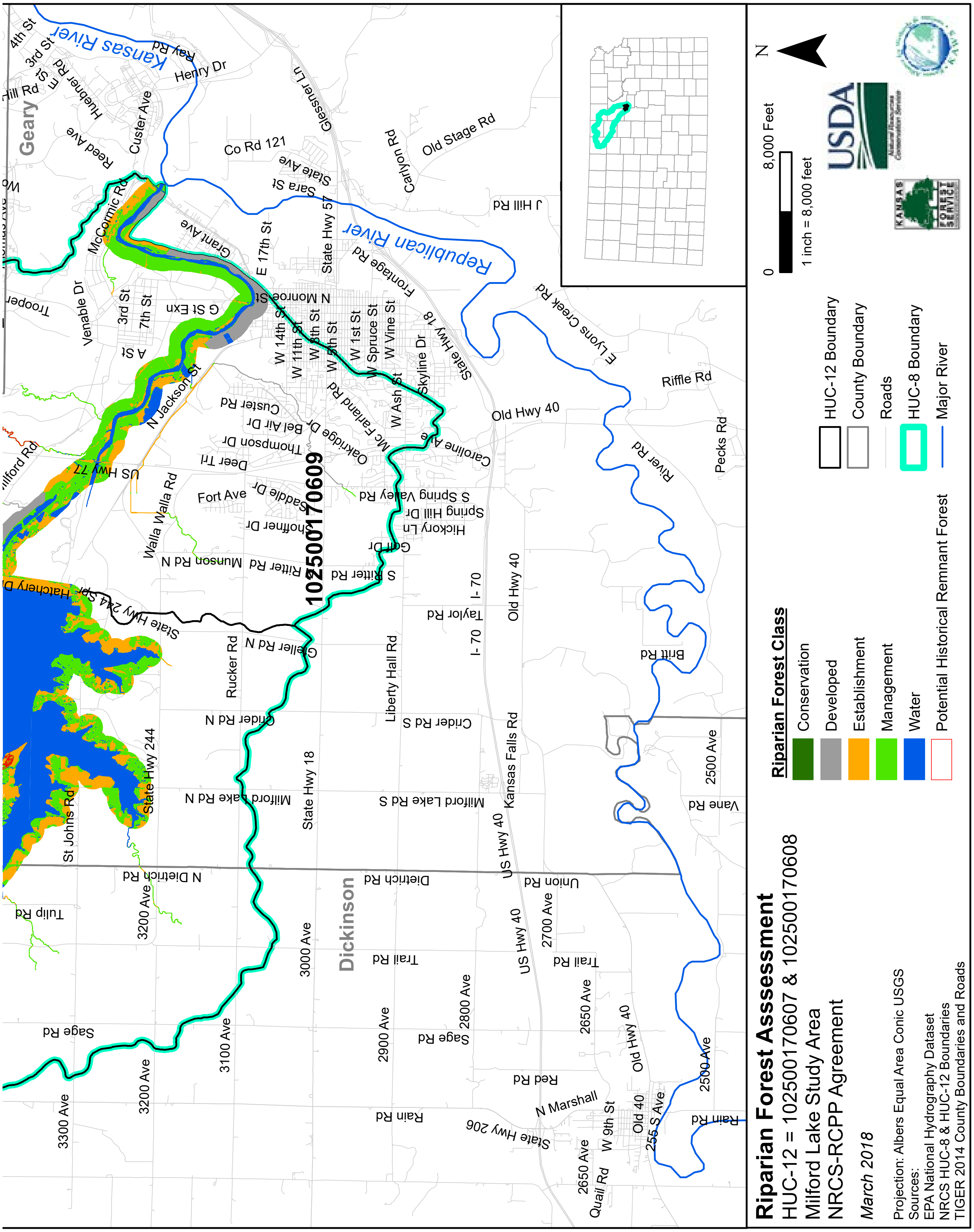
HUC-12 = 102500170604
Milford Lake Study Area
NRCS-RCPP Agreement
March 2018
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads
Riparian Forest Class
Conservation
Developed
Establishment
Management
Water
Potential Historical Remnant Forest
HUC-12 Boundary
County Boundary
Roads
HUC-8 Boundary
Major River
0
6,000 Feet
1 inch = 6,000 feet
N
USDA
102500170604
State Hwy 82
5200 Rd N
17200 Rd W
3200 Rd N
8th Rd
10th Rd
7th Rd
9th Rd
Tinder Rd
Elm St
Fifth
2nd St
6th Rd
Utah Rd
Grove St
Juniper St
Maple
Third
4th Ln
Valley View Rd
Thunder Rd
Sunflower Rd
Co Rd 837
Co Rd 82
Redwood Rd
State Hwy 82
Quail Rd
Co Rd 839
5th Rd
Prairie Rd
4th Rd
Co Rd 404
Co Rd 422

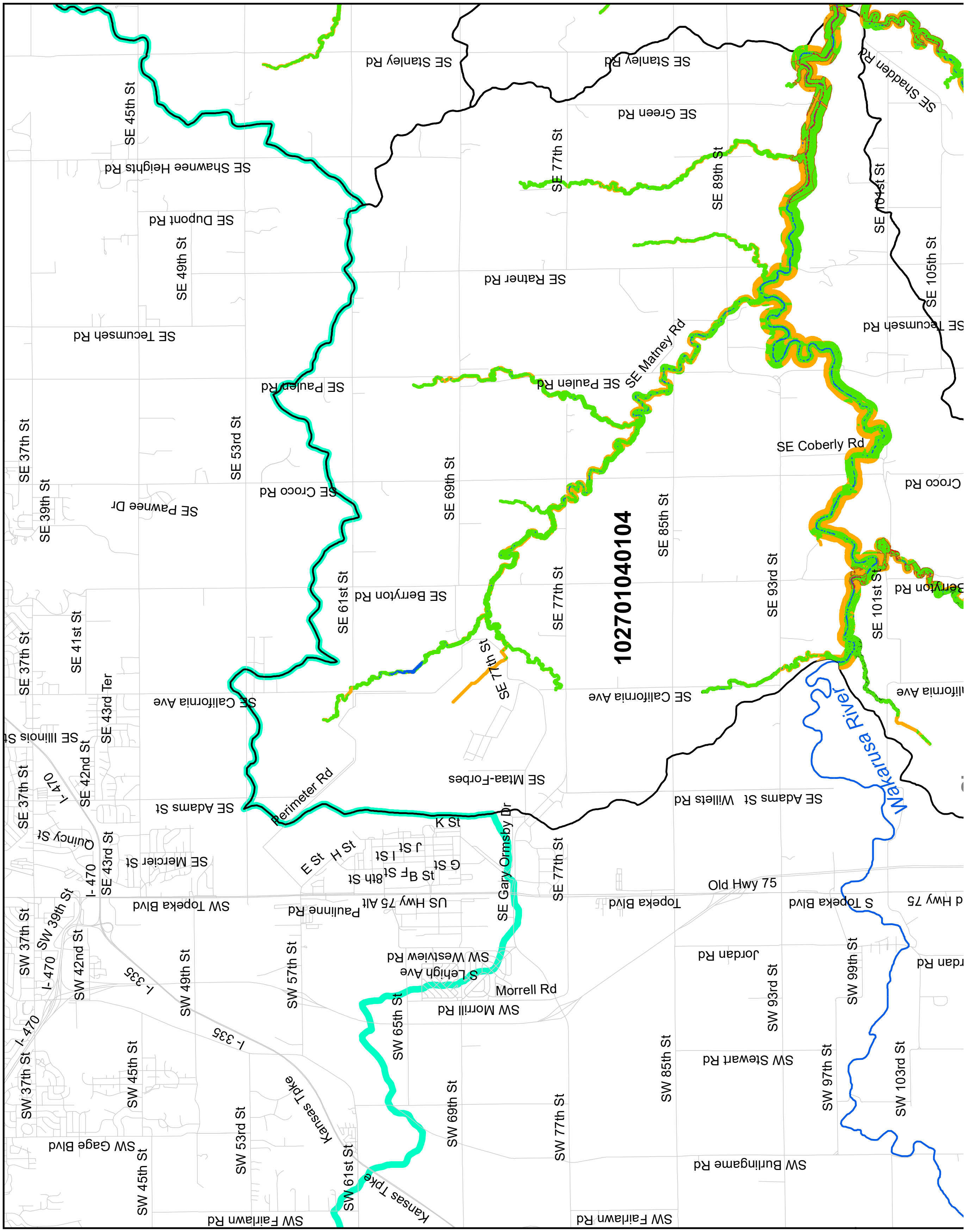

Milford Lake
Clay
Riley
Geary
Governor Harvey Canyon Rd
Crooked Creek Rd
Falcon Rd
Kansas Ave
6600 Rd N
12400 Rd W
3600 Rd N
13200 Rd W
5600 Rd N
2000 Rd N
2800 Rd N
14000 Rd W
Alembic Rd
Shady Ln
Homestead Rd
Alert Rd
Madison Rd
15600 Rd W
6800 Rd N
15200 Rd W
6000 Rd N
4400 Rd N
3600 Rd N
16000 Rd W
15600 Rd W
Cavalry Rd
State Hwy 82
5200 Rd N
Welsh Rd
Bala Rd
7600 Rd N
17200 Rd W
3200 Rd N
Lakeview St
12th St
E 9th St
Houston Rd
Auld Rd
Luttman Rd
County Line Rd
14th Rd
Co Rd 396
Walnut Rd
12th Rd
11th Rd
10th Rd
8th Rd
13th Rd
Co Rd 859
Valleyview Rd
7th Rd
4th Rd
Valley View Rd
Utah Rd
Broughton Rd
Thunder Rd
11th Rd
9th Rd
Tinder Rd
6th St
1st St
8th St
Third
3rd Rd
5th Rd
4th Ln
Sunflower Rd
Co Rd 837
Co Rd 826
Redwood Rd
Co Rd 404
Quail Rd
Co Rd 839
Prairie Rd
Co Rd 400
State Hwy 82
Osage Rd

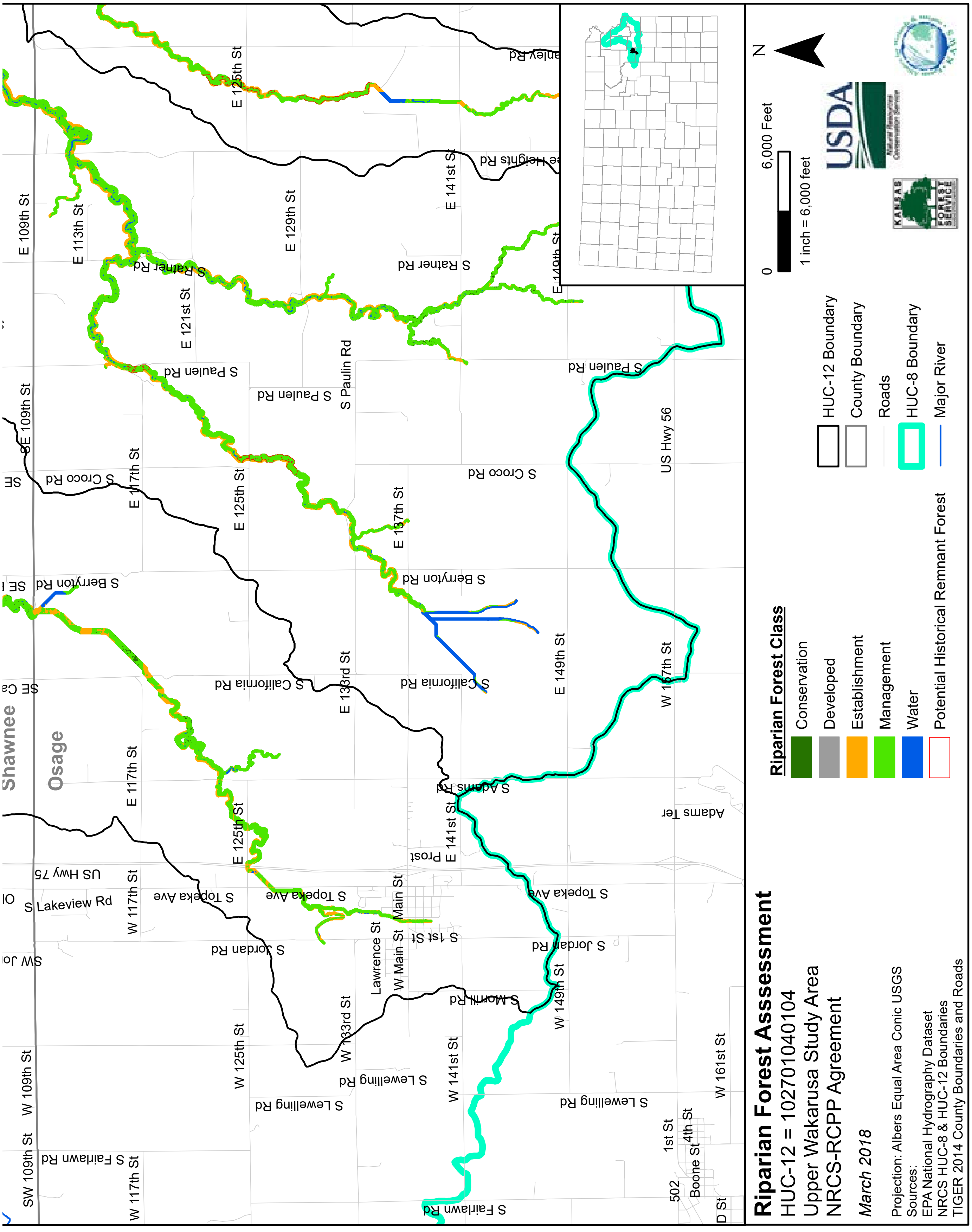


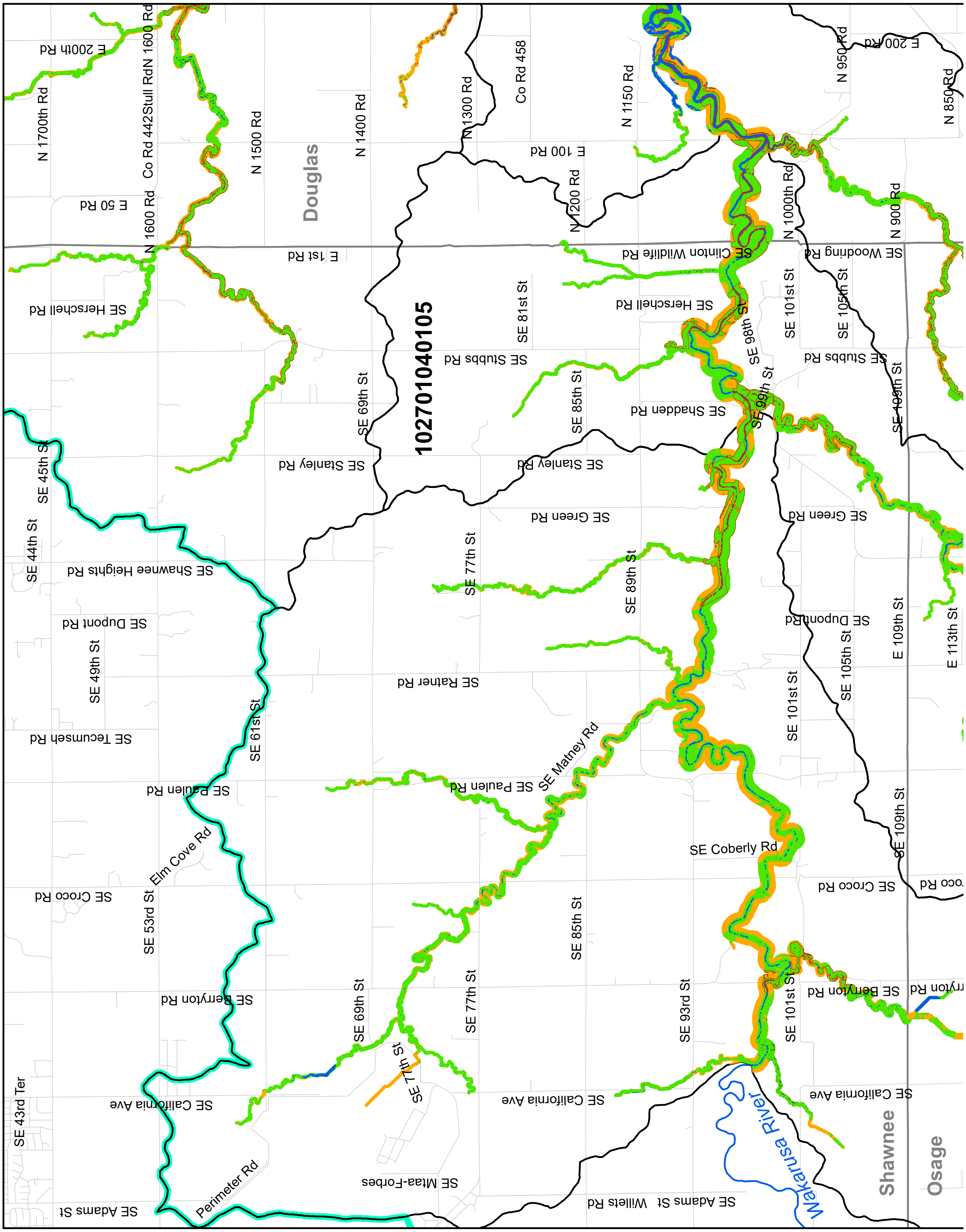
Riparian Forest Asssessment
HUC-12 = 102500170607 & 102500170608
Milford Lake Study Area
NRCS-RCPP Agreement
March 2018
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads
Riparian Forest Class
Conservation
Developed
Establishment
Management
Water
Potential Historical Remnant Forest
HUC-12 Boundary
County Boundary
Roads
HUC-8 Boundary
Major River
0
8,000 Feet
1 inch = 8,000 feet
N
USDA
102500170607
102500170608
Dickinson


Milford Lake
102500170608
Clay
Riley
Co Hwy 412
4800 Rd N
4000 Rd N
10000 Rd W
1600 Rd N
400 Rd S
800 Rd S
Caisson
First Division Rd
Wells St
Walnut Creek Rd
200 Rd S
10800 Rd W
Vinton School Rd
3600 Rd N
2000 Rd N
1200 Rd N
11600 Rd W
800 Rd S
Kitty Dr
Normandy Dr
Jackson Ave
Armestead St
2800 Rd N
Governor Harvey Canyon Rd
1600 Rd S
Rifle Range Rd
13200 Rd W
Range Rd
Old Hwy 77
14000 Rd W
Shady Ln
Walker Rd
Quarry Rd
Hillside Dr
Rockwood Dr
4400 Rd N
3600 Rd N
Dundon Rd
Cedar Rd
12th St
Shady Ln
E 9th St
Houston Rd
State Park Rd
16000 Rd W
15600 Rd W
Lakeview St
School Creek Rd
State Hwy 82
17200 Rd W
3200 Rd N
Auld Rd
Luttman Rd
Ava Rd
Curtis Creek Rd
Tower Dr
8th Rd
7th Rd
County Line Rd
Union Rd
Co Rd 859
State Hwy 82
4th Rd
Valley View Rd
Ksthy 197
3500 Ave
Valley View Rd
9th Rd
6th St
1st St
Utah Rd
3rd Rd
3600 Ave
3500 Ave
3400 Ave
Tinder Rd
9th Rd
8th St
Third
4th Ln
Thunder Rd
2nd Rd
Co Rd 857
7th Rd
6th Rd
5th Rd
1st Rd
Sunflower Rd
Co Rd 837
4th Rd
3700 Ave
Quail Rd

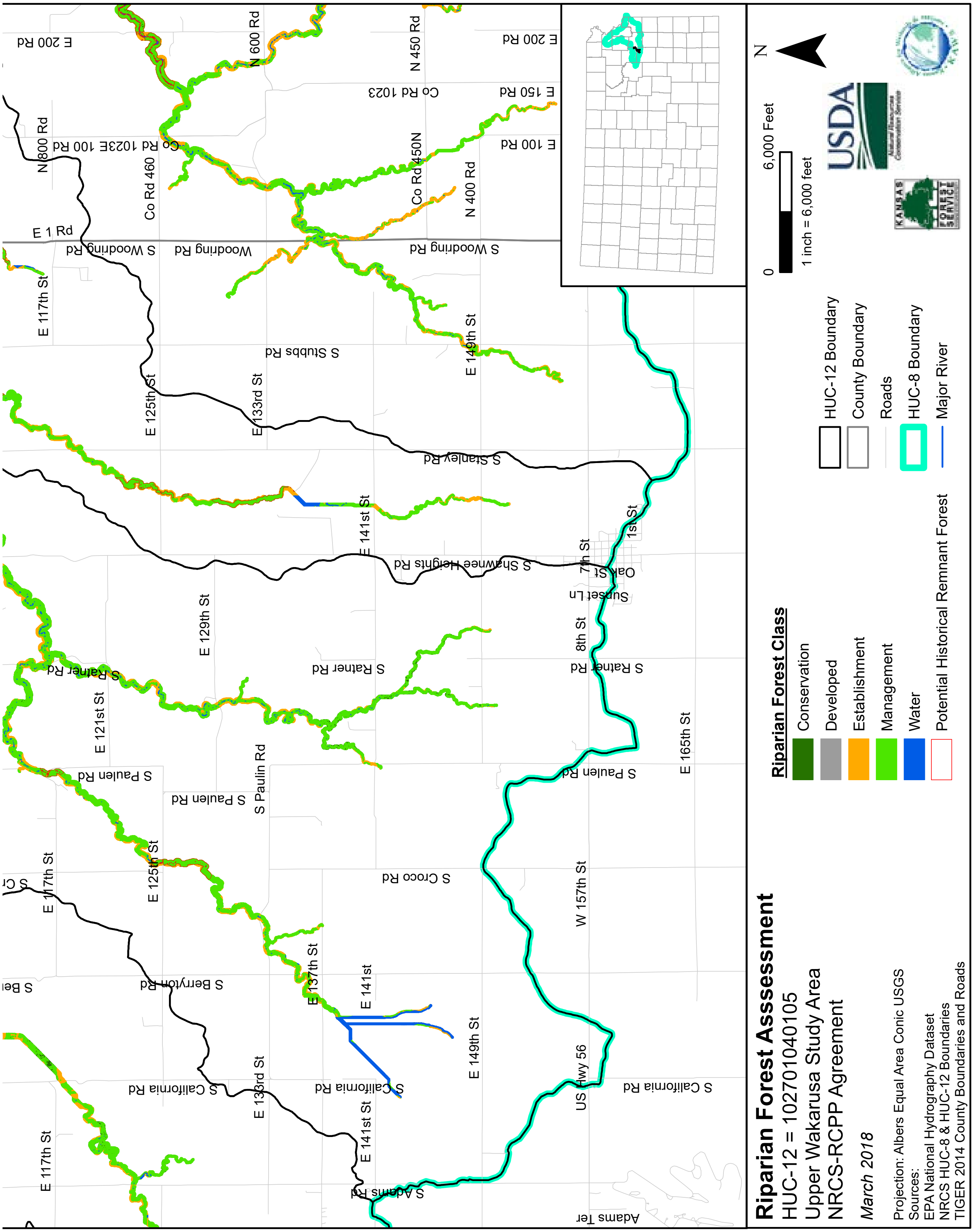

Riparian Forest Asssessment
HUC-12 = 102500170607 & 102500170608
Milford Lake Study Area
NRCS-RCPP Agreement
March 2018
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads
Riparian Forest Class
Conservation
Developed
Establishment
Management
Water
Potential Historical Remnant Forest
HUC-12 Boundary
County Boundary
Roads
HUC-8 Boundary
Major River
0
8,000 Feet
1 inch = 8,000 feet
N
102500170609
Geary
Dickinson
Kansas River
Republican River

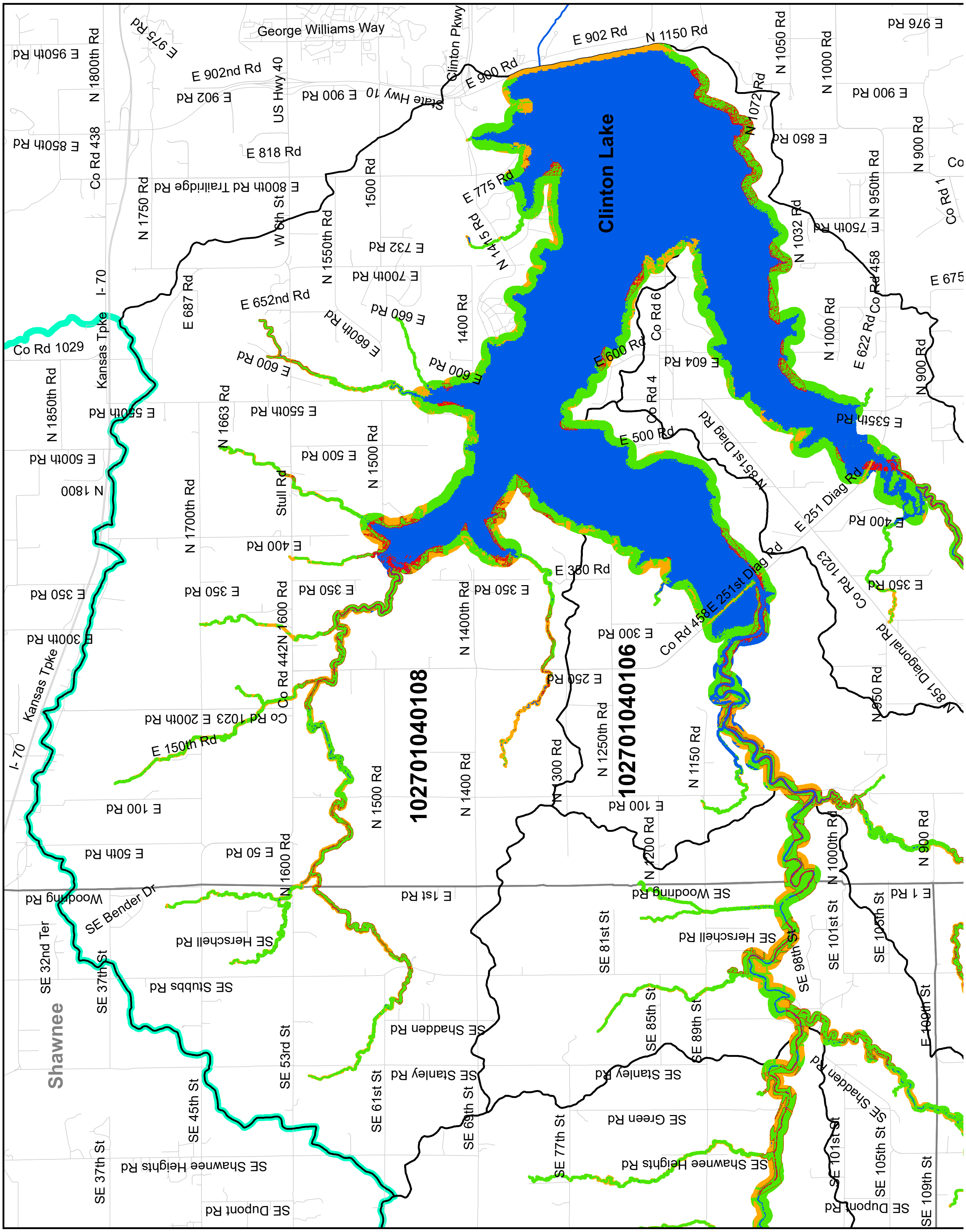

102701040104
Wakarusa River
SE Stanley Rd
SE Shadden Rd
SE Green Rd
SE 45th St
SE Shawnee Heights Rd
SE 77th St
SE 89th St
SE 101st St
SE Dupont Rd
SE 49th St
SE Ratner Rd
SE 105th St
SE Tecumseh Rd
SE Matney Rd
SE Paulen Rd
SE 37th St
SE 53rd St
SE Coberly Rd
SE 69th St
SE Croco Rd
Croco Rd
SE 39th St
SE Pawnee Dr
SE 85th St
SE 93rd St
SE 61st St
SE Berryton Rd
SE 41st St
SE California Ave
SE 43rd Ter
SE Illinois St
SE 42nd St
I-470
SE Mtaa-Forbes
Perimeter Rd
SE Adams St
Willets Rd
K St
SE Gary Ormsby Dr
Quincy St
SE 43rd St
SE Mercier St
E St
H St
J St
I St
G St
8th St
F St
B St
Old Hwy 75
SW 39th St
SW Topeka Blvd
Pauline Rd
US Hwy 75 Alt
Topeka Blvd
S Topeka Blvd
SW 37th St
SW 42nd St
I-335
SW 49th St
SW 57th St
SW Westview Rd
S Lehigh Ave
Morrell Rd
Jordan Rd
SW 99th St
SW 65th St
SW Morrill Rd
SW 93rd St
SW 45th St
Kansas Tpke
SW 85th St
SW Stewart Rd
SW 97th St
SW 103rd St
SW 69th St
SW 53rd St
SW 77th St
SW Gage Blvd
SW Burlingame Rd
SW 61st St
SW Fairlawn Rd

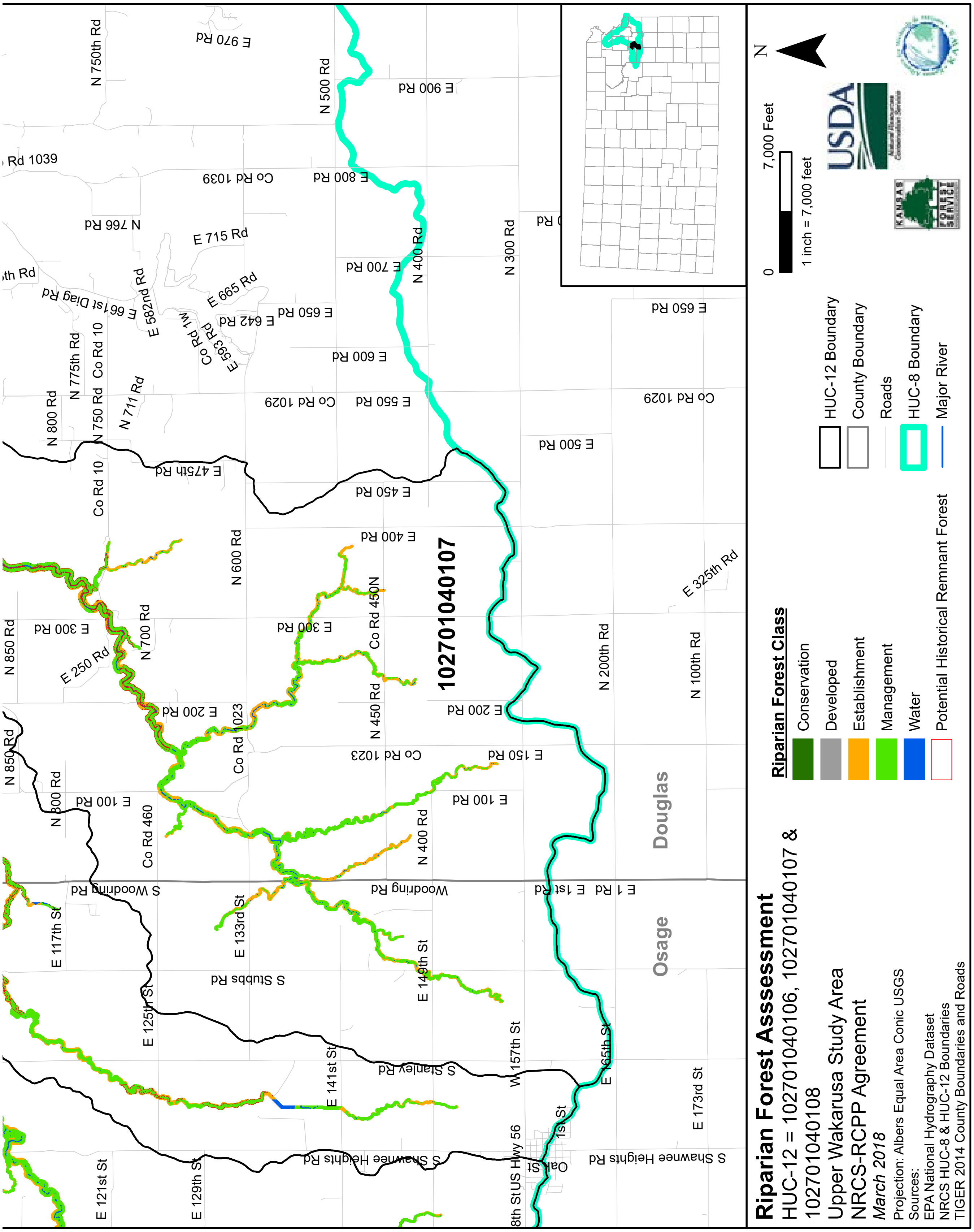

Riparian Forest Asssessment
HUC-12 = 102701040104
Upper Wakarusa Study Area
NRCS-RCPP Agreement
March 2018
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads
Riparian Forest Class
Conservation
Developed
Establishment
Management
Water
Potential Historical Remnant Forest
HUC-12 Boundary
County Boundary
Roads
HUC-8 Boundary
Major River
0
6,000 Feet
1 inch = 6,000 feet
N
Shawnee
Osage

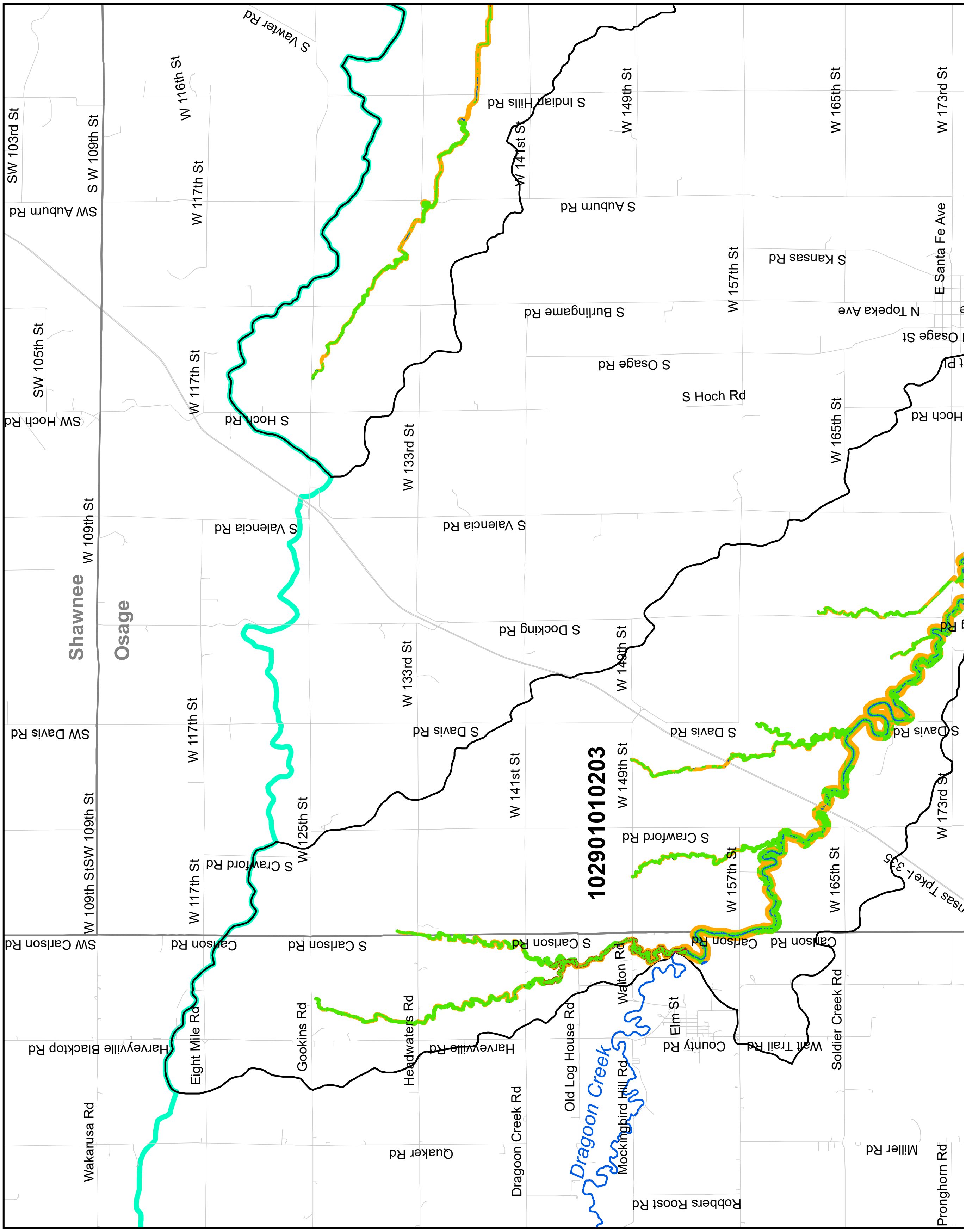


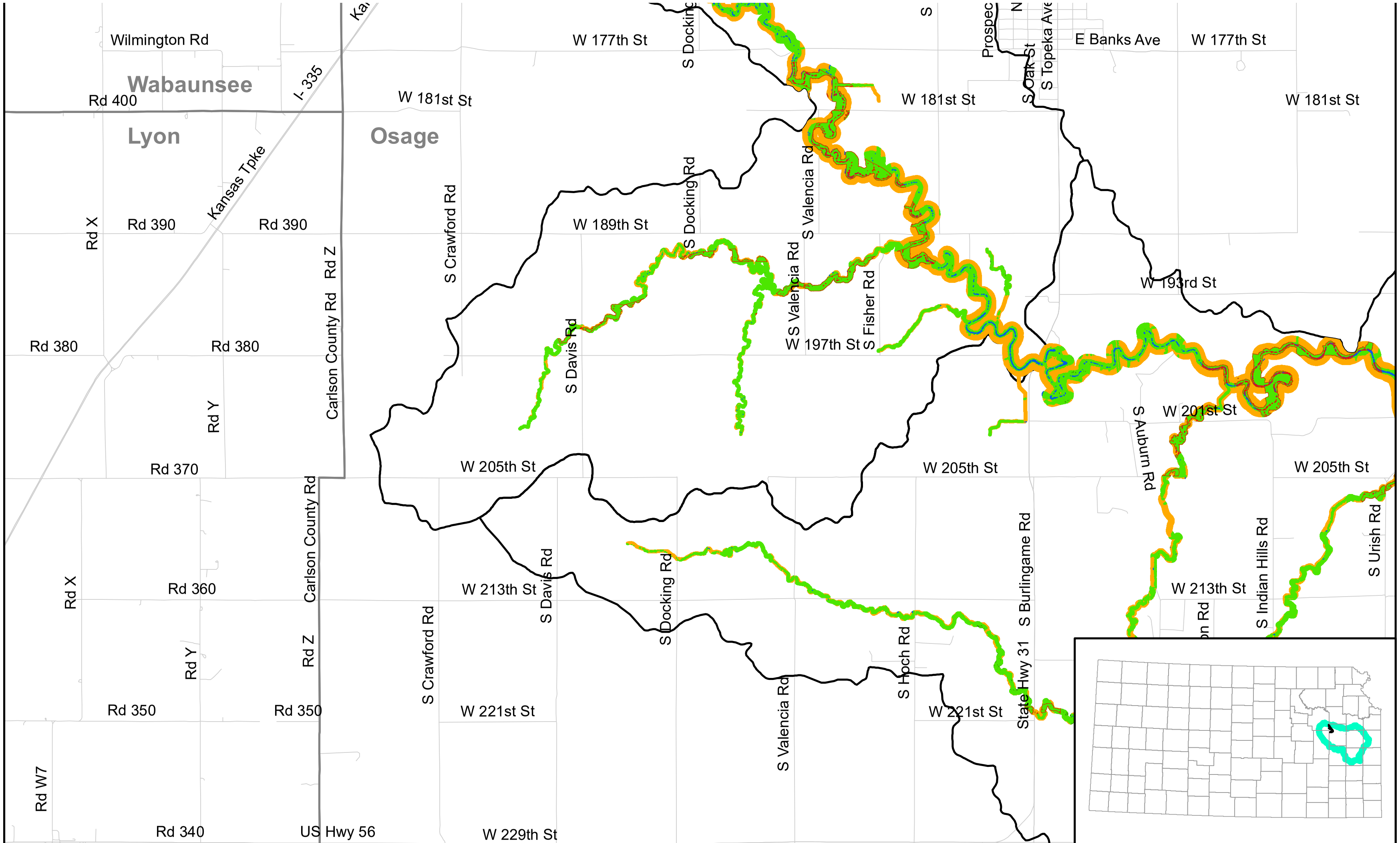
102701040105
Douglas
Shawnee
Osage
Wakarusa River
E 200th Rd
E 50 Rd
E 1st Rd
E 100 Rd
E 200 Rd
N 1700th Rd
N 1600 Rd
N 1500 Rd
N 1400 Rd
N 1300 Rd
N 1200 Rd
N 1150 Rd
N 1000th Rd
N 950 Rd
N 900 Rd
N 850 Rd
Co Rd 442
Stull Rd
Co Rd 458
SE Herschell Rd
SE Clinton Wildlife Rd
SE Wooding Rd
SE Stubbs Rd
SE Shadden Rd
SE Stanley Rd
SE Green Rd
SE Shawnee Heights Rd
SE Dupont Rd
SE Ratner Rd
SE Tecumseh Rd
SE Paulen Rd
SE Matney Rd
Elm Cove Rd
SE Coberly Rd
SE Croco Rd
SE Berryton Rd
SE California Ave
Perimeter Rd
SE Mtaa-Forbes
SE Adams St
SE Willets Rd
SE 43rd Ter
SE 44th St
SE 45th St
SE 49th St
SE 53rd St
SE 61st St
SE 69th St
SE 77th St
SE 81st St
SE 85th St
SE 89th St
SE 93rd St
SE 98th St
SE 99th St
SE 101st St
SE 105th St
SE 109th St
E 109th St
E 113th St


Riparian Forest Assessment
HUC-12 = 102701040105
Upper Wakarusa Study Area
NRCS-RCPP Agreement
March 2018
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads
Riparian Forest Class
Conservation
Developed
Establishment
Management
Water
Potential Historical Remnant Forest
HUC-12 Boundary
County Boundary
Roads
HUC-8 Boundary
Major River
0
6,000 Feet
1 inch = 6,000 feet
N
USDA
E 117th St
E 125th St
E 133rd St
E 137th St
E 141st St
E 149th St
E 121st St
E 129th St
E 165th St
W 157th St
US Hwy 56
S California Rd
S Berryton Rd
S Croco Rd
S Paulen Rd
S Paulin Rd
S Ratner Rd
S Shawnee Heights Rd
S Stanley Rd
S Stubbs Rd
S Wooding Rd
Wooding Rd
S Adams Rd
Adams Ter
Sunset Ln
Oak St
7th St
8th St
1st St
E 1 Rd
Co Rd 460
Co Rd 1023
Co Rd 450N
N 800 Rd
N 600 Rd
N 450 Rd
N 400 Rd
E 100 Rd
E 150 Rd
E 200 Rd


Clinton Lake
102701040108
102701040106
Shawnee
George Williams Way
E 902 Rd
N 1150 Rd
E 900 Rd
Clinton Pkwy
State Hwy 10
US Hwy 40
E 902nd Rd
E 975 Rd
E 950th Rd
N 1800th Rd
E 850th Rd
Co Rd 438
E 818 Rd
E 800th Rd Trailridge Rd
N 1750 Rd
W 6th St
1500 Rd
N 1550th Rd
E 775 Rd
N 1415 Rd
E 732 Rd
E 700th Rd
I- 70
E 687 Rd
E 652nd Rd
E 660th Rd
E 660 Rd
1400 Rd
Co Rd 1029
Kansas Tpke
E 600 Rd
E 550th Rd
N 1850th Rd
N 1663 Rd
E 500th Rd
E 500 Rd
N 1500 Rd
N 1800
Stull Rd
N 1700th Rd
E 400 Rd
E 350 Rd
E 380 Rd
N 1400th Rd
N 1600 Rd
E 300th Rd
E 300 Rd
Co Rd 442
Co Rd 1023 E 200th Rd
E 150th Rd
E 250 Rd
N 1250th Rd
N 1300 Rd
N 1150 Rd
N 1400 Rd
E 100 Rd
E 50th Rd
E 50 Rd
N 1200 Rd
E 1st Rd
Woodling Rd
SE Woodling Rd
SE Bender Dr
SE 32nd Ter
SE 37th St
SE Herschell Rd
SE Stubbs Rd
SE 81st St
SE 53rd St
SE Shadden Rd
SE 85th St
SE 89th St
SE 61st St
SE Stanley Rd
SE 69th St
SE 45th St
SE Green Rd
SE 77th St
SE 37th St
SE Shawnee Heights Rd
SE Dupont Rd
E 600 Rd
Co Rd 6
E 604 Rd
Co Rd 4
E 500 Rd
N 851st Diag Rd
E 251 Diag Rd
E 251st Diag Rd
Co Rd 458
Co Rd 1023
N 851 Diagonal Rd
N 950 Rd
N 1000th Rd
N 900 Rd
E 1 Rd
SE 101st St
SE 105th St
SE 98th St
E 100th St
SE 109th St
E 976 Rd
N 1050 Rd
N 1000 Rd
N 1072 Rd
E 850 Rd
N 900 Rd
N 950th Rd
E 750th Rd
N 1032 Rd
Co Rd 458
E 675
N 1000 Rd
E 622 Rd
E 535th Rd
E 400 Rd
E 350 Rd
Co Rd 1


Riparian Forest Assessment
HUC-12 = 102701040106, 102701040107 & 102701040108
Upper Wakarusa Study Area
NRCS-RCPP Agreement
March 2018
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads
Riparian Forest Class
Conservation
Developed
Establishment
Management
Water
Potential Historical Remnant Forest
HUC-12 Boundary
County Boundary
Roads
HUC-8 Boundary
Major River
0
7,000 Feet
1 inch = 7,000 feet
N
102701040107
Douglas
Osage


Shawnee
Osage
102901010203
Dragoon Creek
S Vawter Rd
SW 103rd St
S W 109th St
W 116th St
W 117th St
S Indian Hills Rd
W 141st St
W 149th St
W 165th St
W 173rd St
SW Auburn Rd
S Auburn Rd
S Kansas Rd
E Santa Fe Ave
W 157th St
SW 105th St
S Burlingame Rd
N Topeka Ave
S Osage Rd
Osage St
S Hoch Rd
SW Hoch Rd
Hoch Rd
W 133rd St
W 109th St
S Valencia Rd
S Docking Rd
SW Davis Rd
S Davis Rd
SW 109th St
W 125th St
S Crawford Rd
SW Carlson Rd
Carlson Rd
S Carlson Rd
Walton Rd
Harveyville Blacktop Rd
Eight Mile Rd
Gookins Rd
Headwaters Rd
Harveyville Rd
Old Log House Rd
Elm St
County Rd
Wolf Trail Rd
Soldier Creek Rd
Wakarusa Rd
Quaker Rd
Dragoon Creek Rd
Mockingbird Hill Rd
Robbers Roost Rd
Miller Rd
Pronghorn Rd



Riparian Forest Asssessment

HUC-12 = 102901010203
Pomona Lake Study Area
NRCS-RCPP Agreement

March 2018

Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads

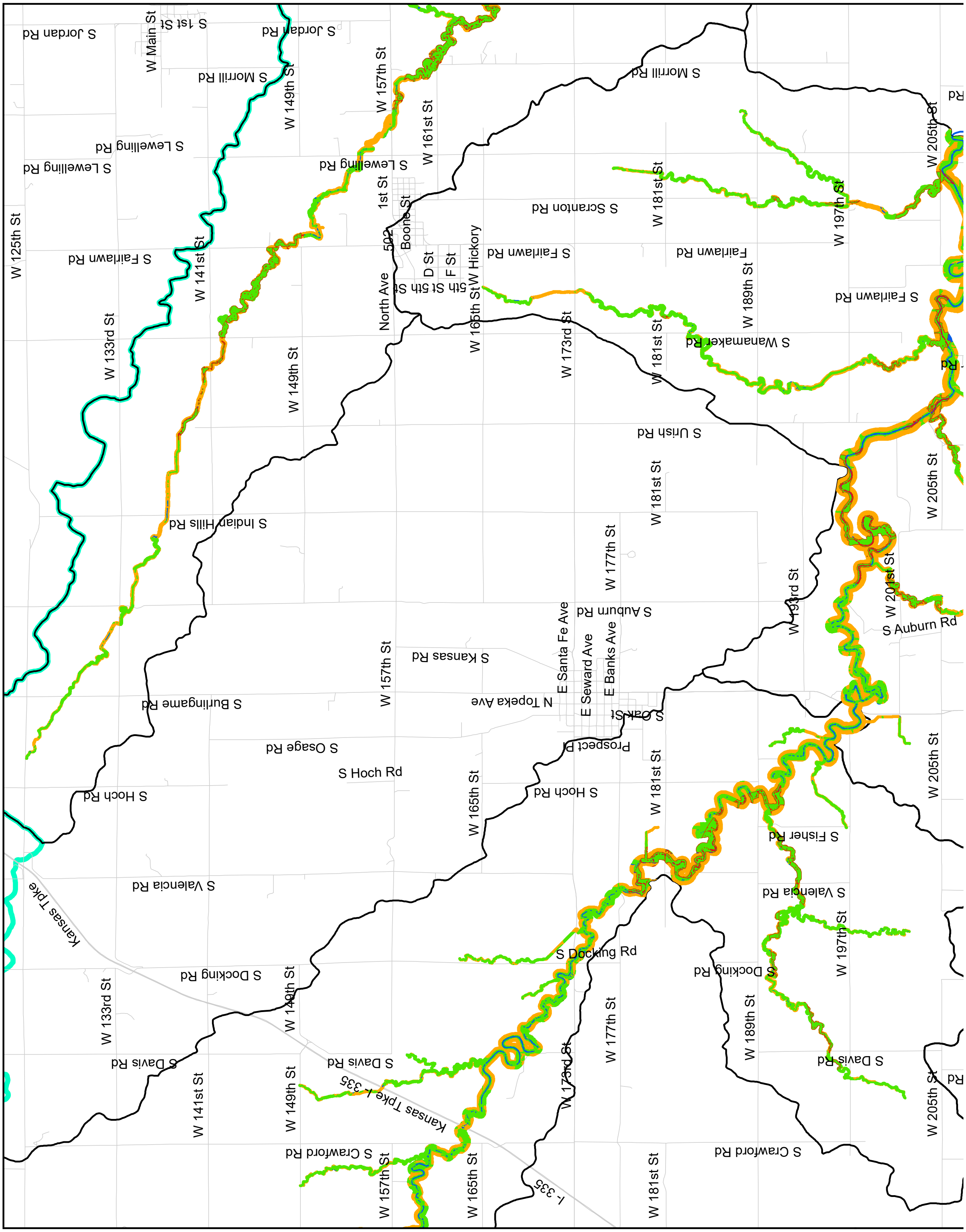
Riparian Forest Class

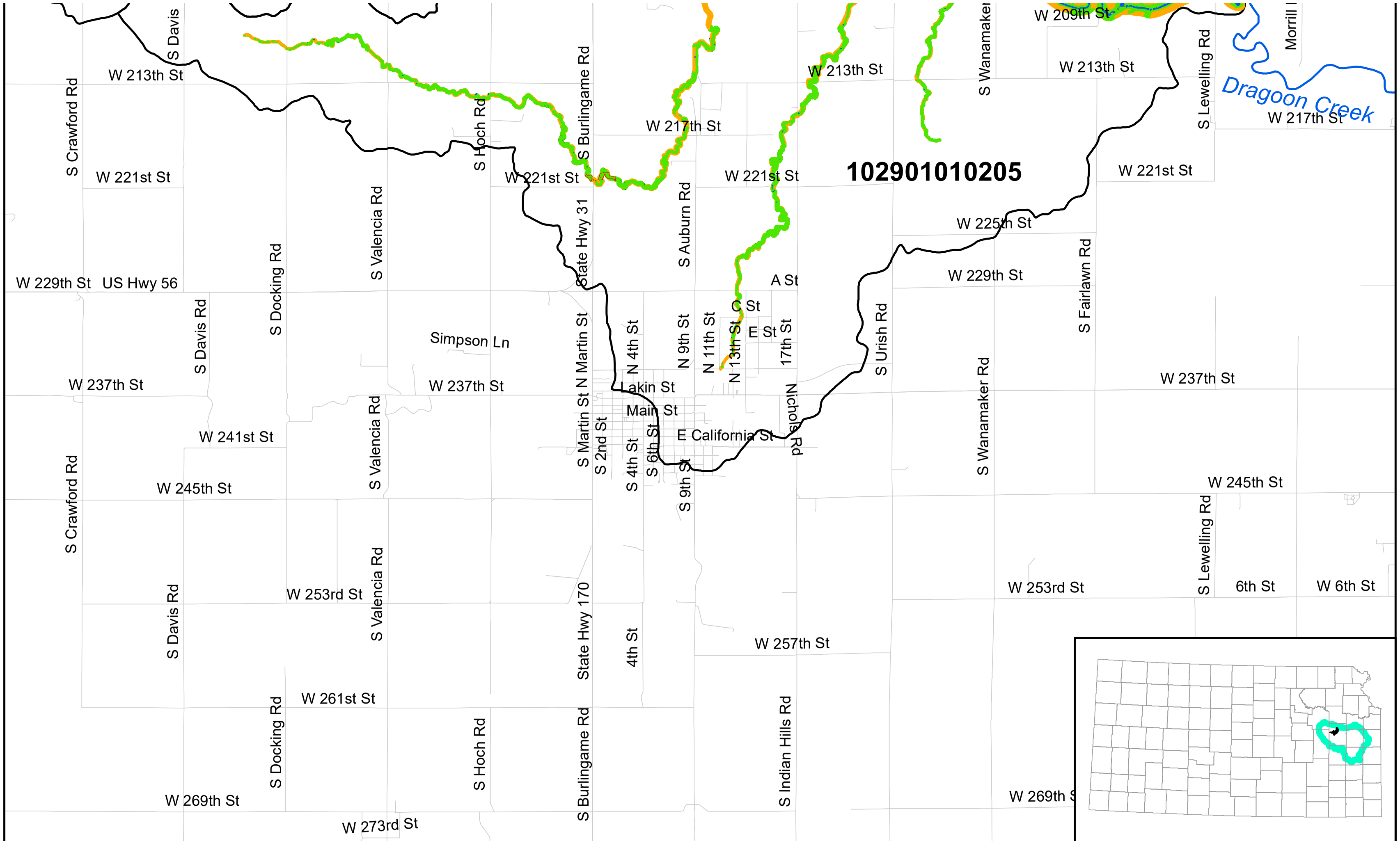
- Conservation
- Developed
- Establishment
- Management
- Water
- Potential Historical Remnant Forest

- HUC-12 Boundary
- County Boundary
- Roads
- HUC-8 Boundary
- Major River

0 6,000 Feet
1 inch = 6,000 feet

N


S Jordan Rd
S 1st St
W Main St
S Morrill Rd
W 149th St
W 157th St
W 161st St
S Lewelling Rd
1st St
Boone St
502
D St
F St
5th St
W Hickory
North Ave
W 165th St
S Scranton Rd
W 181st St
W 197th St
W 205th St
S Fairlawn Rd
Fairlawn Rd
W 189th St
W 125th St
W 141st St
W 133rd St
W 173rd St
S Wanamaker Rd
S Urish Rd
S Indian Hills Rd
W 177th St
W 193rd St
W 201st St
S Auburn Rd
E Santa Fe Ave
E Seward Ave
E Banks Ave
S Kansas Rd
S Burlingame Rd
N Topeka Ave
S Oak St
S Osage Rd
Prospect Pl
S Hoch Rd
S Fisher Rd
S Valencia Rd
Kansas Tpke
S Docking Rd
S Davis Rd
Kansas Tpke I-335
S Crawford Rd
I-335
Rd



Riparian Forest Asssessment
HUC-12 = 102901010205
Pomona Lake Study Area
NRCS-RCPP Agreement
March 2018

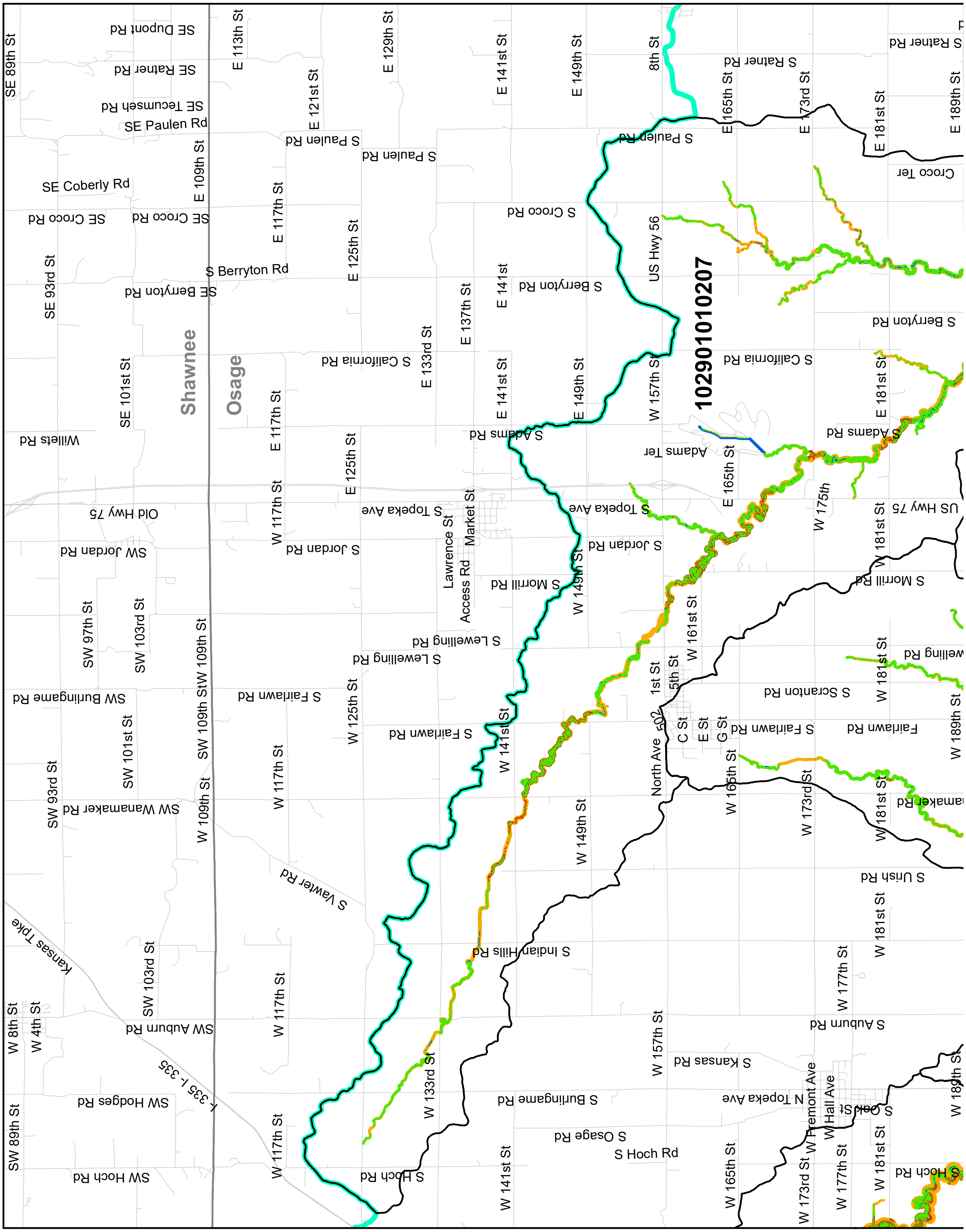
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads

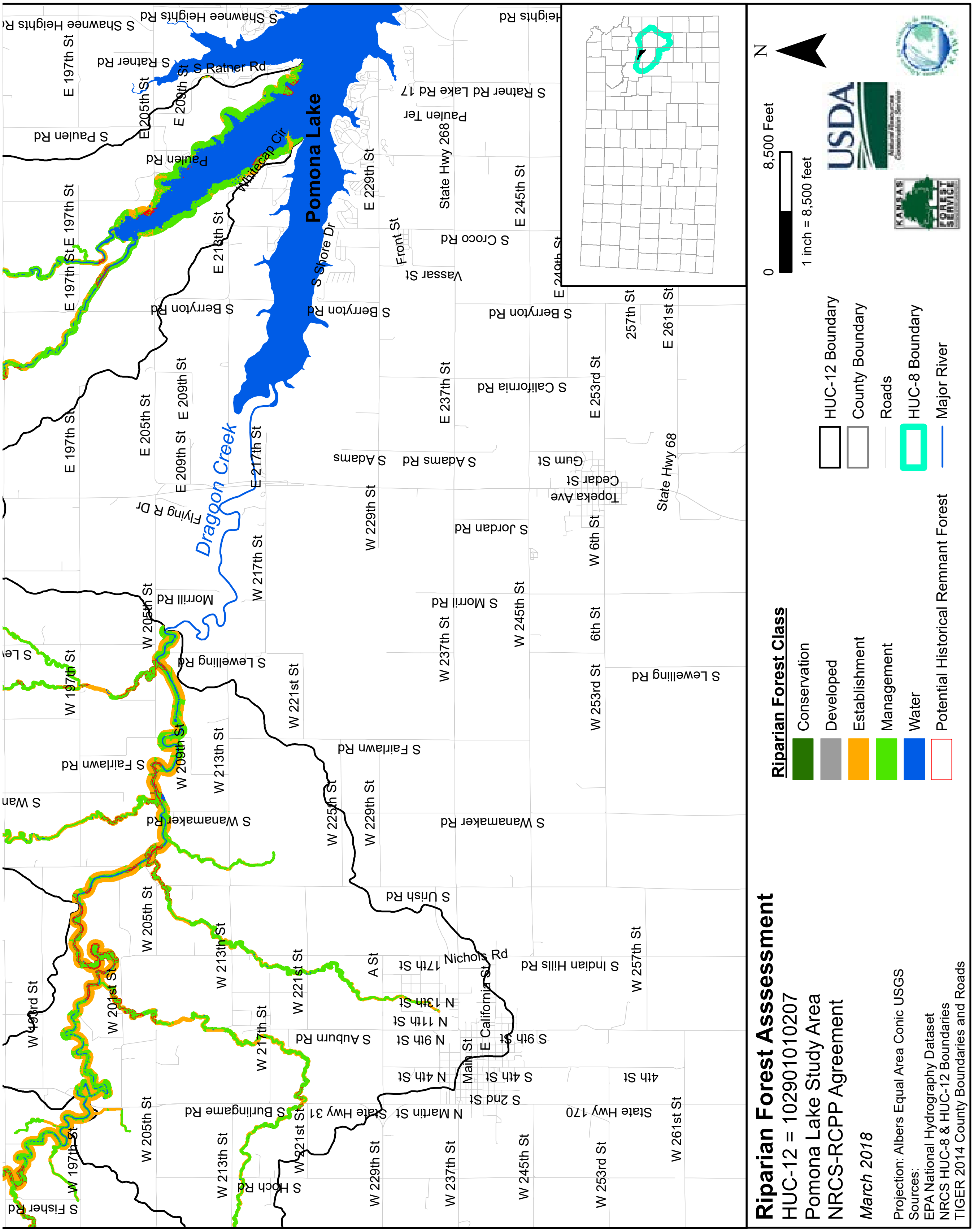
Riparian Forest Class
- Conservation
- Developed
- Establishment
- Management
- Water
- Potential Historical Remnant Forest

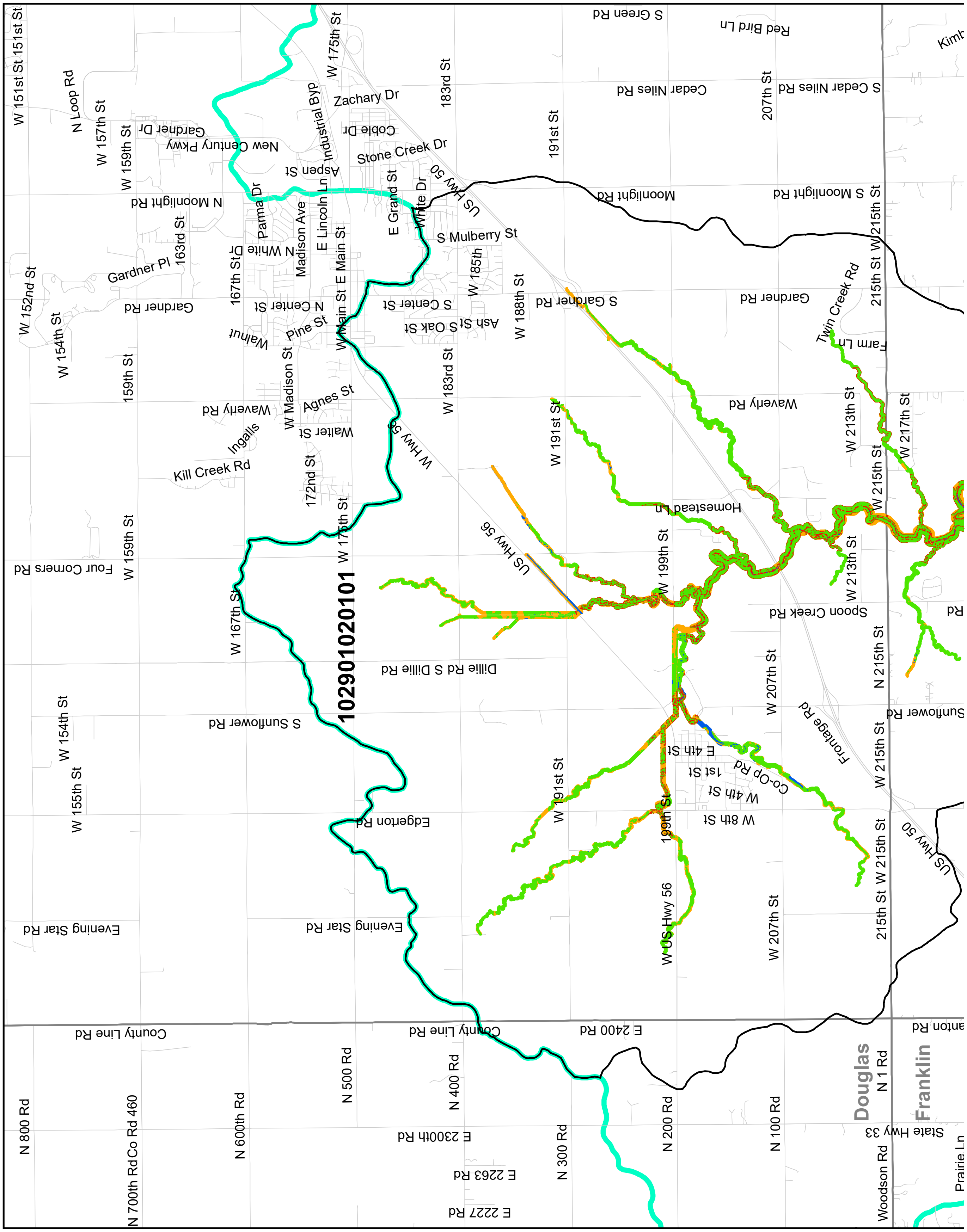
- HUC-12 Boundary
- County Boundary
- Roads
- HUC-8 Boundary
- Major River

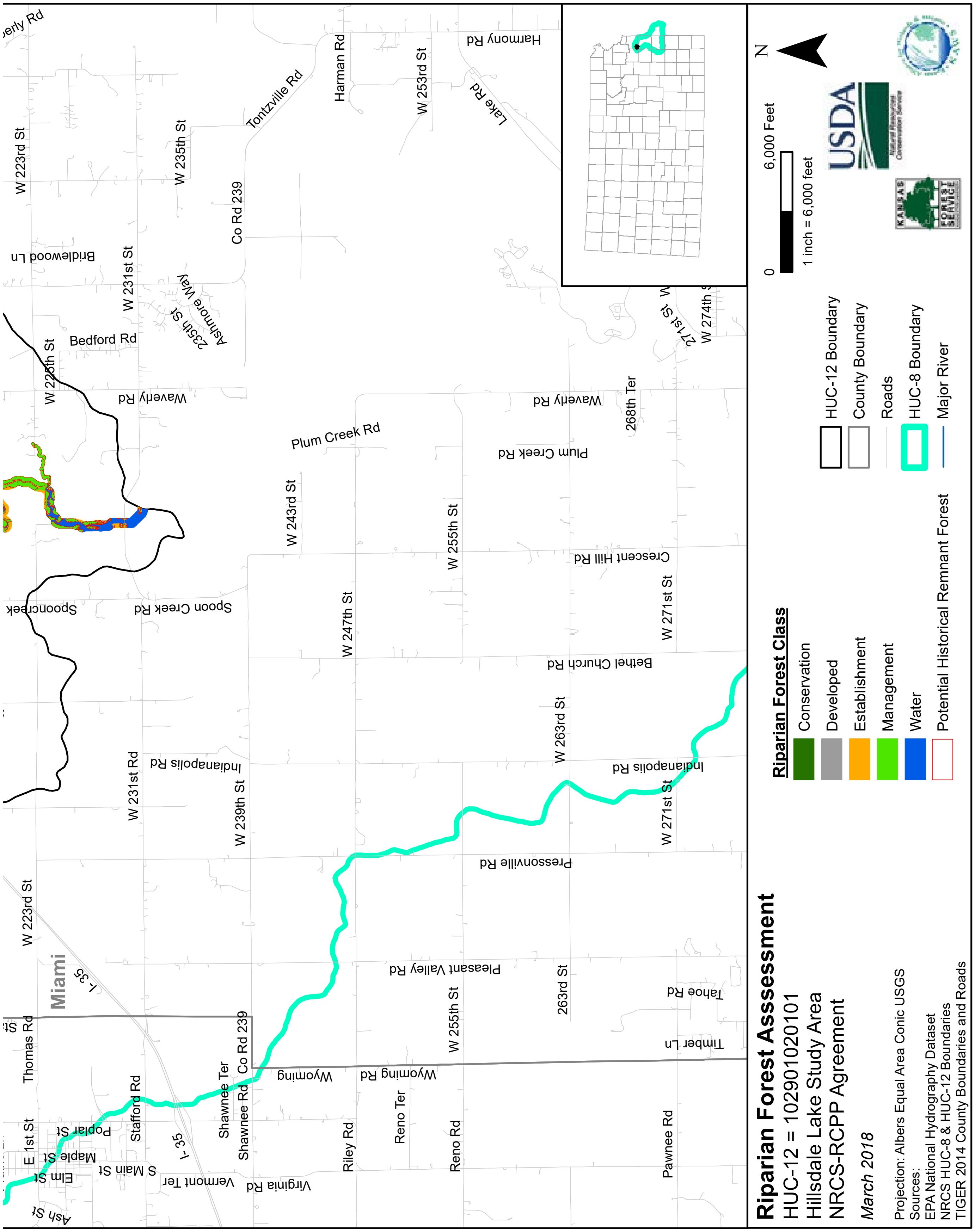
0 7,000 Feet
1 inch = 7,000 feet

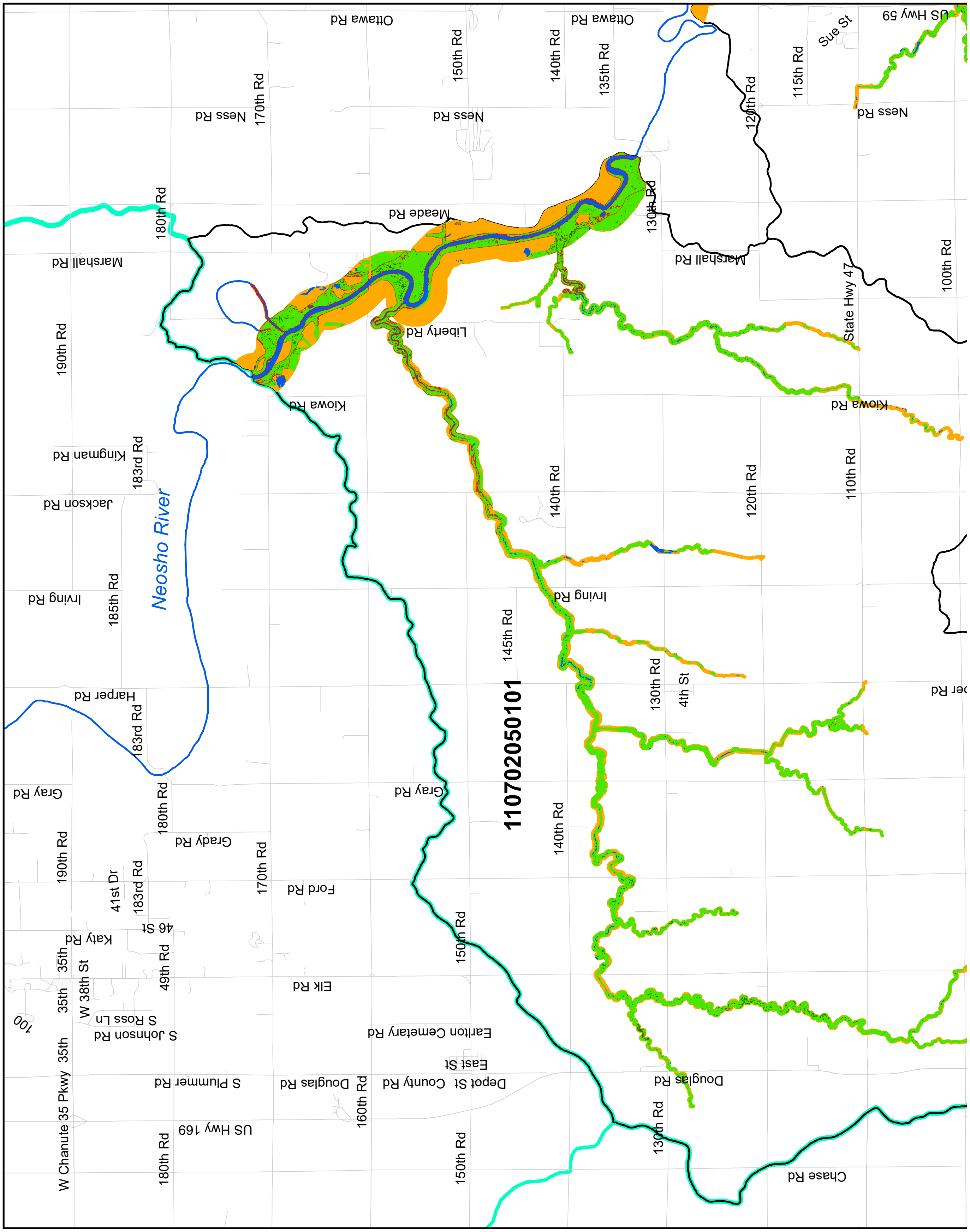
N

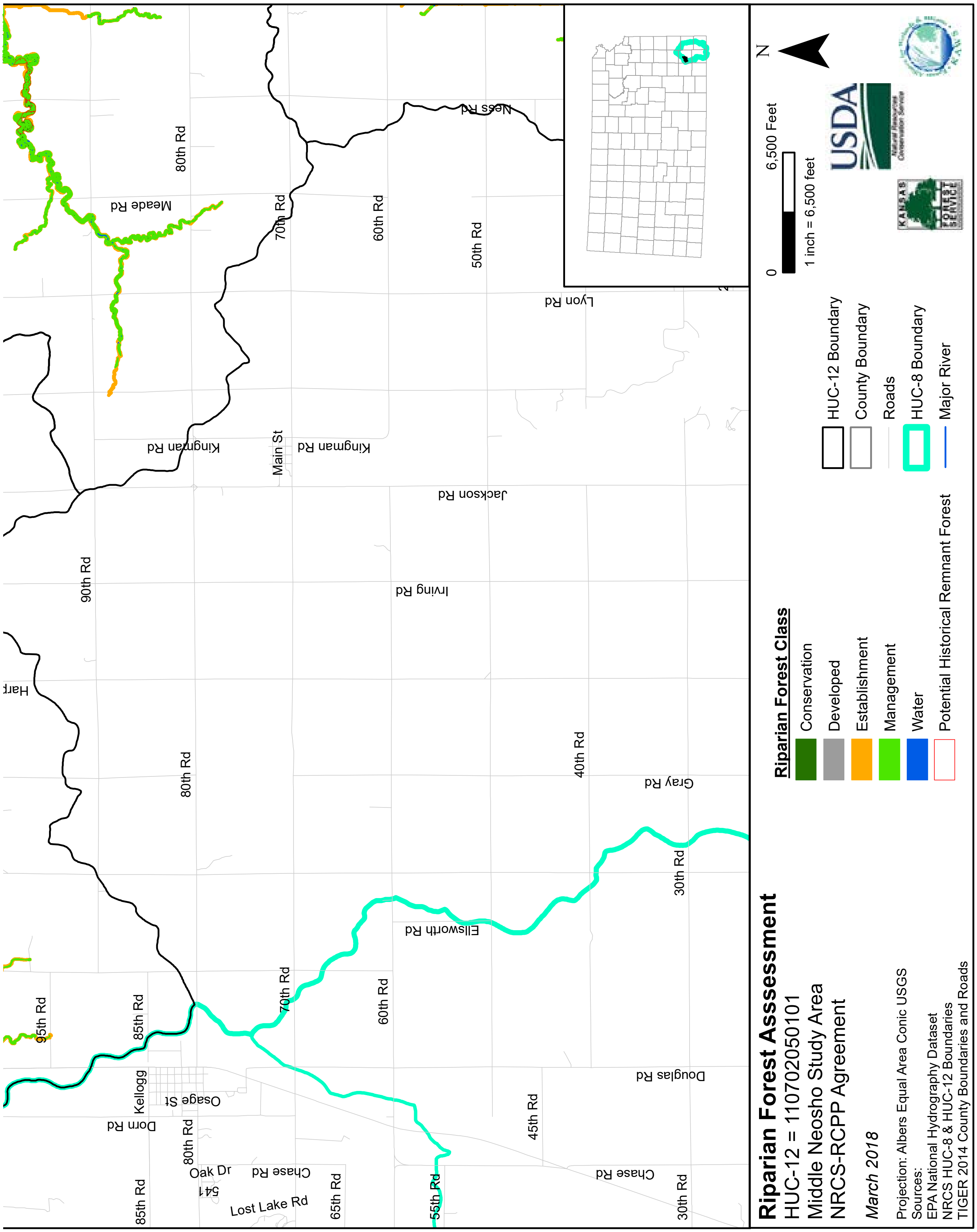

102901010207
Shawnee
Osage
US Hwy 56
US Hwy 75
Old Hwy 75
I-335 I-335
Kansas Tpke
S Topeka Ave
S Berryton Rd
S California Rd
S Adams Rd
S Jordan Rd
S Morrill Rd
S Lewelling Rd
S Fairlawn Rd
S Scranton Rd
S Urish Rd
S Indian Hills Rd
S Auburn Rd
S Kansas Rd
S Burlingame Rd
S Osage Rd
S Hoch Rd
S Vawter Rd
S Paulen Rd
S Croco Rd
S Rater Rd
Croco Ter
Adams Ter
SE Dupont Rd
SE Rater Rd
SE Tecumseh Rd
SE Paulen Rd
SE Coberly Rd
SE Croco Rd
SE Berryton Rd
Willets Rd
SW Jordan Rd
SW Burlingame Rd
SW Wanamaker Rd
SW Auburn Rd
SW Hodges Rd
SW Hoch Rd
Lawrence St
Market St
Access Rd
North Ave
N Topeka Ave
W Fremont Ave
W Hall Ave
S Oak St
C St
E St
G St
1st St
5th St
8th St
E 113th St
E 117th St
E 121st St
E 125th St
E 129th St
E 133rd St
E 137th St
E 141st St
E 149th St
E 157th St
E 165th St
E 173rd St
E 181st St
E 189th St
W 109th St
W 117th St
W 125th St
W 133rd St
W 141st St
W 149th St
W 157th St
W 161st St
W 165th St
W 173rd St
W 175th
W 177th St
W 181st St
W 189th St
SE 89th St
SE 93rd St
SE 101st St
E 109th St
SW 89th St
SW 93rd St
SW 97th St
SW 101st St
SW 103rd St
SW 109th St
W 4th St
W 8th St

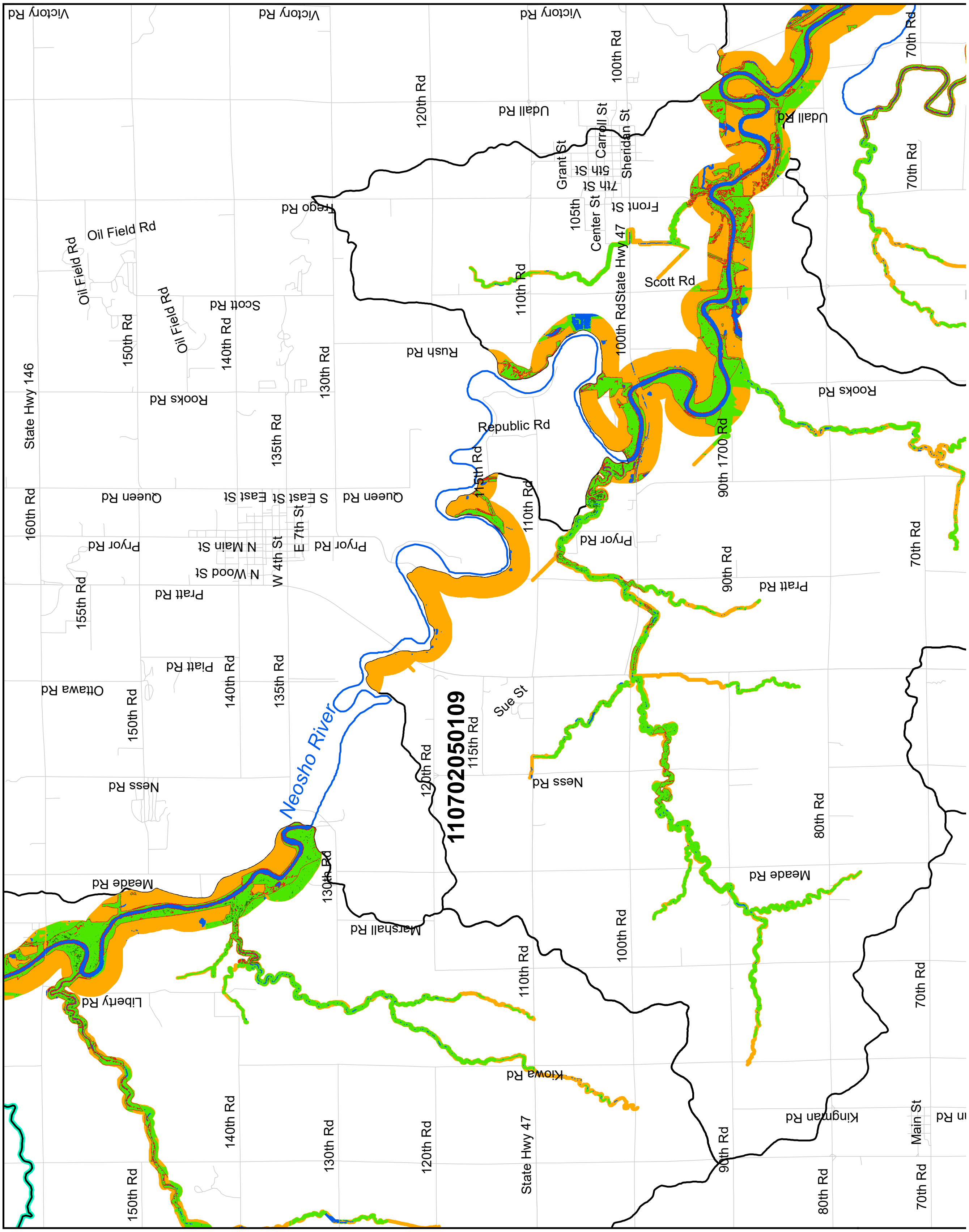

Riparian Forest Assessment
HUC-12 = 102901010207
Pomona Lake Study Area
NRCS-RCPP Agreement
March 2018
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads
Riparian Forest Class
Conservation
Developed
Establishment
Management
Water
Potential Historical Remnant Forest
HUC-12 Boundary
County Boundary
Roads
HUC-8 Boundary
Major River
0
8,500 Feet
1 inch = 8,500 feet
N
Pomona Lake
Dragoon Creek


102901020101
W 151st St
151st St
N Loop Rd
W 157th St
W 159th St
Gardner Dr
New Century Pkwy
Aspen St
Industrial Byp
W 175th St
Zachary Dr
Coble Dr
Stone Creek Dr
183rd St
US Hwy 50
White Dr
E Grand St
E Lincoln Ln
Parma Dr
Madison Ave
N White Dr
E Main St
S Mulberry St
W 185th
191st St
S Green Rd
Red Bird Ln
Cedar Niles Rd
207th St
S Cedar Niles Rd
Moonlight Rd
S Moonlight Rd
N Moonlight Rd
215th St
W 215th St
163rd St
Gardner Pl
W 152nd St
167th St
Gardner Rd
S Gardner Rd
N Center St
S Center St
Ash St
S Oak St
W 188th St
Twin Creek Rd
Farm Ln
W 154th St
159th St
Walnut
Pine St
W Main St
W 183rd St
Waverly Rd
W Madison St
Agnes St
Walter St
Ingalls
Kill Creek Rd
172nd St
W Hwy 56
W 191st St
W 213th St
W 217th St
W 215th St
Homestead Ln
W 159th St
W 175th St
US Hwy 56
Four Corners Rd
W 167th St
W 199th St
Spoon Creek Rd
Rd
Dillie Rd
S Dillie Rd
N 215th St
W 207th St
S Sunflower Rd
Sunflower Rd
Frontage Rd
W 154th St
W 155th St
E 4th St
1st St
Co-Op Rd
W 4th St
W 8th St
199th St
Edgerton Rd
US Hwy 50
Evening Star Rd
W US Hwy 56
County Line Rd
E 2400 Rd
anton Rd
N 800 Rd
N 700th Rd
Co Rd 460
N 600th Rd
N 500 Rd
N 400 Rd
N 300 Rd
N 200 Rd
N 100 Rd
Douglas
N 1 Rd
Franklin
E 2300th Rd
E 2263 Rd
E 2227 Rd
State Hwy 33
Woodson Rd
Prairie Ln


Riparian Forest Asssessment
HUC-12 = 102901020101
Hillsdale Lake Study Area
NRCS-RCPP Agreement
March 2018
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads
Riparian Forest Class
Conservation
Developed
Establishment
Management
Water
Potential Historical Remnant Forest
HUC-12 Boundary
County Boundary
Roads
HUC-8 Boundary
Major River
0
6,000 Feet
1 inch = 6,000 feet
N
Miami


11070205010101
Neosho River
Ottawa Rd
Ness Rd
Meade Rd
Marshall Rd
Liberty Rd
Kiowa Rd
Kingman Rd
Jackson Rd
Irving Rd
Harper Rd
Gray Rd
Grady Rd
Ford Rd
Katy Rd
46 St
Elk Rd
Earlton Cemetary Rd
S Ross Ln
S Johnson Rd
East St
Depot St
County Rd
Douglas Rd
S Plummer Rd
US Hwy 169
Chase Rd
US Hwy 59
Sue St
State Hwy 47
100th Rd
110th Rd
115th Rd
120th Rd
130th Rd
135th Rd
140th Rd
145th Rd
150th Rd
160th Rd
170th Rd
180th Rd
183rd Rd
185th Rd
190th Rd
4th St
41st Dr
49th Rd
W 38th St
35th
W Chanute 35 Pkwy
100


Riparian Forest Asssessment
HUC-12 = 110702050101
Middle Neosho Study Area
NRCS-RCPP Agreement
March 2018
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads
Riparian Forest Class
Conservation
Developed
Establishment
Management
Water
Potential Historical Remnant Forest
HUC-12 Boundary
County Boundary
Roads
HUC-8 Boundary
Major River
0
6,500 Feet
1 inch = 6,500 feet
N
USDA
Natural Resources Conservation Service
KANSAS FOREST SERVICE
Meade Rd
Ness Rd
80th Rd
70th Rd
60th Rd
50th Rd
Lyon Rd
Kingman Rd
Main St
Jackson Rd
90th Rd
Irving Rd
Harp
80th Rd
40th Rd
Gray Rd
30th Rd
Ellsworth Rd
70th Rd
60th Rd
95th Rd
85th Rd
Kellogg
Osage St
Dorn Rd
Douglas Rd
45th Rd
80th Rd
Oak Dr
Chase Rd
54
Lost Lake Rd
85th Rd
65th Rd
55th Rd
30th Rd
Chase Rd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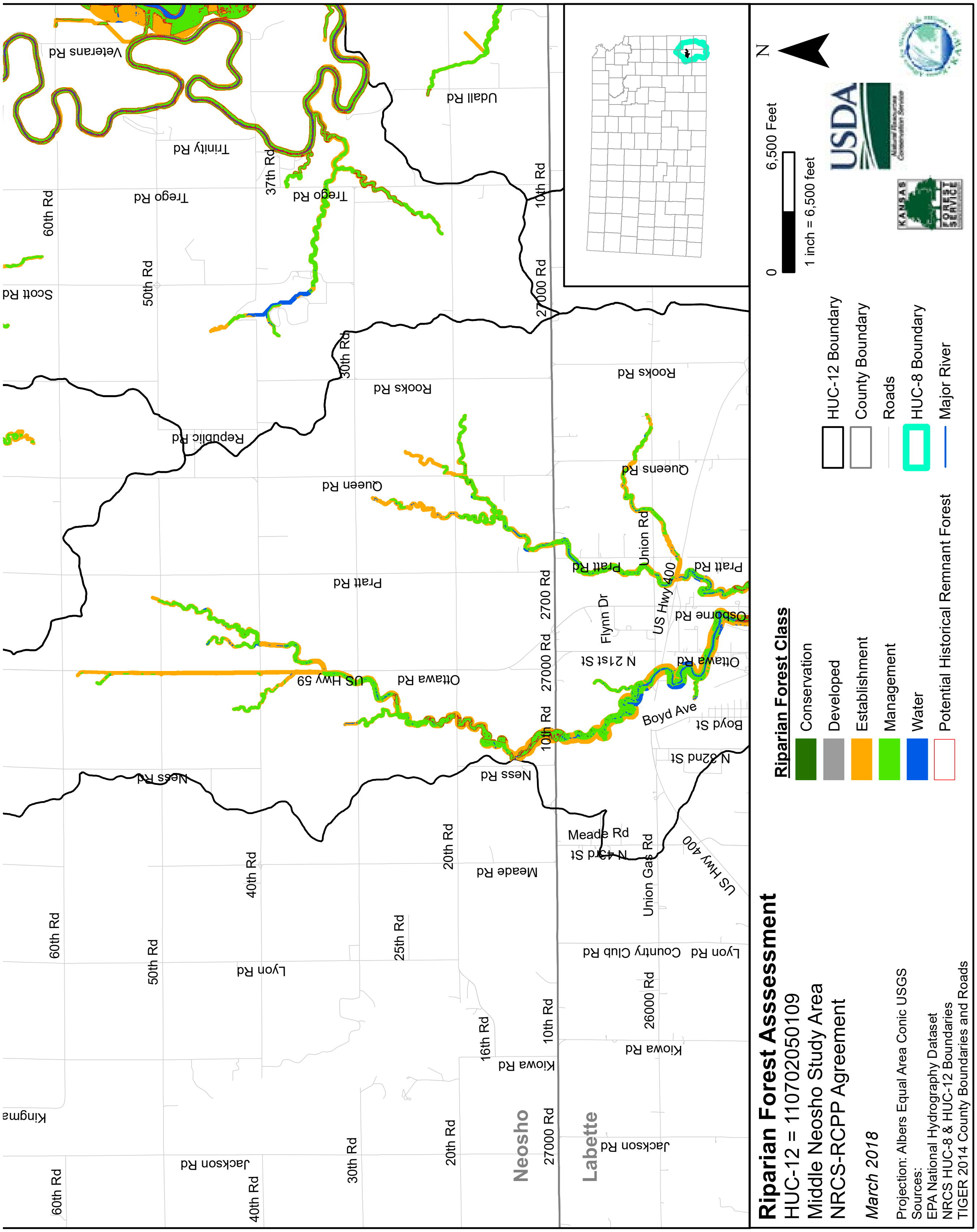
Neosho River
Victory Rd
Udall Rd
Trego Rd
Oil Field Rd
Scott Rd
Rush Rd
Rooks Rd
Republic Rd
Queen Rd
Pryor Rd
Pratt Rd
Platt Rd
Ottawa Rd
Ness Rd
Meade Rd
Marshall Rd
Liberty Rd
Kiowa Rd
Kingman Rd
State Hwy 146
State Hwy 47
160th Rd
155th Rd
150th Rd
140th Rd
135th Rd
130th Rd
120th Rd
115th Rd
110th Rd
105th
100th Rd
90th Rd
90th 1700 Rd
80th Rd
70th Rd
Grant St
Carroll St
Sheridan St
5th St
7th St
Front St
Center St
S East St
East St
E 7th St
N Main St
W 4th St
N Wood St
Sue St
Main St


Riparian Forest Asssessment
HUC-12 = 110702050109
Middle Neosho Study Area
NRCS-RCPP Agreement
March 2018
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
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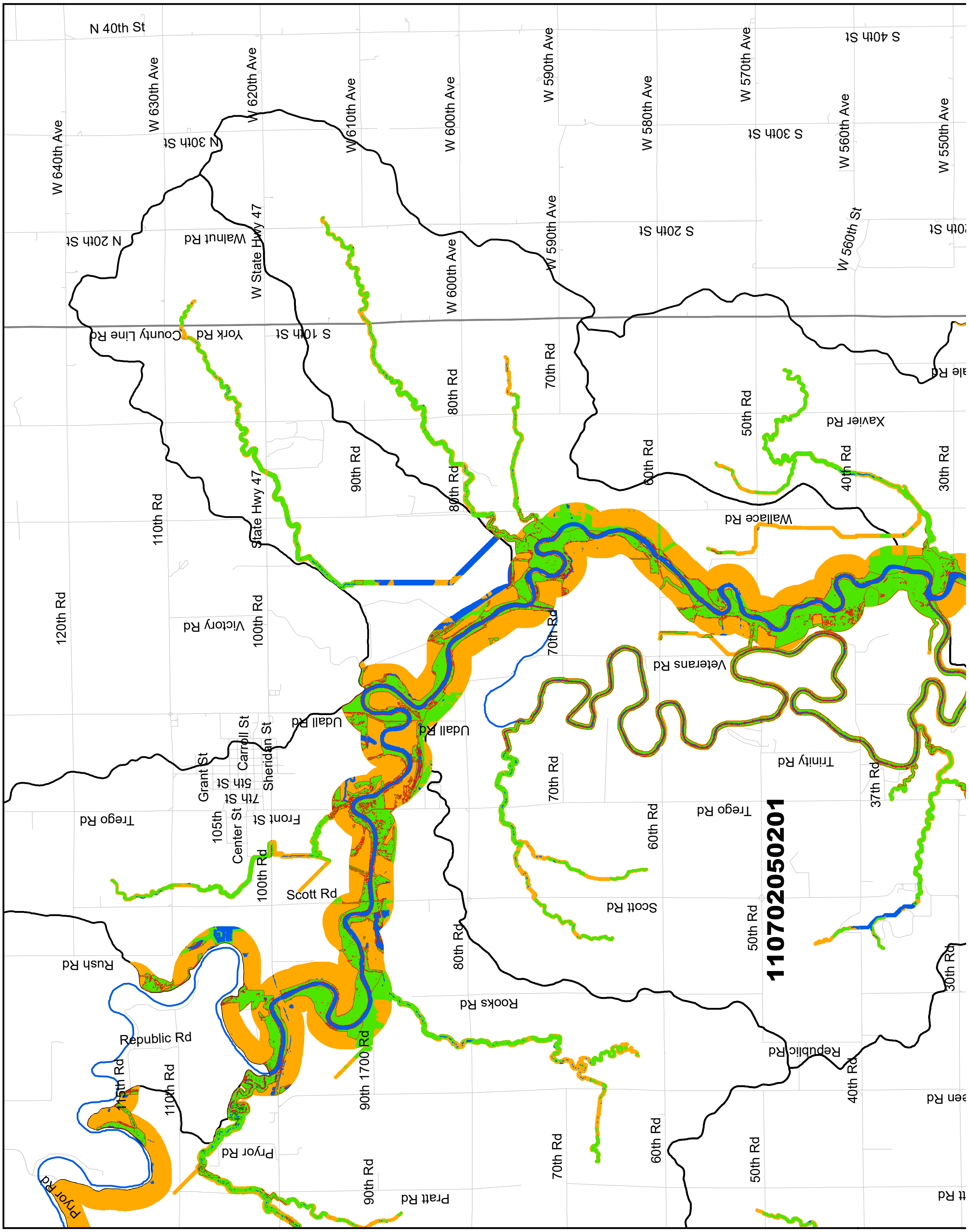
Conservation
Developed
Establishment
Management
Water
Potential Historical Remnant Forest
HUC-12 Boundary
County Boundary
Roads
HUC-8 Boundary
Major River
0
6,500 Feet
1 inch = 6,500 feet
N
USDA
Neosho
Labette
Veterans Rd
Trinity Rd
Udall Rd
Trego Rd
Scott Rd
Republic Rd
Rooks Rd
Queen Rd
Queens Rd
Pratt Rd
Ottawa Rd
US Hwy 59
Ness Rd
Meade Rd
Lyon Rd
Country Club Rd
Kiowa Rd
Jackson Rd
Kingman
Osborne Rd
Boyd Ave
Boyd St
N 32nd St
N 21st St
N 43rd St
Flynn Dr
Union Rd
Union Gas Rd
US Hwy 400
60th Rd
50th Rd
40th Rd
37th Rd
30th Rd
25th Rd
20th Rd
16th Rd
10th Rd
27000 Rd
2700 Rd
26000 Rd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N 30th St
N 20th St
S 10th St
S 20th St
S 30th St
S 40th St
W 640th Ave
W 630th Ave
W 620th Ave
W 610th Ave
W 600th Ave
W 590th Ave
W 580th Ave
W 570th Ave
W 560th Ave
W 550th Ave
W State Hwy 47
W 560th St
Walnut Rd
County Line Rd
York Rd
Xavier Rd
Wallace Rd
Victory Rd
Veterans Rd
Udall Rd
Trinity Rd
Trego Rd
Front St
Scott Rd
Rush Rd
Rooks Rd
Republic Rd
Pryor Rd
Pratt Rd
120th Rd
115th Rd
110th Rd
105th
100th Rd
90th Rd
90th 1700 Rd
80th Rd
70th Rd
60th Rd
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40th Rd
37th Rd
30th Rd
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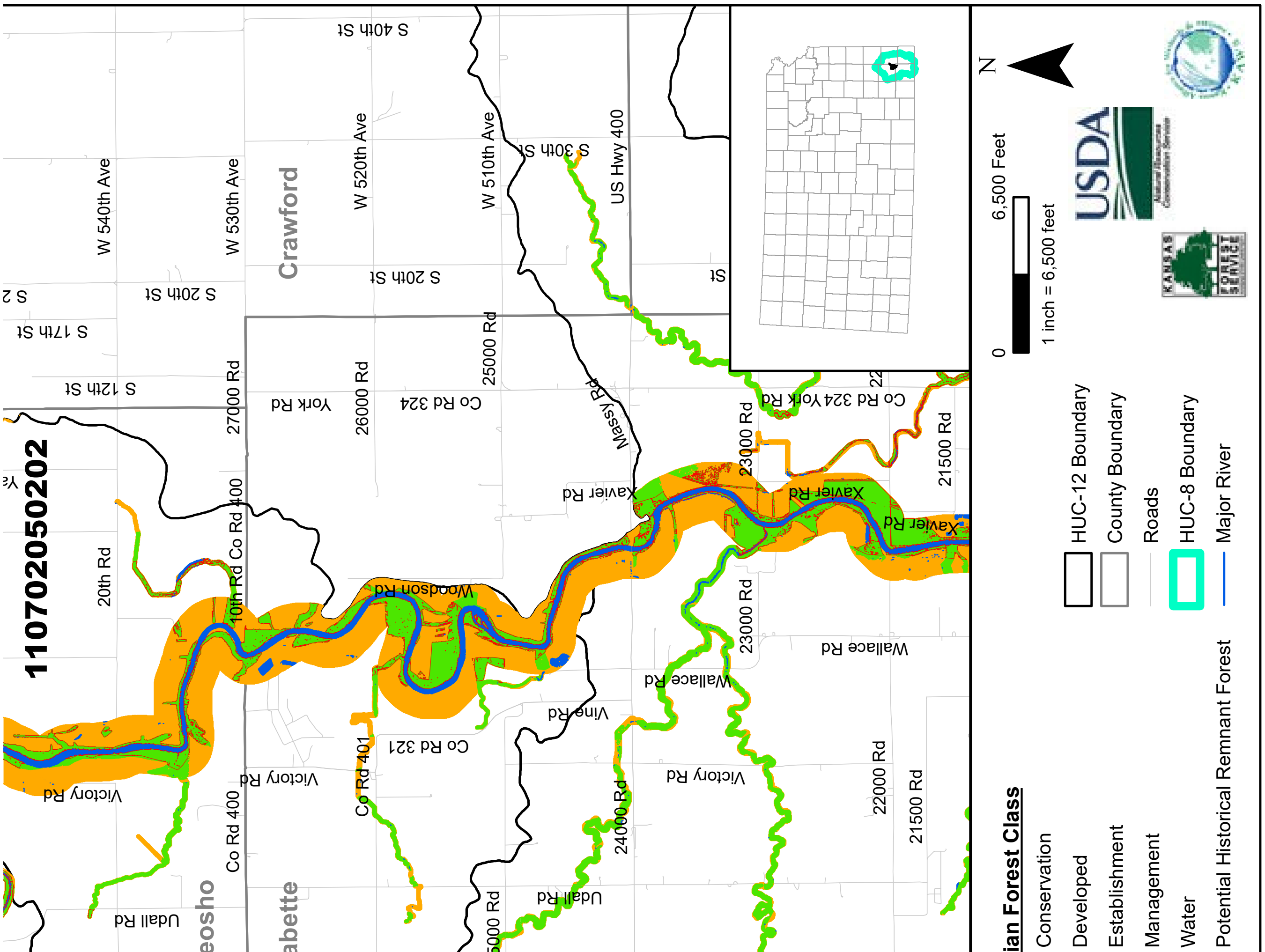
Carroll St
Sheridan St
5th St
7th St
Center St
State Hwy 47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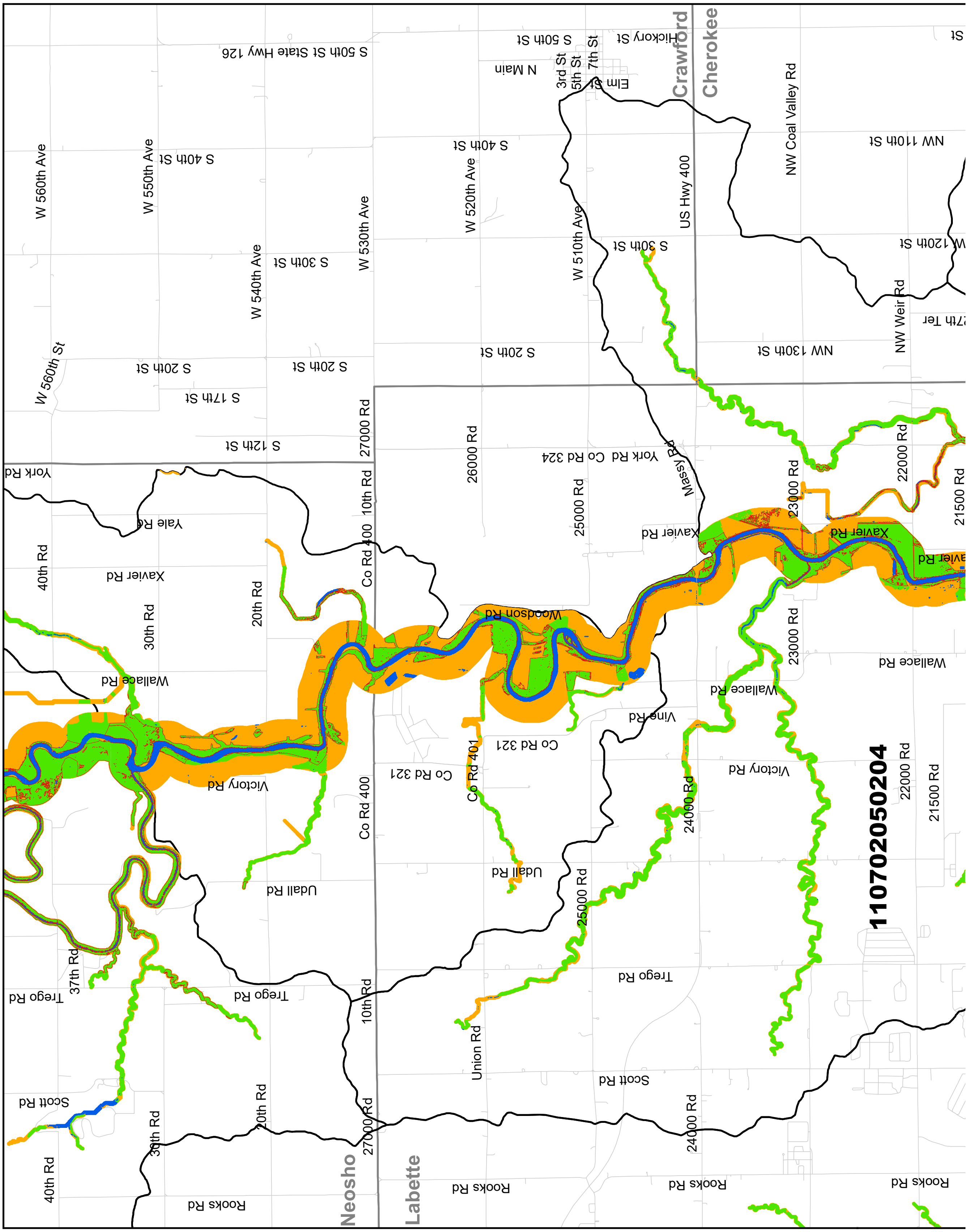
Middle Neosho Study Area
NRCS-RCPP Agreement
March 2018
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads
Riparian Forest Class
Conservation
Developed
Establishment
Management
Water
Potential Historical Remnant Forest
HUC-12 Boundary
County Boundary
Roads
HUC-8 Boundary
Major River
0
6,500 Feet
1 inch = 6,500 feet
N
USDA
Neosho
Labette
Crawford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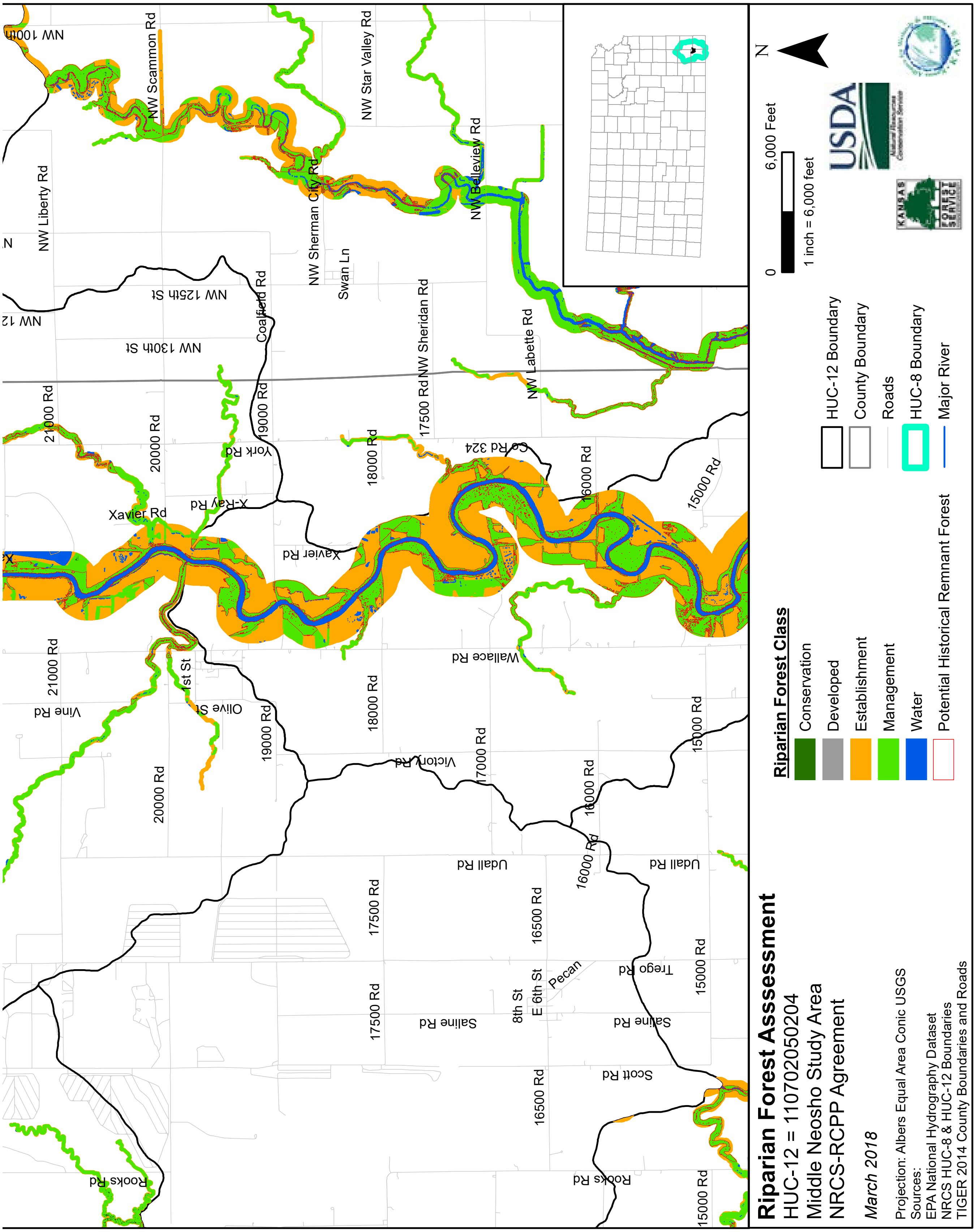
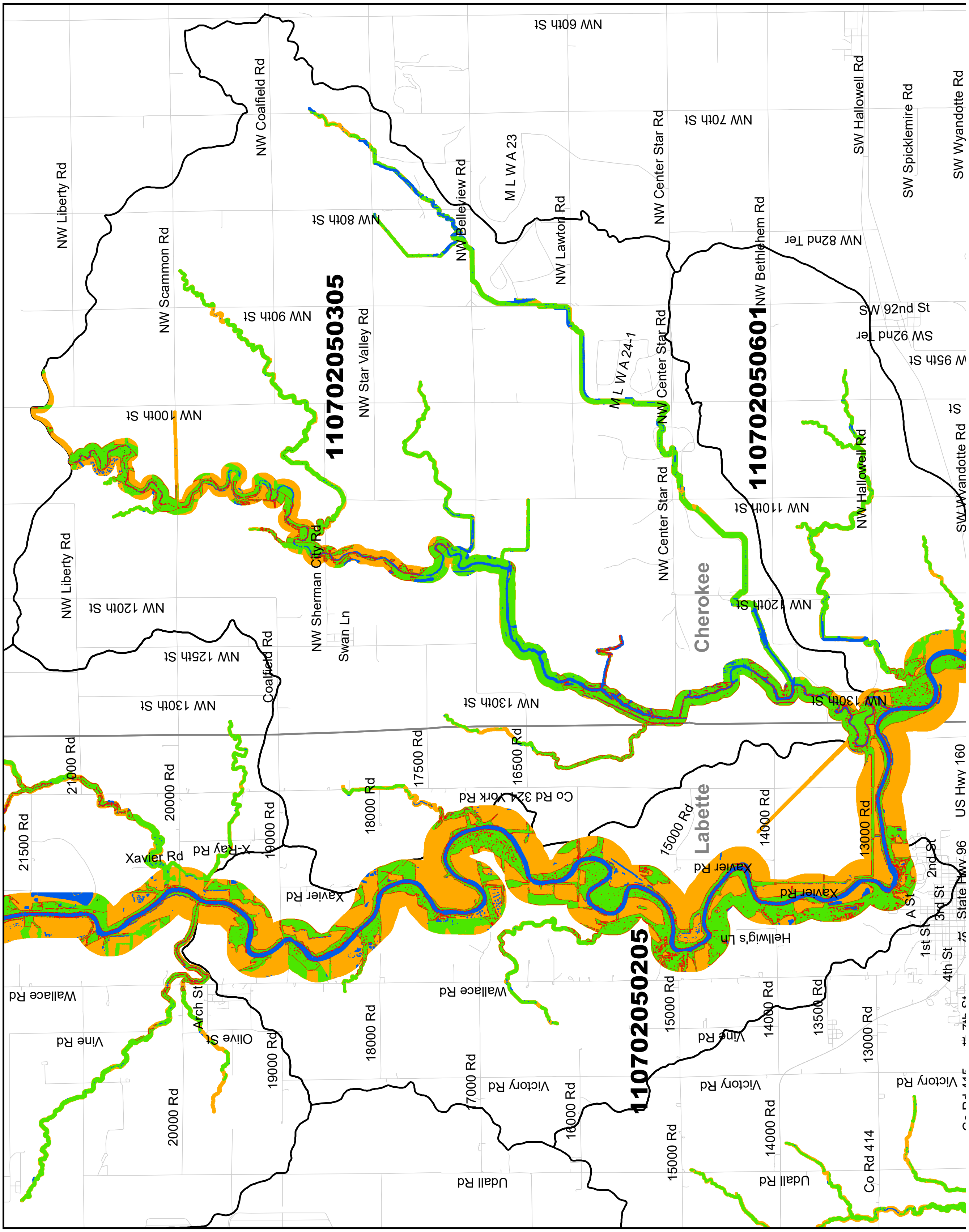
Crawford
Cherokee
Neosho
Labette
S 50th St State Hwy 126
S 50th St
Hickory St
N Main
3rd St
5th St
7th St
Elm St
W 560th Ave
W 550th Ave
S 40th St
W 530th Ave
W 540th Ave
S 30th St
W 520th Ave
W 510th Ave
US Hwy 400
NW Coal Valley Rd
NW 110th St
NW 120th St
NW Weir Rd
NW 130th St
W 560th St
S 20th St
S 17th St
S 12th St
27000 Rd
26000 Rd
25000 Rd
24000 Rd
23000 Rd
22000 Rd
21500 Rd
York Rd
Co Rd 324
Massy Rd
10th Rd
Co Rd 400
Yale Rd
Xavier Rd
40th Rd
30th Rd
20th Rd
Woodson Rd
Wallace Rd
Vine Rd
Co Rd 321
Co Rd 401
Victory Rd
Udall Rd
37th Rd
Trego Rd
Union Rd
Scott Rd
Rooks Rd


Riparian Forest Asssessment
HUC-12 = 110702050204
Middle Neosho Study Area
NRCS-RCPP Agreement
March 2018
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads
Riparian Forest Class
Conservation
Developed
Establishment
Management
Water
Potential Historical Remnant Forest
HUC-12 Boundary
County Boundary
Roads
HUC-8 Boundary
Major River
0
6,000 Feet
1 inch = 6,000 feet
N
USDA
NW Scammon Rd
NW Star Valley Rd
NW Liberty Rd
NW Sherman City Rd
NW Belleview Rd
Swan Ln
NW 125th St
NW 130th St
Coalfield Rd
NW Sheridan Rd
NW Labette Rd
21000 Rd
20000 Rd
19000 Rd
18000 Rd
17500 Rd
16000 Rd
15000 Rd
Xavier Rd
X-Ray Rd
York Rd
Co Rd 324
Wallace Rd
Vine Rd
Olive St
1st St
Victory Rd
17000 Rd
Udall Rd
16500 Rd
8th St
E 6th St
Pecan
Trego Rd
Saline Rd
Scott Rd
Rooks Rd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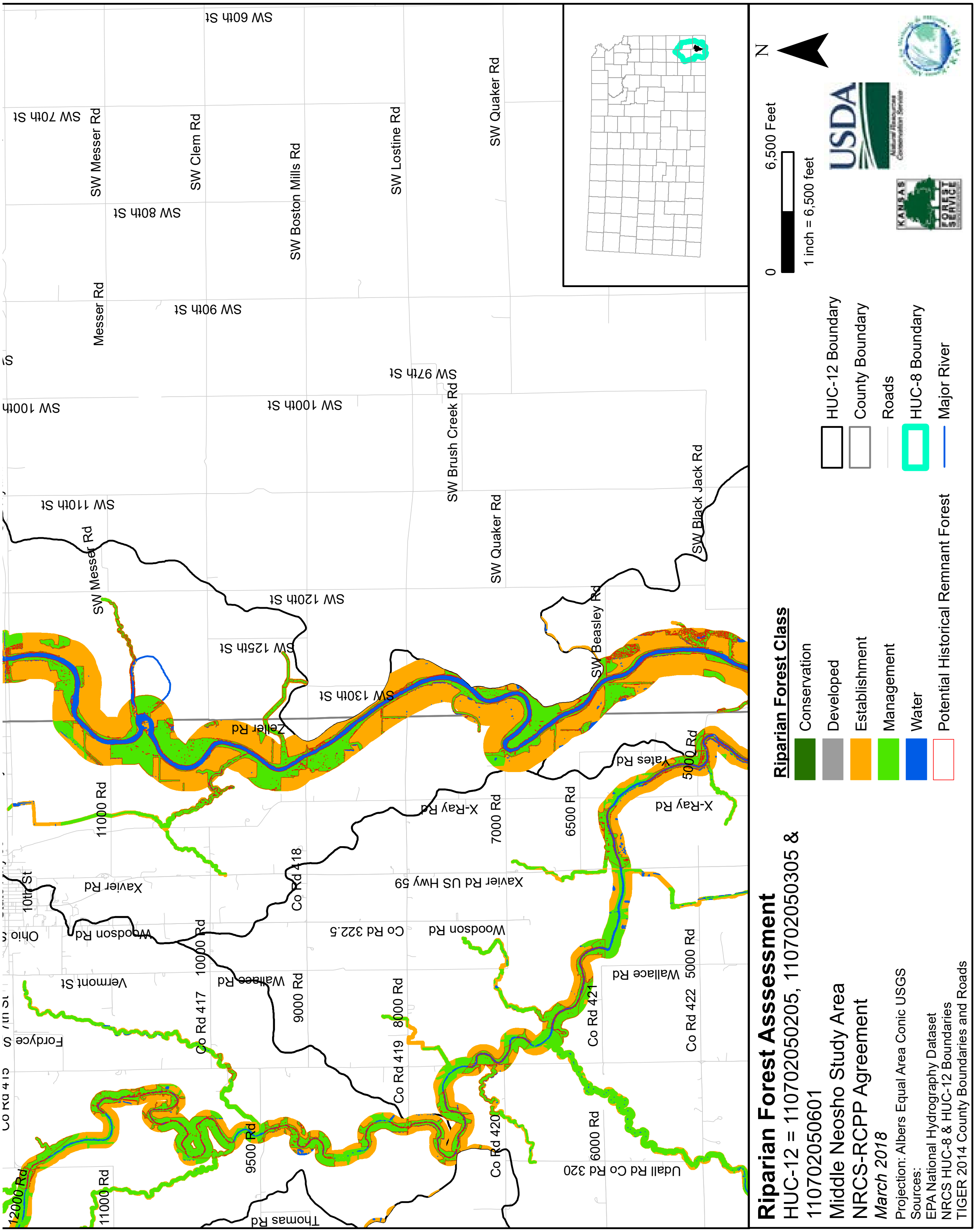
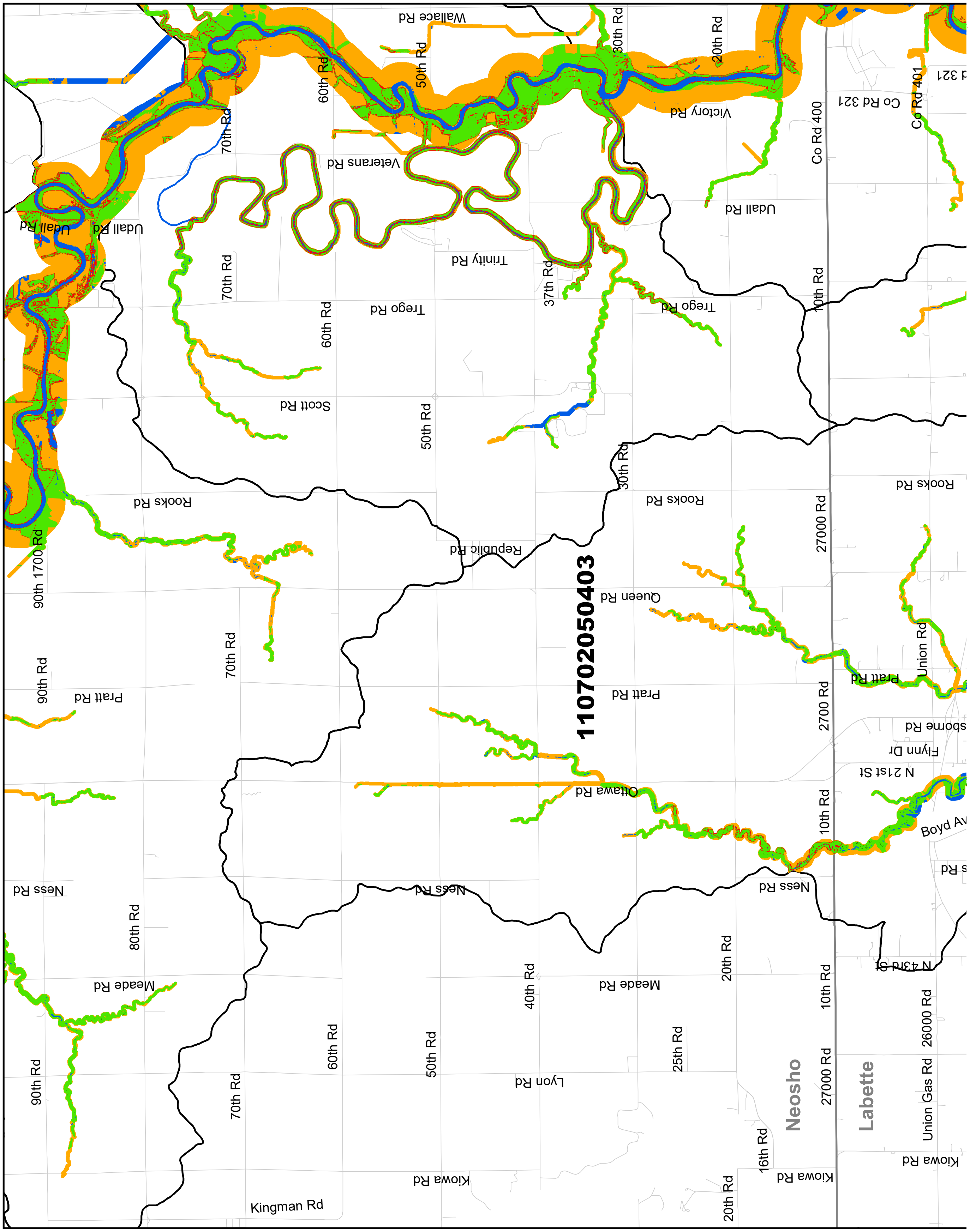
110702050601
110702050205
Cherokee
Labette
NW 60th St
NW 70th St
NW 80th St
NW 82nd Ter
NW 90th St
NW 100th St
NW 110th St
NW 120th St
NW 125th St
NW 130th St
SW 92nd St
SW 92nd Ter
NW Liberty Rd
NW Scammon Rd
NW Coalfield Rd
NW Star Valley Rd
NW Belleview Rd
M L W A 23
M L W A 24-1
NW Lawton Rd
NW Center Star Rd
NW Bethlehem Rd
SW Hallowell Rd
SW Spicklemire Rd
SW Wyandotte Rd
NW Hallowell Rd
NW Sherman City Rd
Swan Ln
Coalfield Rd
21500 Rd
21000 Rd
20000 Rd
19000 Rd
18000 Rd
17500 Rd
17000 Rd
16500 Rd
16000 Rd
15000 Rd
14000 Rd
13500 Rd
13000 Rd
Co Rd 324 York Rd
Co Rd 414
Xavier Rd
X-Ray Rd
Hellwig's Ln
Wallace Rd
Vine Rd
Olive St
Arch St
Victory Rd
Udall Rd
US Hwy 160
State Hwy 96
A St
1st St
2nd St
3rd St
4th St


Riparian Forest Assessment
HUC-12 = 110702050205, 110702050305 & 110702050601
Middle Neosho Study Area
NRCS-RCPP Agreement
March 2018
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads
Riparian Forest Class
Conservation
Developed
Establishment
Management
Water
Potential Historical Remnant Forest
HUC-12 Boundary
County Boundary
Roads
HUC-8 Boundary
Major River
0
6,500 Feet
1 inch = 6,500 feet
N
USDA
SW 60th St
SW 70th St
SW 80th St
SW 90th St
SW 97th St
SW 100th St
SW 110th St
SW 120th St
SW 125th St
SW 130th St
SW Messer Rd
SW Clem Rd
SW Boston Mills Rd
SW Lostine Rd
SW Quaker Rd
Messer Rd
SW Brush Creek Rd
SW Black Jack Rd
SW Beasley Rd
Zeller Rd
Yates Rd
5000 Rd
X-Ray Rd
7000 Rd
6500 Rd
11000 Rd
Xavier Rd
Xavier Rd US Hwy 59
Co Rd 418
10th St
Ohio St
Woodson Rd
Co Rd 322.5
10000 Rd
Vermont St
Wallace Rd
9000 Rd
Co Rd 417
Fordyce St
8000 Rd
Co Rd 419
Co Rd 421
5000 Rd
Co Rd 422
Co Rd 420
6000 Rd
Udall Rd Co Rd 320
9500 Rd
Thomas Rd
11000 Rd
12000 Rd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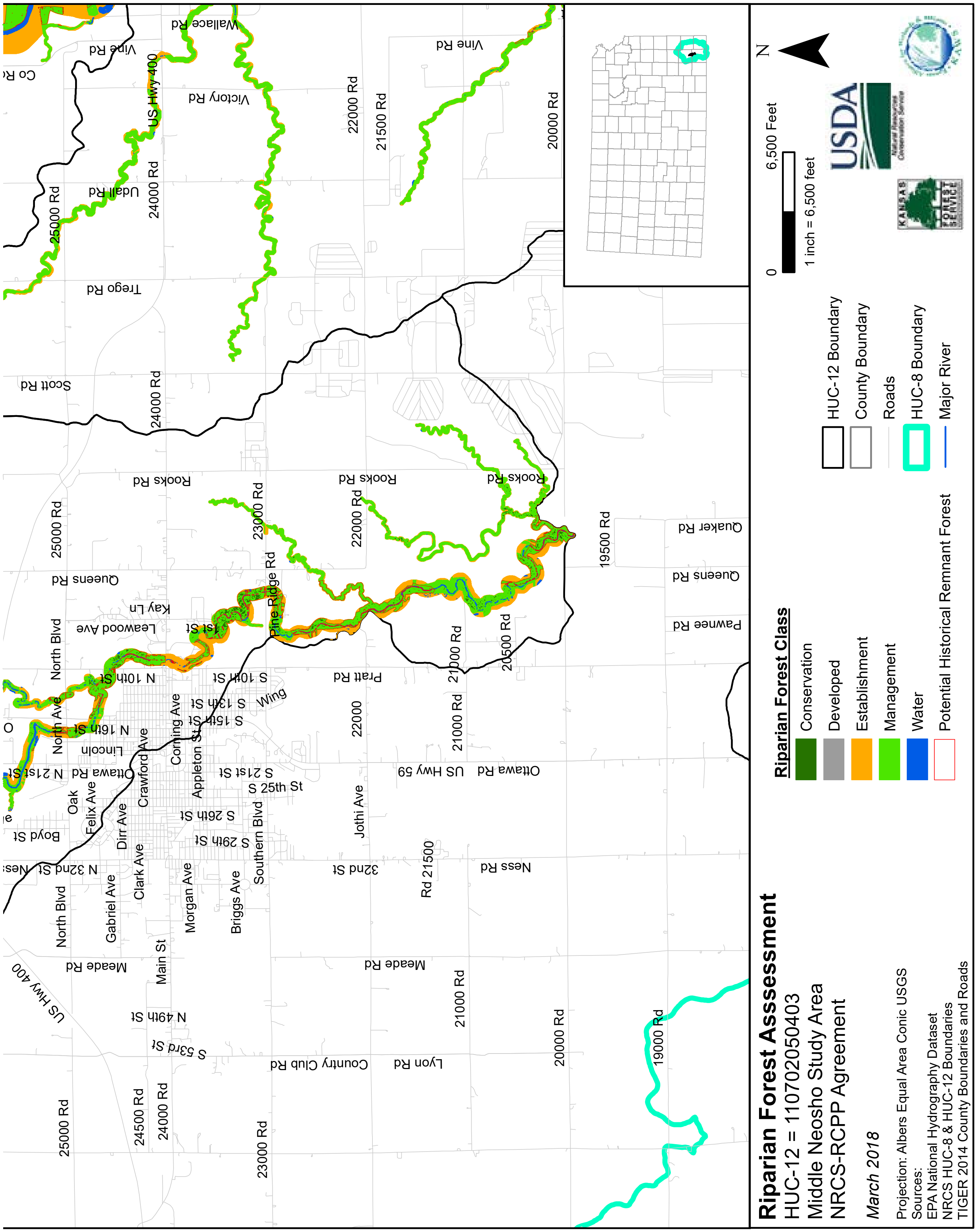
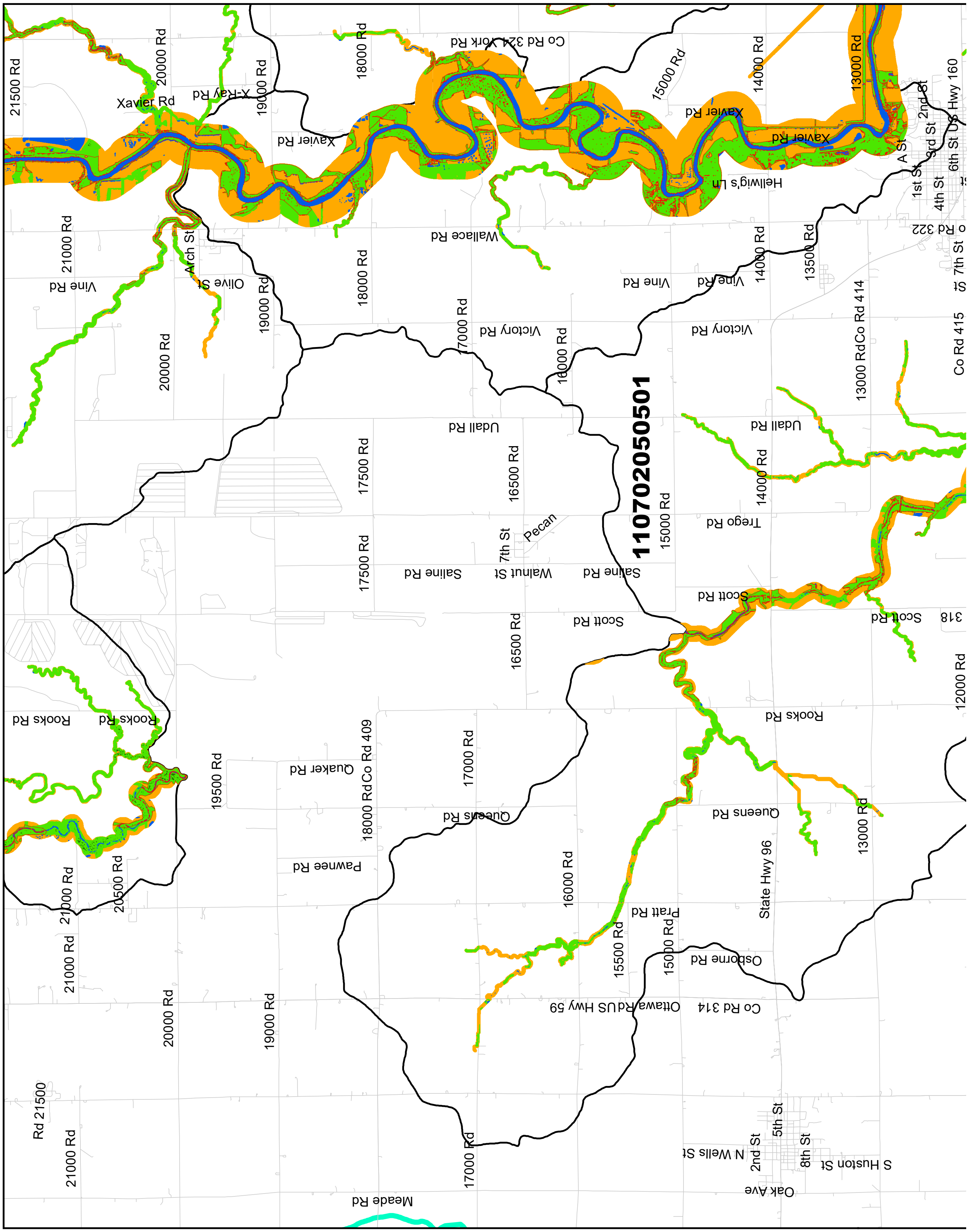
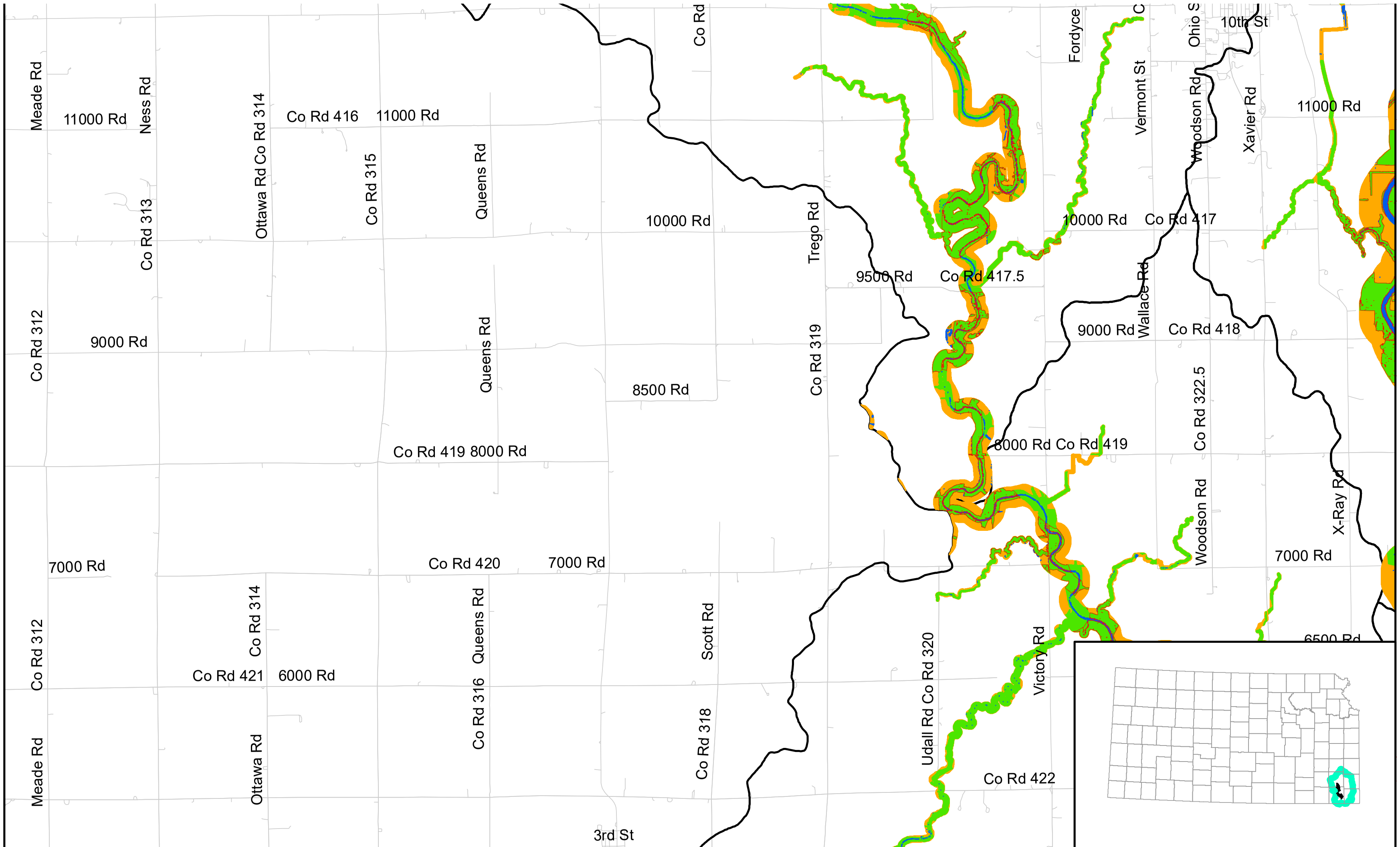
Neosho
Labette
Wallace Rd
60th Rd
50th Rd
30th Rd
20th Rd
Victory Rd
Co Rd 400
Co Rd 321
Co Rd 401
70th Rd
Veterans Rd
Udall Rd
Trinity Rd
37th Rd
Trego Rd
10th Rd
Scott Rd
Rooks Rd
27000 Rd
90th 1700 Rd
Republic Rd
Queen Rd
Union Rd
90th Rd
Pratt Rd
2700 Rd
Flynn Dr
N 21st St
Ottawa Rd
Boyd Av
Ness Rd
80th Rd
N 43rd St
Meade Rd
40th Rd
26000 Rd
Lyon Rd
25th Rd
Union Gas Rd
16th Rd
Kiowa Rd
Kingman Rd


Riparian Forest Asssessment
HUC-12 = 110702050403
Middle Neosho Study Area
NRCS-RCPP Agreement
March 2018
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads
Riparian Forest Class
Conservation
Developed
Establishment
Management
Water
Potential Historical Remnant Forest
HUC-12 Boundary
County Boundary
Roads
HUC-8 Boundary
Major River
0
6,500 Feet
1 inch = 6,500 feet
N
USDA


110702050501
21500 Rd
20000 Rd
Xavier Rd
X-Ray Rd
19000 Rd
18000 Rd
Co Rd 324 York Rd
15000 Rd
14000 Rd
13000 Rd
Hellwig's Ln
Wallace Rd
21000 Rd
Vine Rd
Arch St
Olive St
Victory Rd
17000 Rd
16000 Rd
13500 Rd
13000 RdCo Rd 414
Co Rd 415
Udall Rd
17500 Rd
16500 Rd
Trego Rd
7th St
Pecan
Saline Rd
Walnut St
Scott Rd
12000 Rd
Rooks Rd
19500 Rd
Quaker Rd
18000 RdCo Rd 409
Queens Rd
Pawnee Rd
20500 Rd
State Hwy 96
Pratt Rd
15500 Rd
Osborne Rd
Ottawa RdUS Hwy 59
Co Rd 314
Rd 21500
5th St
2nd St
8th St
N Wells St
S Huston St
Oak Ave
Meade Rd
A St
1st St
2nd St
3rd St
4th St
6th St US Hwy 160
Co Rd 322
7th St
318



Riparian Forest Asssessment

HUC-12 = 110702050501
Middle Neosho Study Area
NRCS-RCPP Agreement

March 2018

Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads

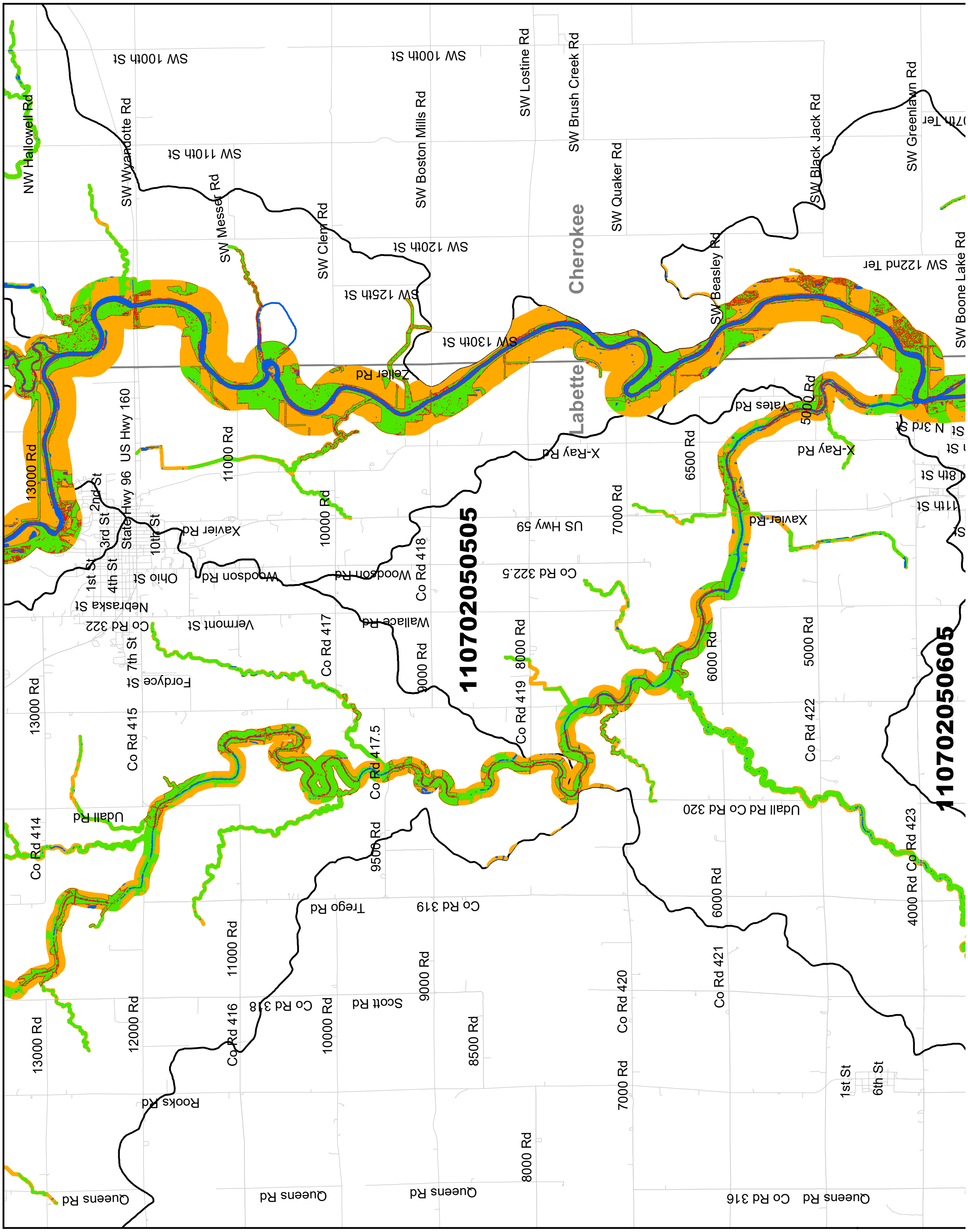
Riparian Forest Class

- Conservation
- Developed
- Establishment
- Management
- Water
- Potential Historical Remnant Forest

- HUC-12 Boundary
- County Boundary
- Roads
- HUC-8 Boundary
- Major River

0 6,500 Feet
1 inch = 6,500 feet

N



Cherokee
Labette
11070205050505
11070205060605
SW 100th St
SW 110th St
SW 120th St
SW 125th St
SW 130th St
SW 122nd Ter
NW Hallowell Rd
SW Wyandotte Rd
SW Messer Rd
SW Clem Rd
SW Boston Mills Rd
SW Lostine Rd
SW Brush Creek Rd
SW Quaker Rd
SW Beasley Rd
SW Black Jack Rd
SW Greenlawn Rd
SW Boone Lake Rd
US Hwy 160
State Hwy 96
US Hwy 59
Zeller Rd
Yates Rd
X-Ray Rd
Xavier Rd
Woodson Rd
Wallace Rd
Vermont St
Ohio St
Nebraska St
Fordyce St
Udall Rd
Udall Rd Co Rd 320
Trego Rd
Scott Rd
Rooks Rd
Queens Rd
Queens Rd Co Rd 316
Co Rd 319
Co Rd 318
Co Rd 322
Co Rd 322.5
Co Rd 414
Co Rd 415
Co Rd 416
Co Rd 417
Co Rd 417.5
Co Rd 418
Co Rd 419
Co Rd 420
Co Rd 421
Co Rd 422
4000 Rd Co Rd 423
13000 Rd
12000 Rd
11000 Rd
10000 Rd
9500 Rd
9000 Rd
8500 Rd
8000 Rd
7000 Rd
6500 Rd
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2nd St
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10th St
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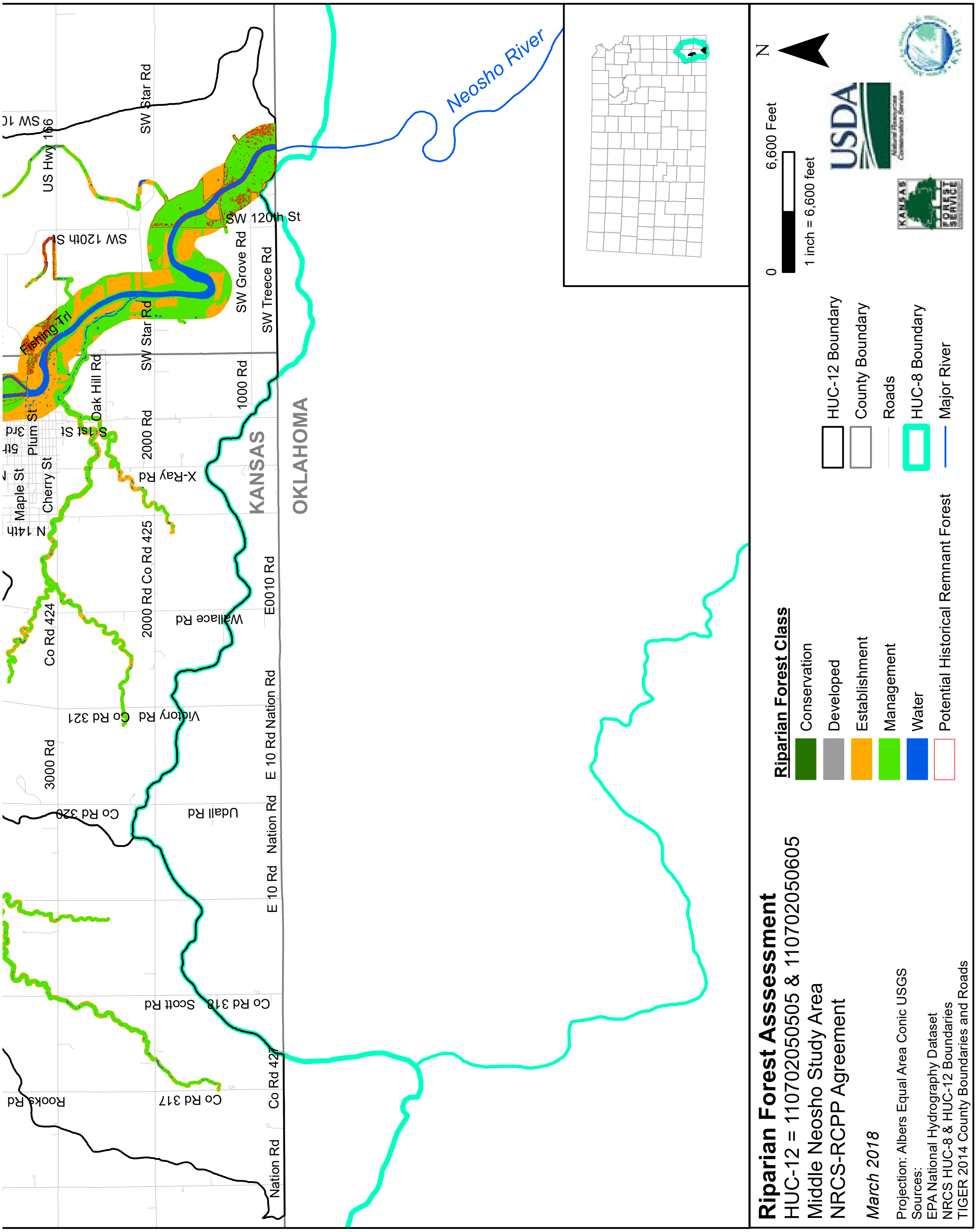
N 3rd St


Riparian Forest Assessment
HUC-12 = 110702050505 & 110702050605
Middle Neosho Study Area
NRCS-RCPP Agreement
March 2018
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
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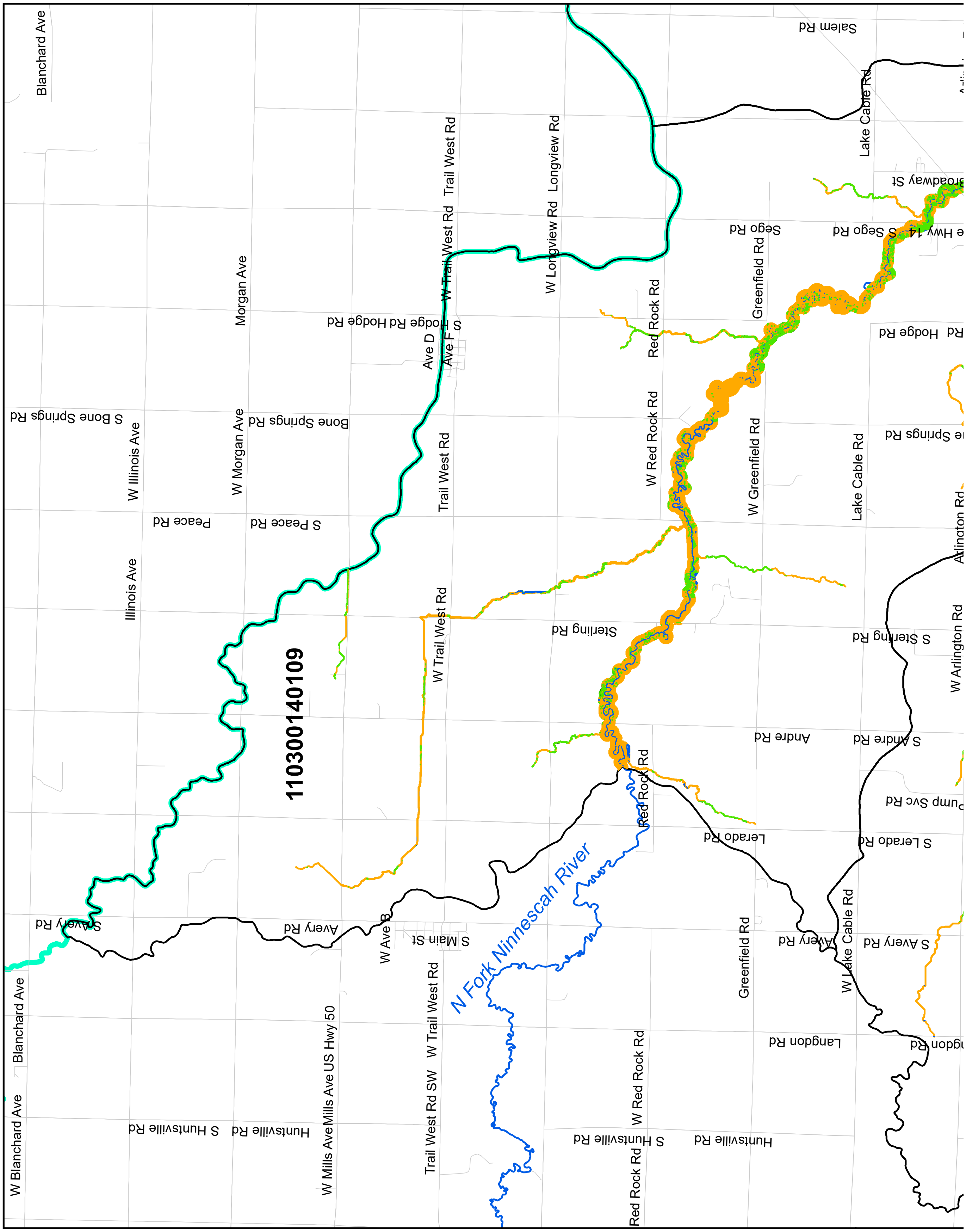
Developed
Establishment
Management
Water
Potential Historical Remnant Forest
HUC-12 Boundary
County Boundary
Roads
HUC-8 Boundary
Major River
0
6,600 Feet
1 inch = 6,600 feet
N
USDA
Natural Resources Conservation Service
KANSAS FOREST SERVICE
Neosho River
KANSAS
OKLAHOMA
Fishing Trl
SW Star Rd
SW Grove Rd
SW Treece Rd
SW 120th St
US Hwy 166
1000 Rd
2000 Rd
Oak Hill Rd
S 1st St
Plum St
Cherry St
Maple St
N 14th
X-Ray Rd
2000 Rd Co Rd 425
Co Rd 424
Wallace Rd
E0010 Rd
Victory Rd
Co Rd 321
3000 Rd
E 10 Rd Nation Rd
Udall Rd
Co Rd 320
Nation Rd
E 10 Rd
Scott Rd
Co Rd 318
Co Rd 427
Co Rd 317
Rooks Rd
Nation Rd


110300140109
N Fork Ninnescah River
Blanchard Ave
W Blanchard Ave
Morgan Ave
W Morgan Ave
Illinois Ave
W Illinois Ave
Trail West Rd
W Trail West Rd
Trail West Rd SW
Longview Rd
W Longview Rd
Red Rock Rd
W Red Rock Rd
Greenfield Rd
W Greenfield Rd
Lake Cable Rd
W Lake Cable Rd
Arlington Rd
W Arlington Rd
W Mills Ave
Mills Ave
US Hwy 50
Salem Rd
Broadway St
Sego Rd
S Sego Rd
Hodge Rd
S Hodge Rd
Bone Springs Rd
S Bone Springs Rd
Peace Rd
S Peace Rd
Sterling Rd
S Sterling Rd
Andre Rd
S Andre Rd
Pump Svc Rd
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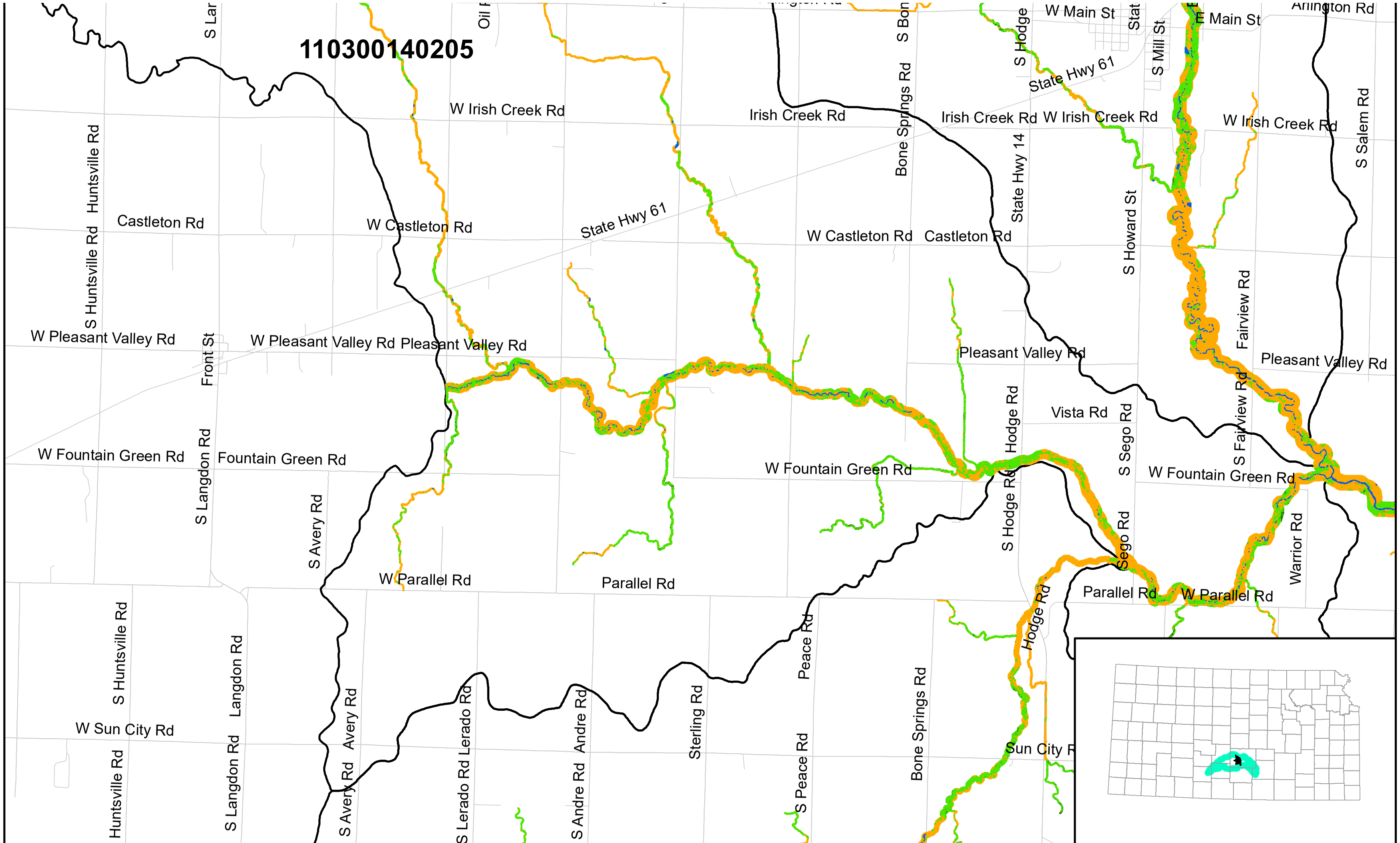
Ave F
W Ave B
S Main St



Riparian Forest Asssessment

HUC-12 = 110300140109 & 110300140205
Cheney Lake Study Area
NRCS-RCPP Agreement

March 2018

Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads

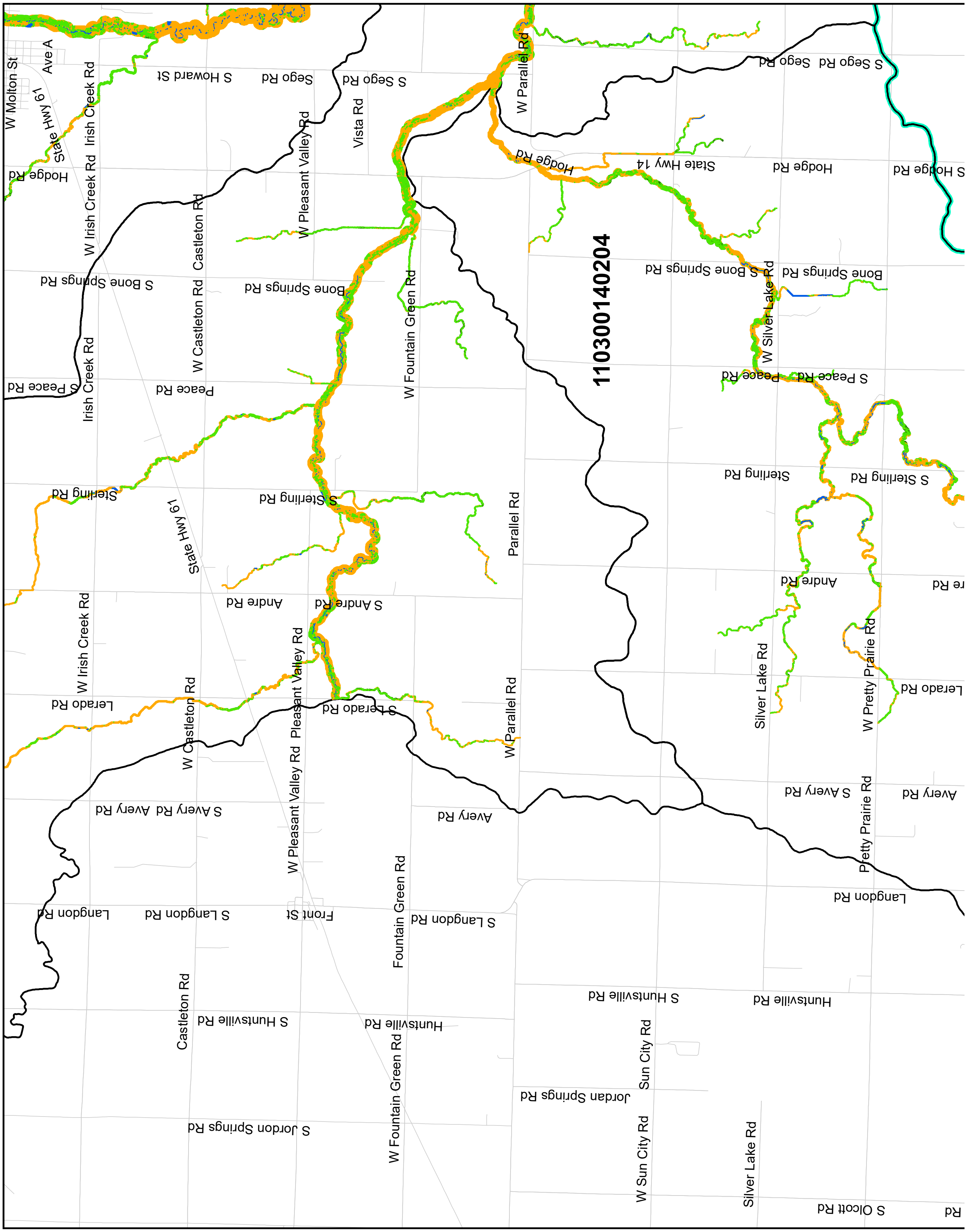
Riparian Forest Class

- Conservation
- Developed
- Establishment
- Management
- Water
- Potential Historical Remnant Forest

- HUC-12 Boundary
- County Boundary
- Roads
- HUC-8 Boundary
- Major River

0 6,200 Feet
1 inch = 6,200 feet

N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Ave A
State Hwy 61
Irish Creek Rd
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Hodge Rd
S Howard St
Sego Rd
S Sego Rd
W Pleasant Valley Rd
Vista Rd
W Parallel Rd
State Hwy 14
S Hodge Rd
Castleton Rd
W Castleton Rd
S Bone Springs Rd
Bone Springs Rd
W Fountain Green Rd
W Silver Lake Rd
Peace Rd
S Peace Rd
Sterling Rd
S Sterling Rd
Parallel Rd
Andre Rd
S Andre Rd
Lerado Rd
S Lerado Rd
Pleasant Valley Rd
W Pretty Prairie Rd
Silver Lake Rd
Avery Rd
S Avery Rd
Pretty Prairie Rd
Langdon Rd
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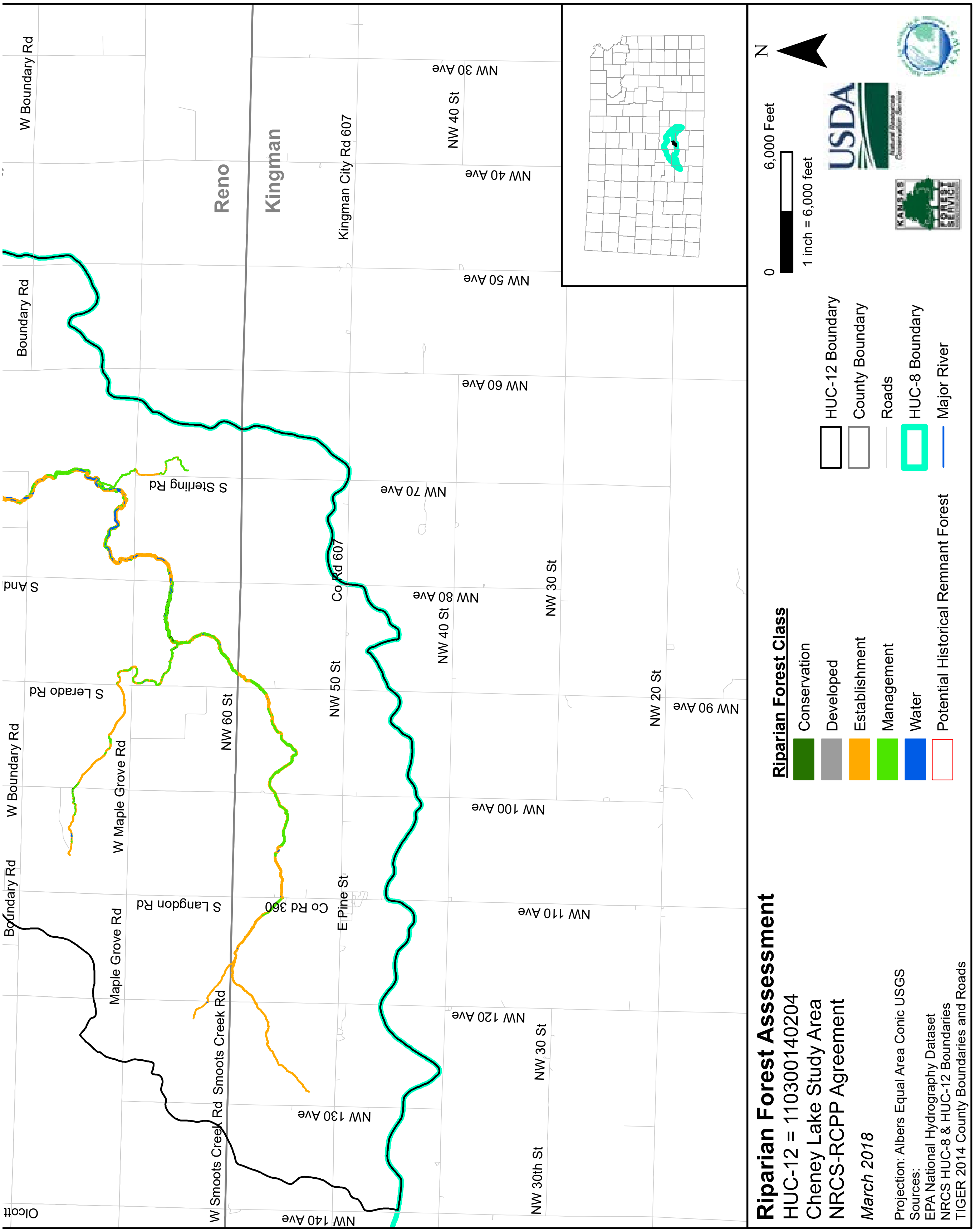
Front St
Fountain Green Rd
Huntsville Rd
S Huntsville Rd
Sun City Rd
W Sun City Rd
Jordan Springs Rd
S Jordan Springs Rd
S Olcott Rd



Riparian Forest Assessment
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Cheney Lake Study Area
NRCS-RCPP Agreement
March 2018
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
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Conservation
Developed
Establishment
Management
Water
Potential Historical Remnant Forest
HUC-12 Boundary
County Boundary
Roads
HUC-8 Boundary
Major River
0
6,000 Feet
1 inch = 6,000 feet
N
Reno
Kingman
W Boundary Rd
Boundary Rd
Kingman City Rd 607
NW 40 St
NW 30 Ave
NW 40 Ave
NW 50 Ave
NW 60 Ave
NW 70 Ave
S Sterling Rd
S And
Co Rd 607
NW 80 Ave
NW 40 St
NW 30 St
S Lerado Rd
NW 60 St
NW 50 St
NW 20 St
NW 90 Ave
W Maple Grove Rd
NW 100 Ave
S Langdon Rd
Co Rd 360
E Pine St
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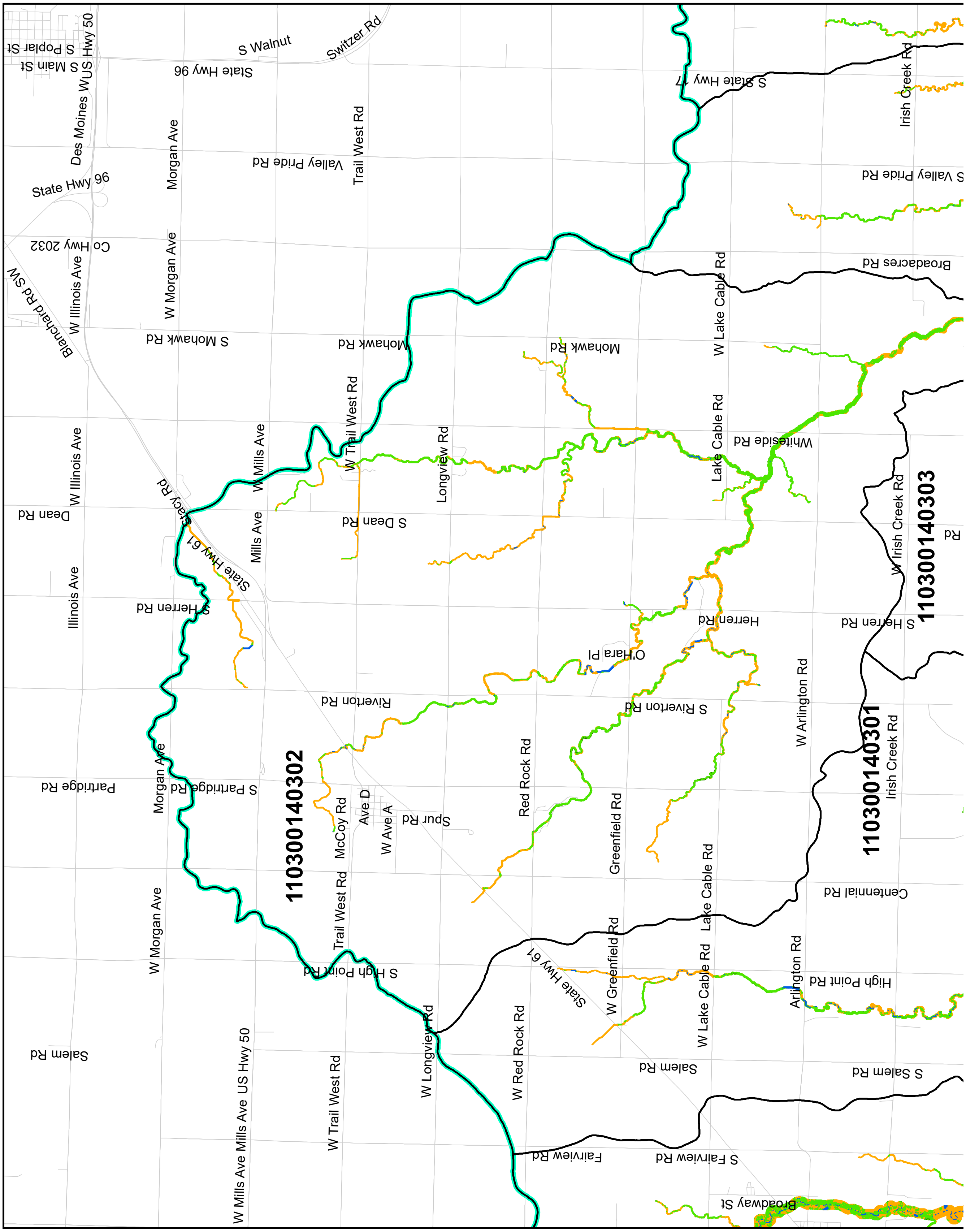
NW 30 St
W Smoots Creek Rd
NW 130 Ave
NW 30th St
Olcott
NW 140 Ave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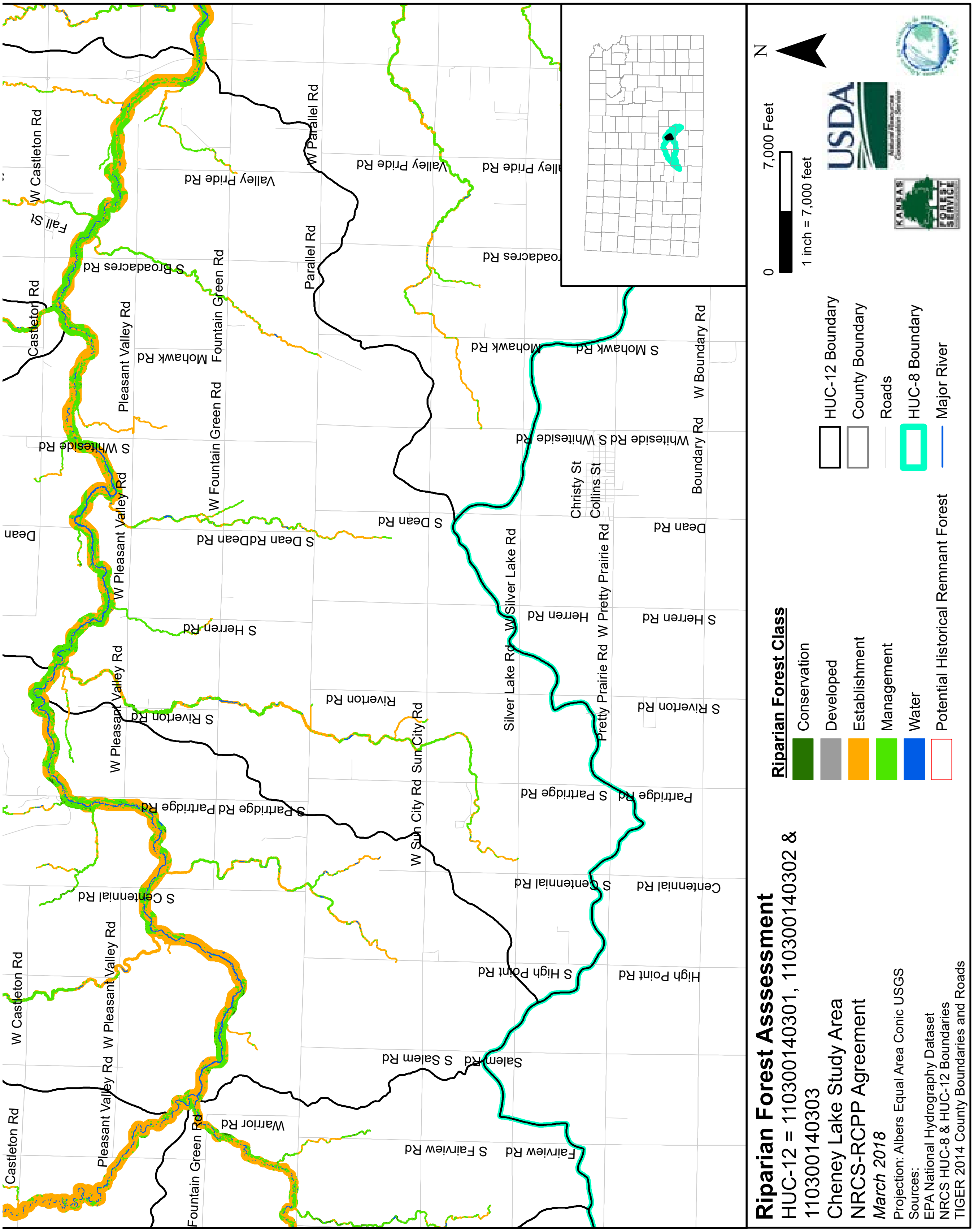
S Main St
W US Hwy 50
Des Moines
State Hwy 96
S Walnut
Switzer Rd
Morgan Ave
Valley Pride Rd
Trail West Rd
S State Hwy 17
Irish Creek Rd
S Valley Pride Rd
Co Hwy 2032
W Illinois Ave
Blanchard Rd SW
W Morgan Ave
Broadacres Rd
W Lake Cable Rd
S Mohawk Rd
Mohawk Rd
W Trail West Rd
W Mills Ave
Longview Rd
Lake Cable Rd
Whiteside Rd
Dean Rd
Stacy Rd
S Dean Rd
Mills Ave
W Irish Creek Rd
Illinois Ave
State Hwy 61
S Herren Rd
Herren Rd
O'Hara Pl
Riverton Rd
S Riverton Rd
W Arlington Rd
Partridge Rd
S Partridge Rd
McCoy Rd
Ave D
W Ave A
Spur Rd
Red Rock Rd
Greenfield Rd
Centennial Rd
S High Point Rd
High Point Rd
W Greenfield Rd
W Lake Cable Rd
Arlington Rd
W Longview Rd
Salem Rd
S Salem Rd
W Red Rock Rd
W Trail West Rd
W Mills Ave Mills Ave US Hwy 50
Fairview Rd
S Fairview Rd
Broadway St


Riparian Forest Assessment
HUC-12 = 110300140301, 110300140302 & 110300140303
Cheney Lake Study Area
NRCS-RCPP Agreement
March 2018
Projection: Albers Equal Area Conic USGS
Sources:
EPA National Hydrography Dataset
NRCS HUC-8 & HUC-12 Boundaries
TIGER 2014 County Boundaries and Roads
Riparian Forest Class
Conservation
Developed
Establishment
Management
Water
Potential Historical Remnant Forest
HUC-12 Boundary
County Boundary
Roads
HUC-8 Boundary
Major River
0
7,000 Feet
1 inch = 7,000 feet
N

Appendix B: Twin Lakes Riparian Assessment

Twin Lakes Watershed Riparian Forest Assessment

Level Creek and Haun Creek Huc-12s

Prepared by:

Jeff Neel, Kansas Alliance for Wetlands and Streams; **Frank Norman**, Kansas Alliance for Wetlands and Streams, and **Bob Atchison**, Kansas Forest Service.

Prepared for:

Kansas Forest Service, Natural Resource Conservation Service, Twin Lakes WRAPS, and Kansas Department of Health and Environment-Water Bureau-Watershed Management

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

Table of Contents

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.*

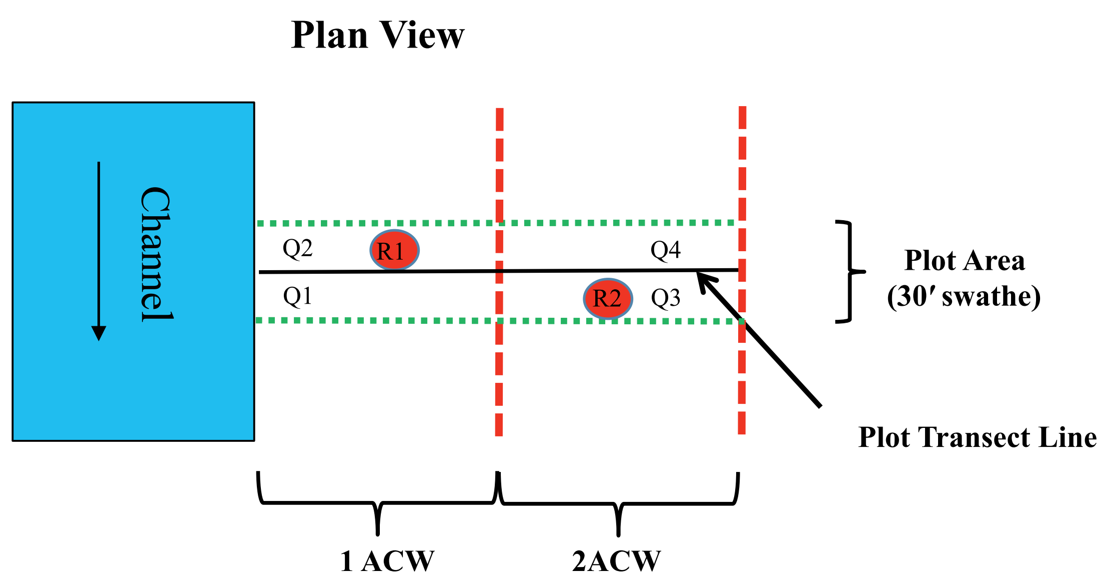


Table 1. *Riparian zone width estimates based on regression formulas for bankfull width (1ACW), bankfull depth, bankfull cross-sectional area, bankfull discharge, and drainage area by site number and watershed for Level Creek and Haun Creek watersheds. 1ACW refers to the extent from top of bankfull streambank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

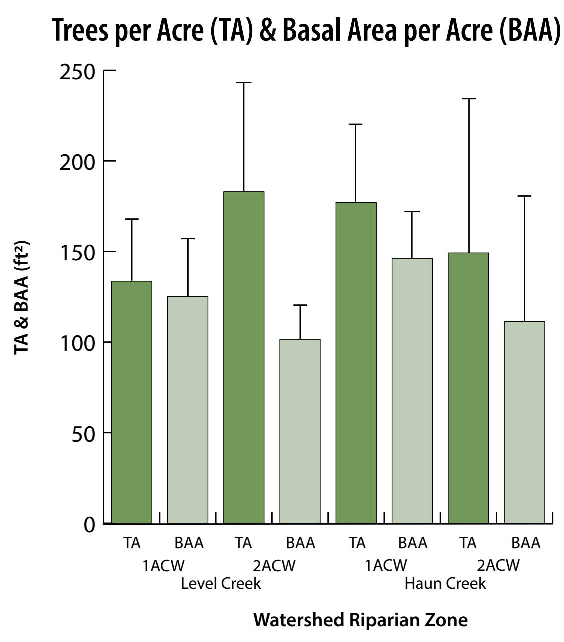


Figure 7. *Total BAA and TA (all species combined) by watershed and riparian zone (i.e., stream bank at 1ACW and 2ACW where it existed). Error bars are one standard error for the transect plots evaluated for all of the sites in each watershed riparian zone.*

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.

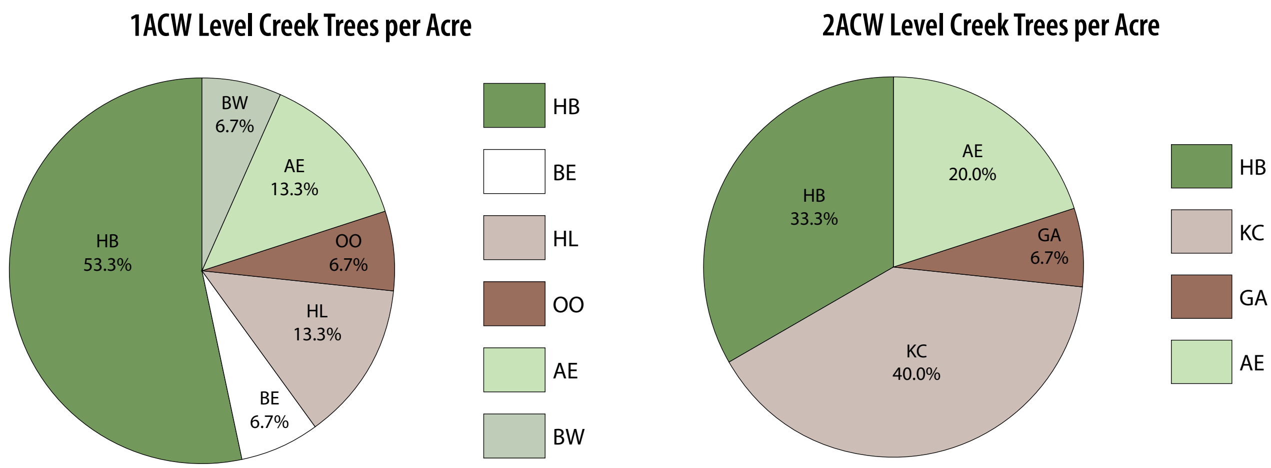


Figure 8. *Level Creek BAA composition by species for 1ACW and 2ACW riparian zones. BW= black walnut, AE= American elm, GA= green ash, OO= Osage orange, HL= honey locust, BE= boxelder, HB= common hackberry.*

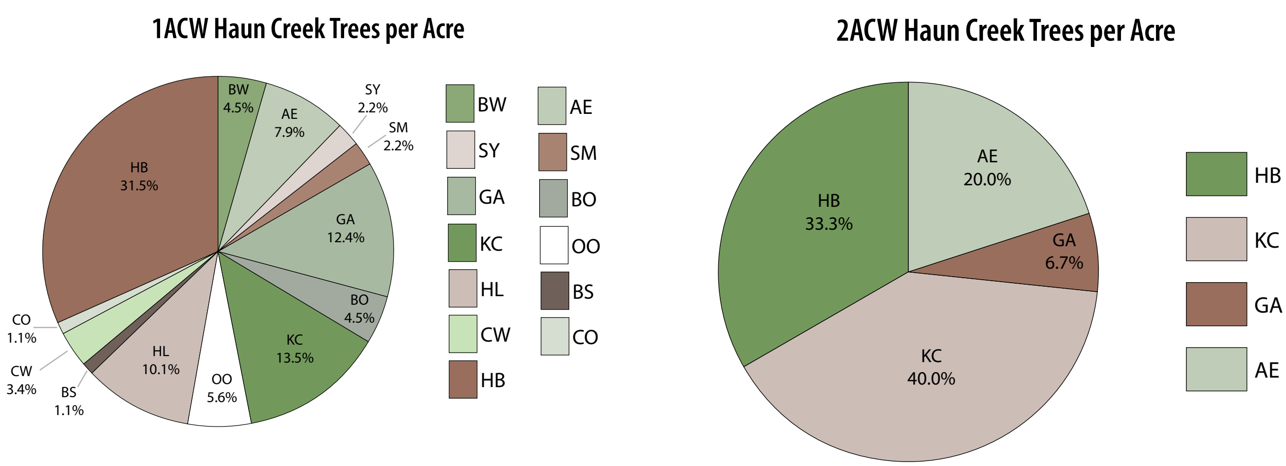


Figure 9. *Haun Creek BAA composition by species for 1ACW and 2ACW riparian zones. BW= black walnut, AE= American elm, SY= sycamore, SM= silver maple, GA= green ash, BO= bur oak, KC= Kentucky coffeetree, OO= Osage orange, HL= honey locust, BS= basswood, CW= plains cottonwood, CO= chinkapin oak, HB= common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

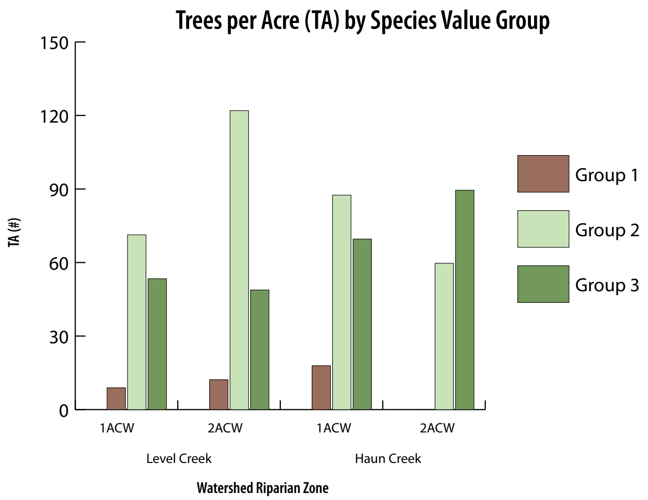


Figure 10. *Trees per Acre (TA) by Species Value Group and Watershed Riparian Zone.*

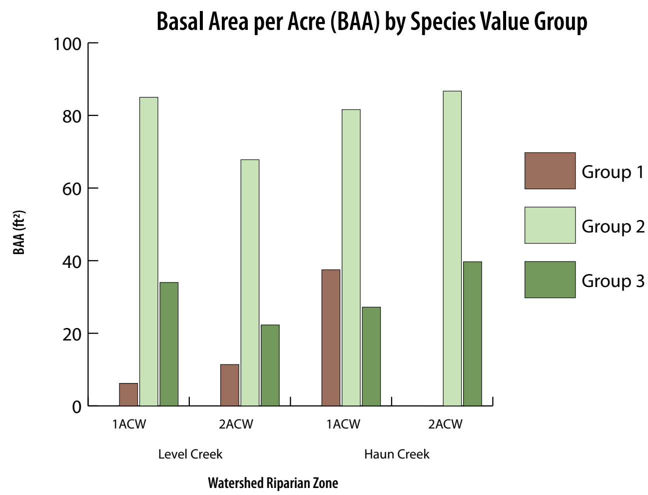


Figure 11. *Basal Area per Acre (BAA) by Species Value Group and Watershed Riparian Zone.*

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**

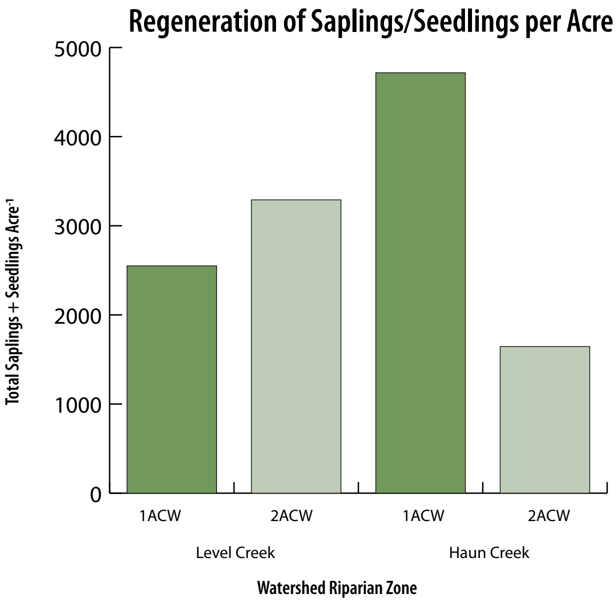


Figure 12. *Total regeneration per acre (tree saplings and seedlings) by watershed riparian zone.*

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.

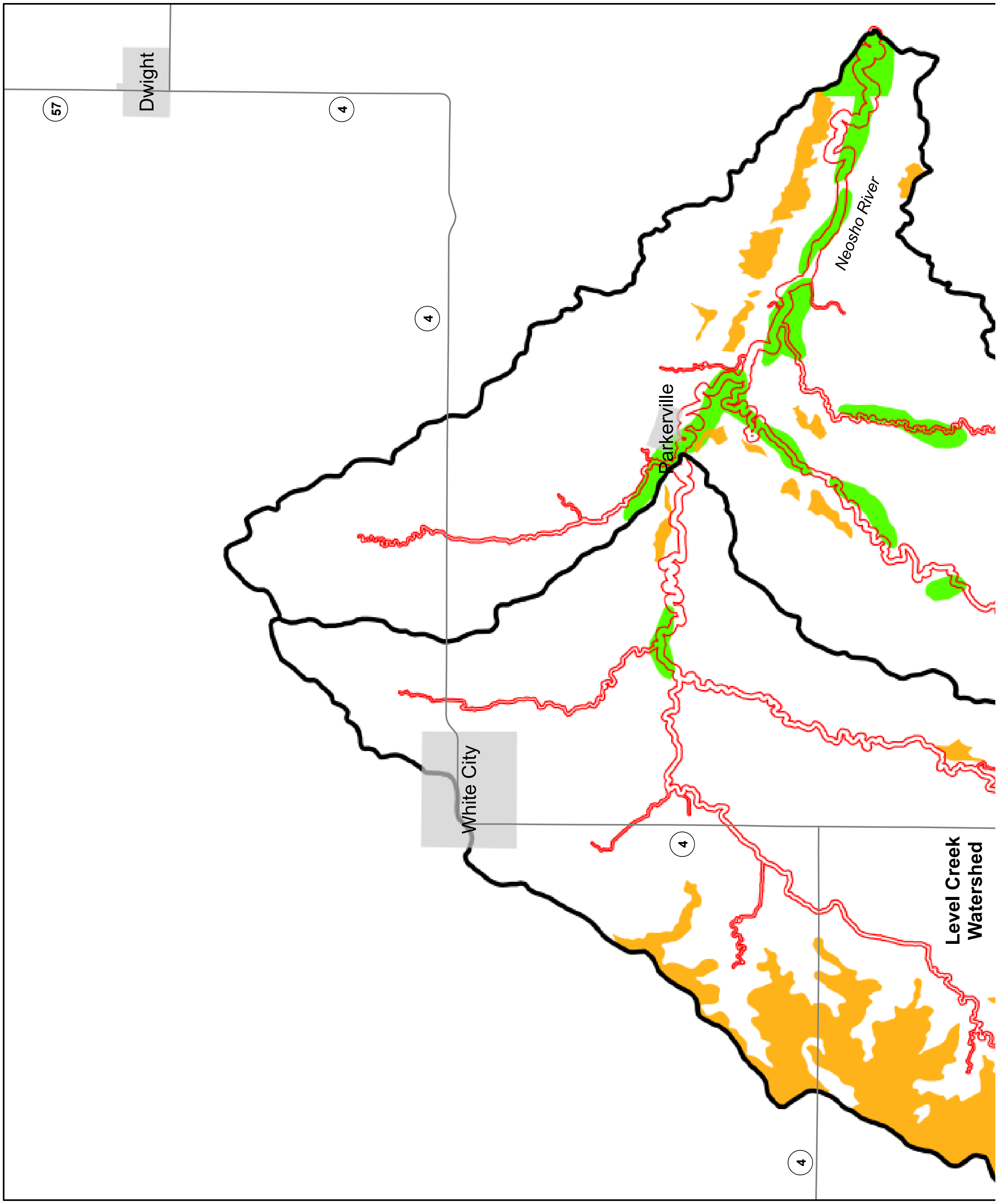
BEHI scores indicated “very high” potential for streambank erosion for Level Creek and Haun Creek watersheds based on study sites. NBS scores indicated that the major resource concerns were likely for streambank types similar to those assessed along acutely bending stream meanders, especially those without 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).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Parkerville
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Level Creek Watershed

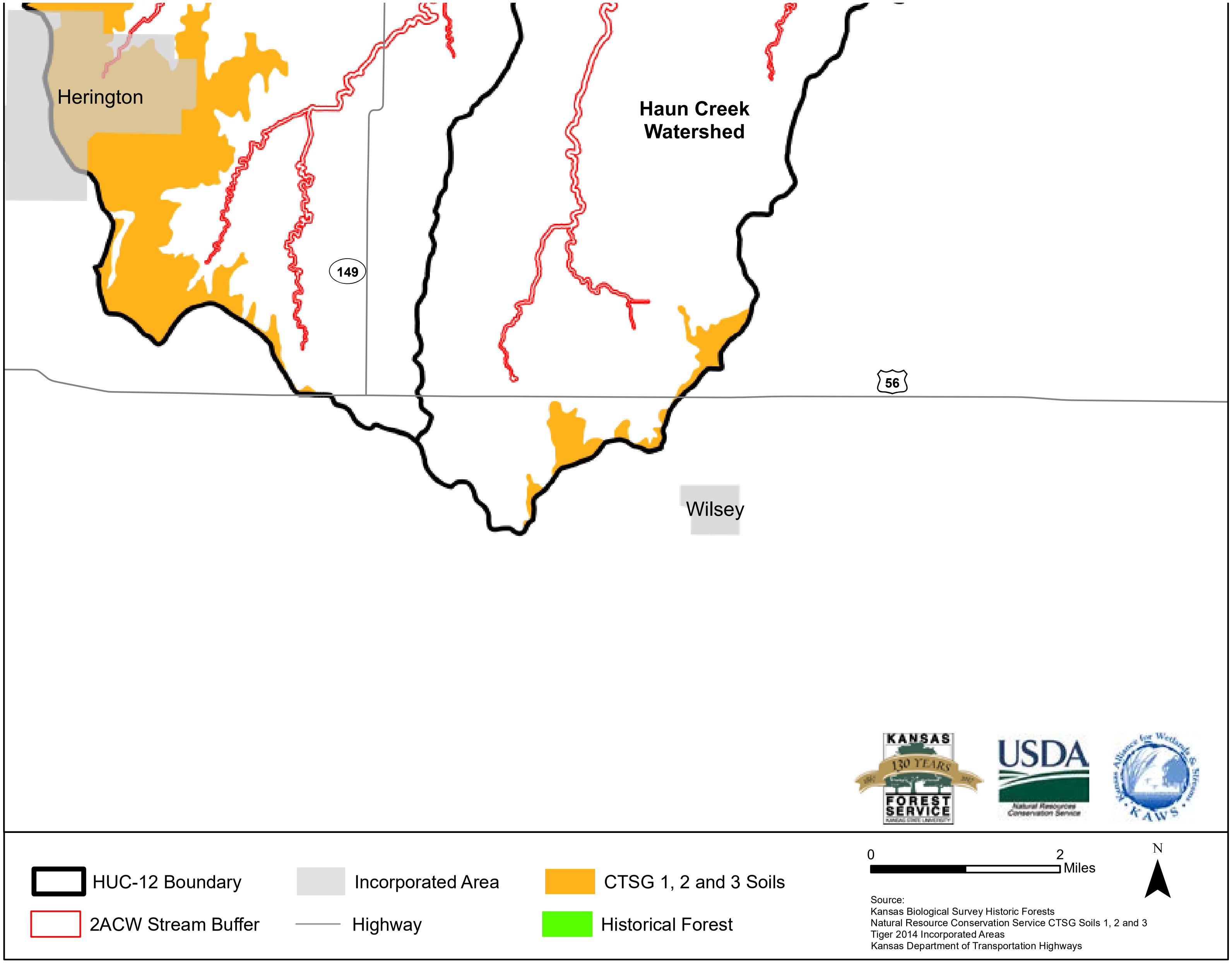
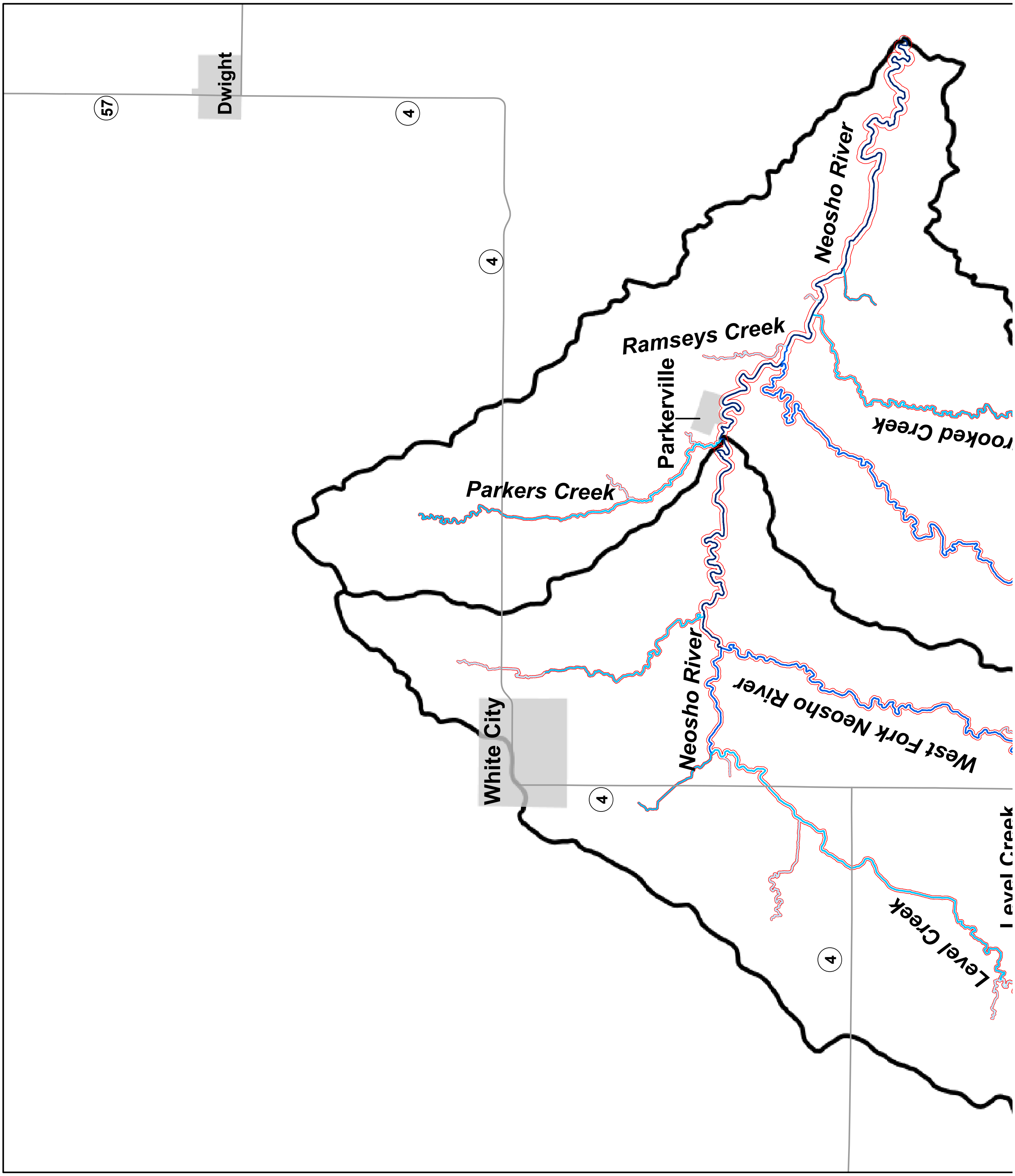


Figure 2. Extent of CTSG 1, 2, and 3 soils and historical forests in Level Creek and Haun Creek watersheds.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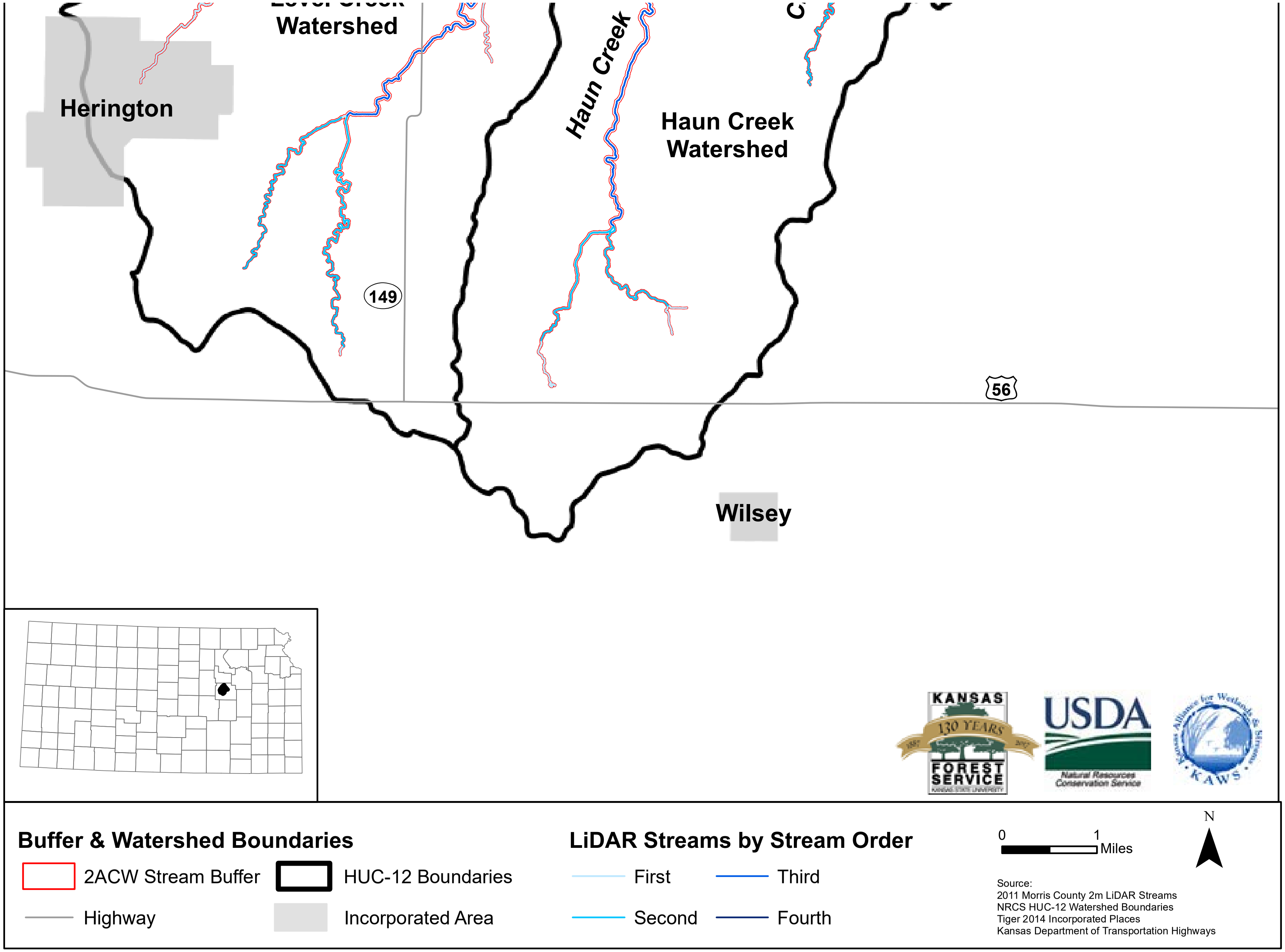
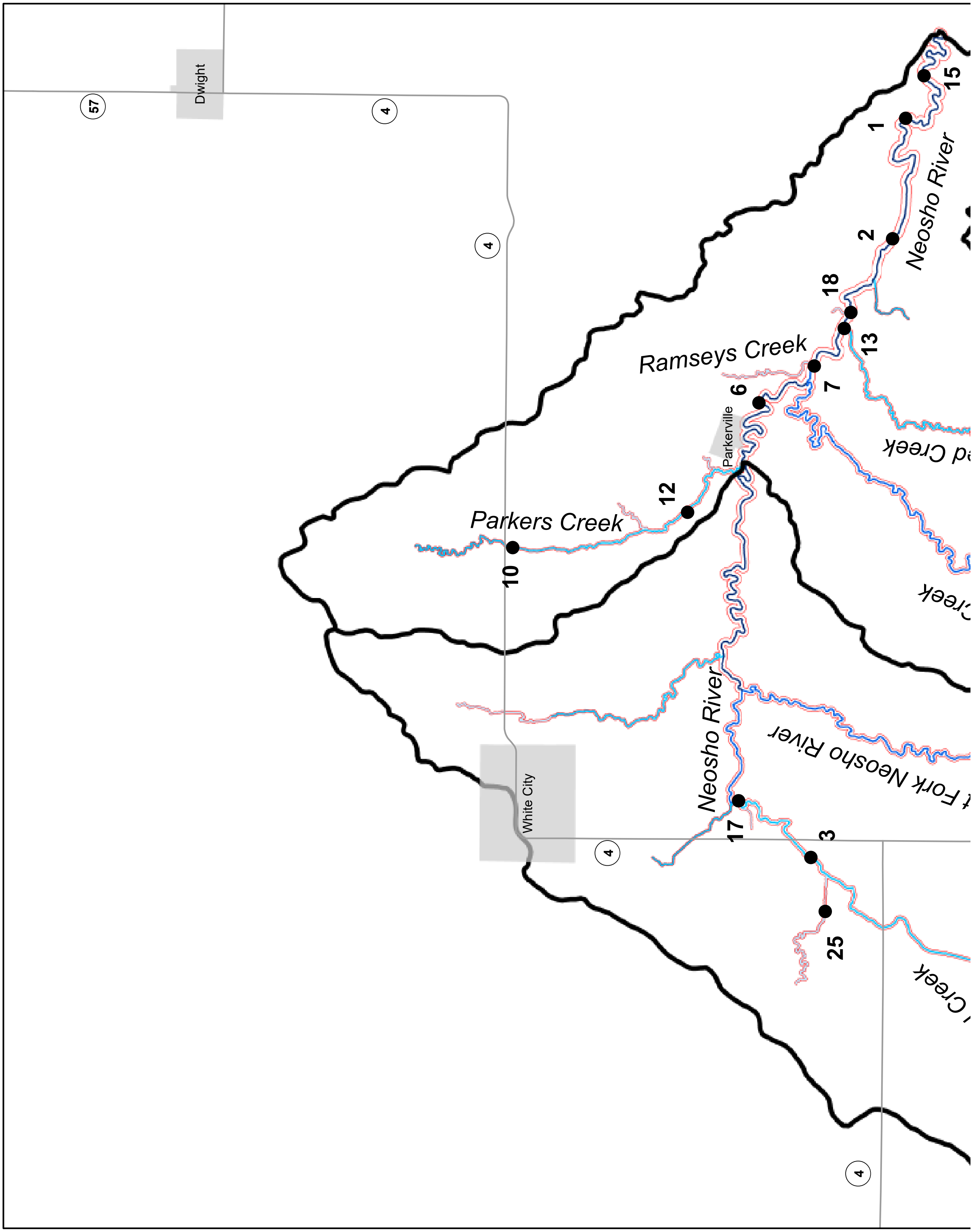


Figure 1. Location of Level Creek-Neosho River (Level Creek) and Haun Creek-Neosho River (Haun Creek) HUC-12 watersheds and riparian study areas in Morris County, Kansas. The two HUC-12 study areas are located within the Twin Lakes WRAPS and have been identified as priority watersheds for BMP implementation.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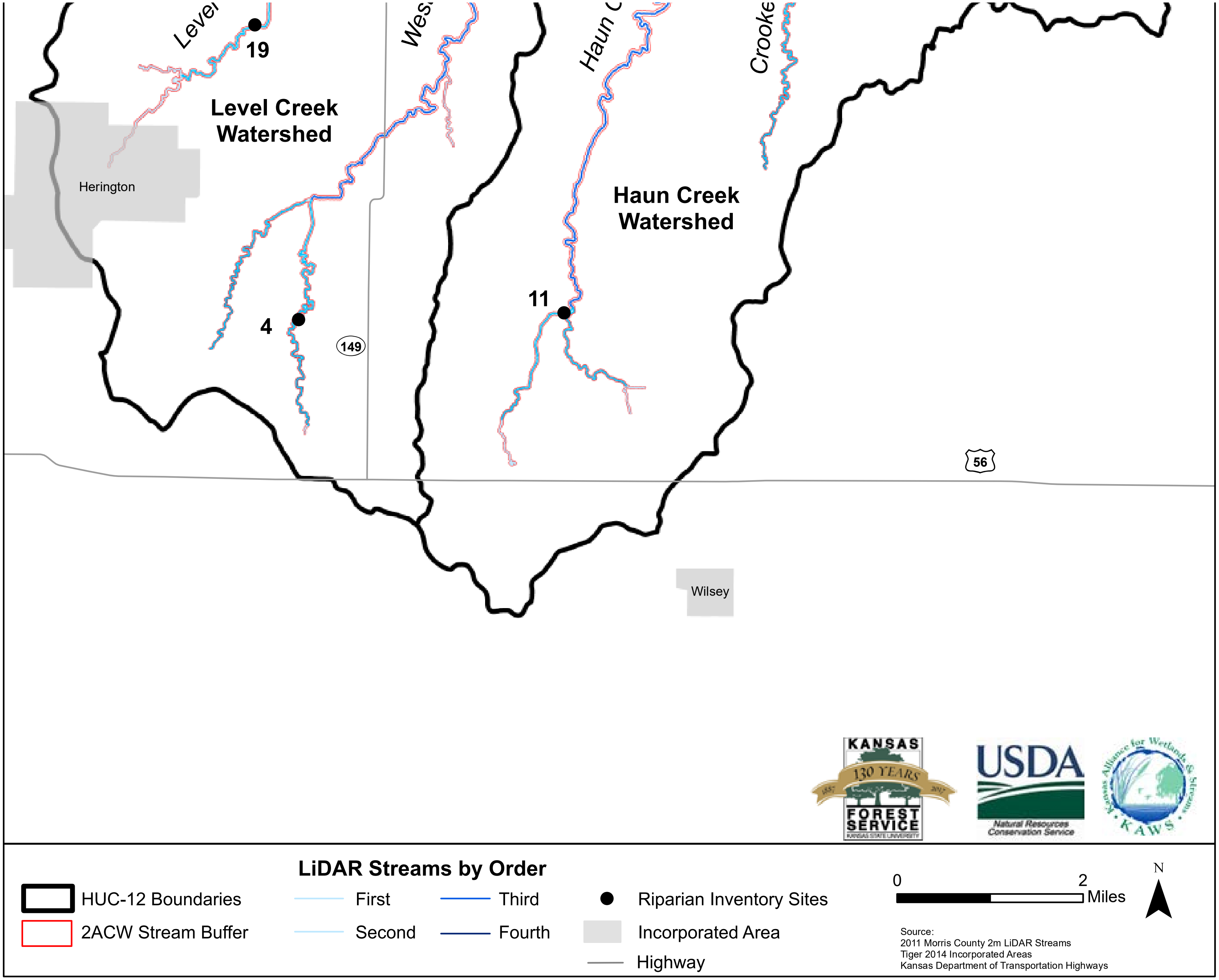
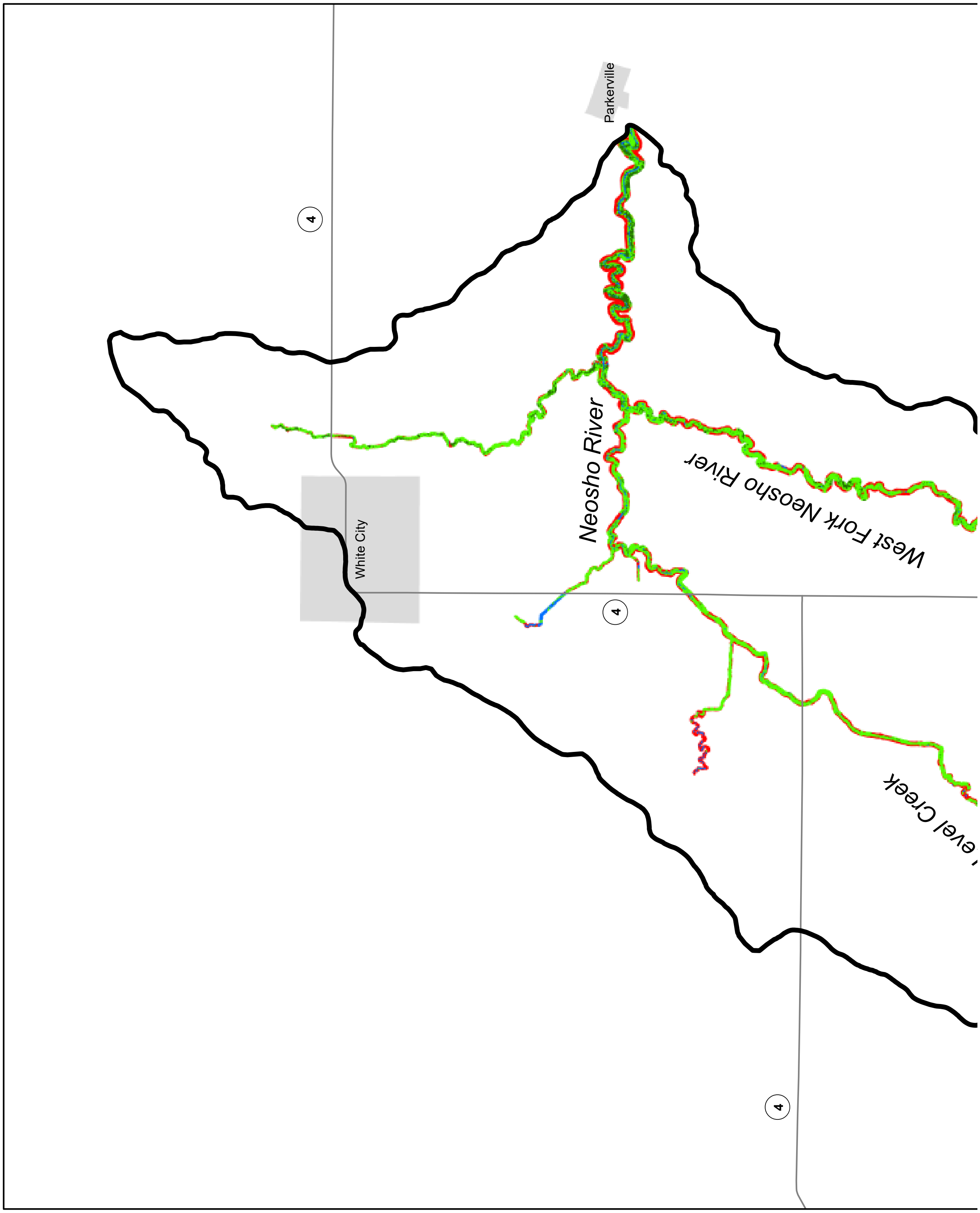


Figure 3. Location of riparian inventory sites in Level Creek and Haun Creek watersheds.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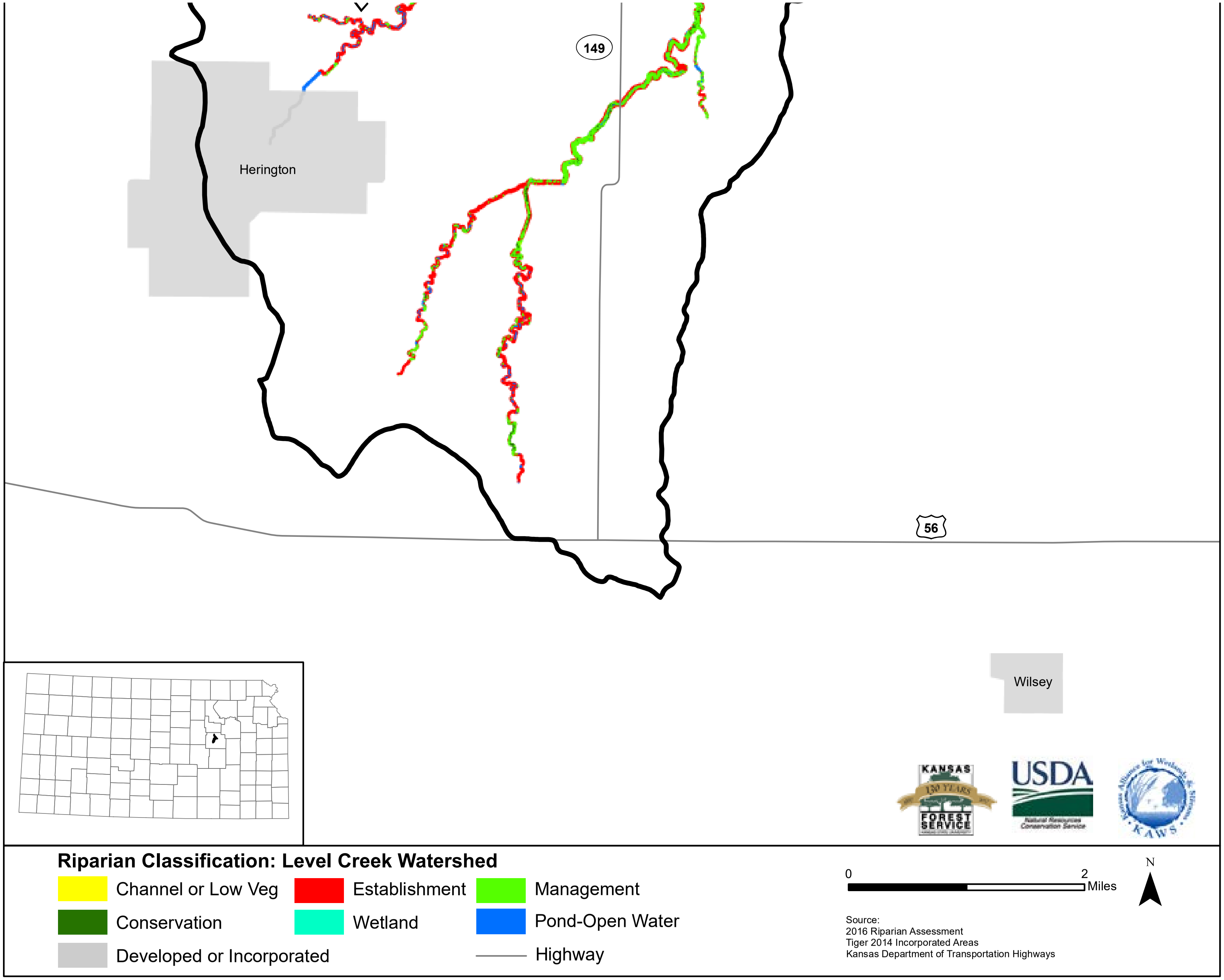
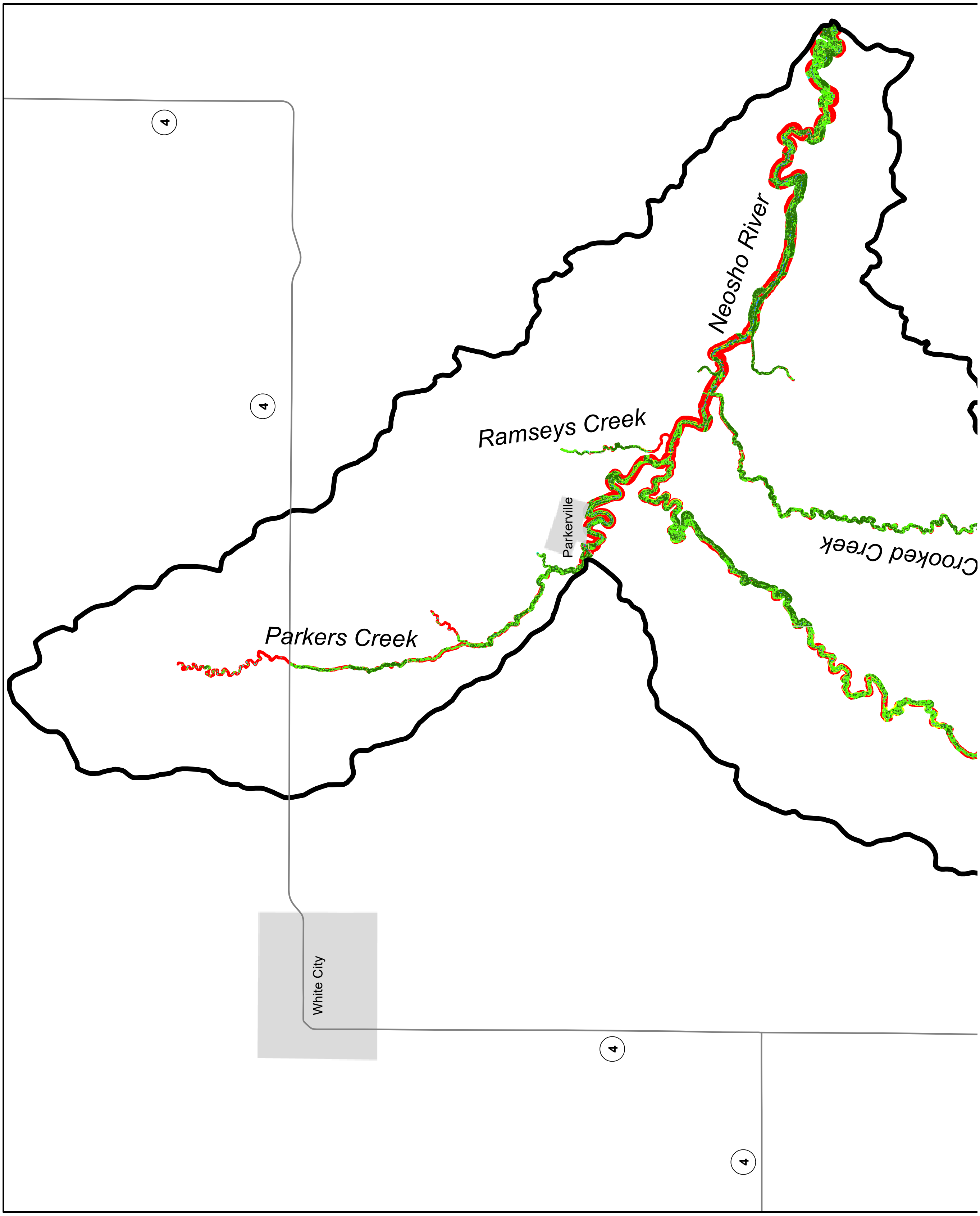


Figure 5. Riparian forest functioning condition classification of 2ACW riparian zone in Level Creek watershed, Morris County, Kansas.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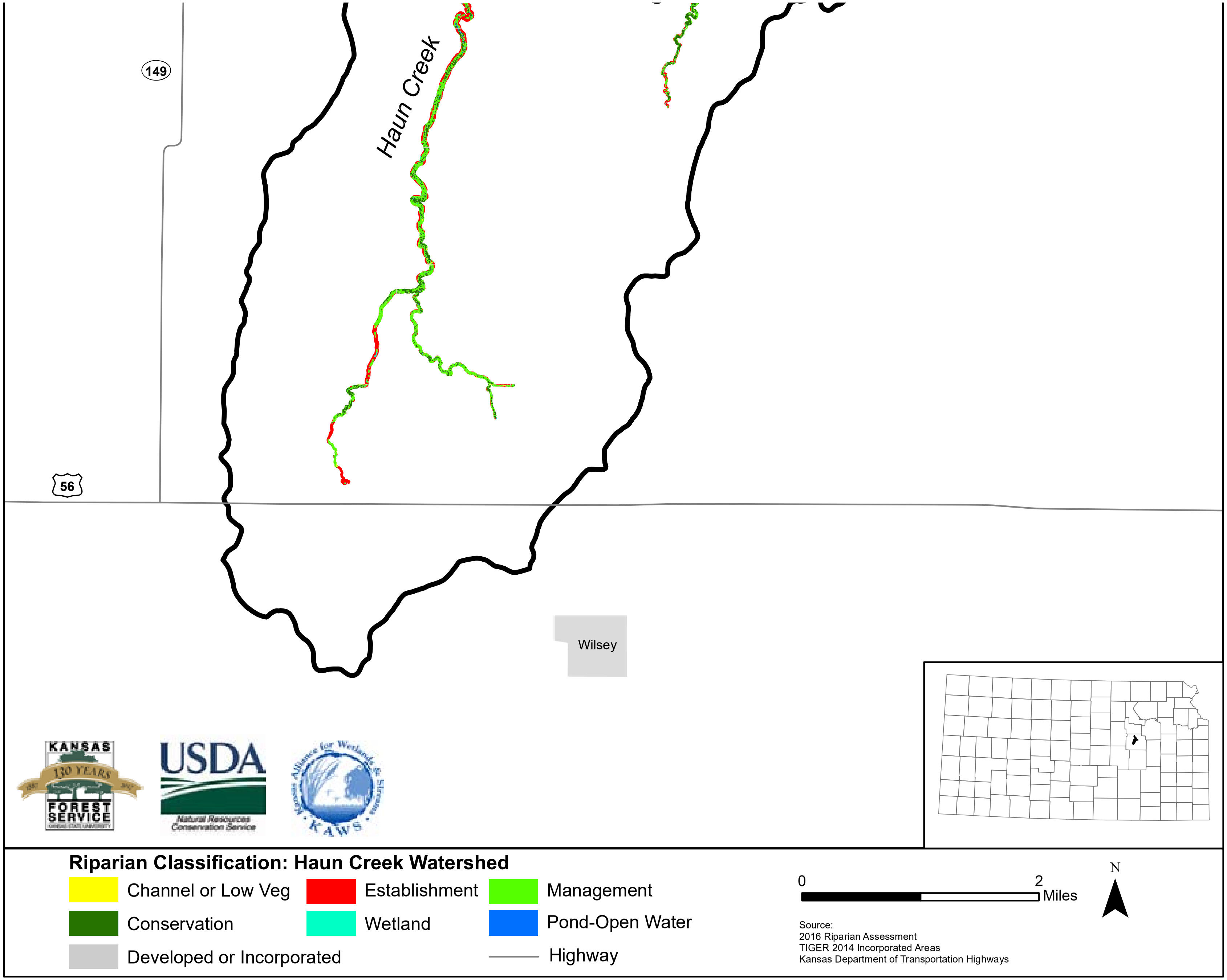

Figure 6. Riparian forest functioning condition classification of 2ACW riparian zone in Haun Creek watershed, Morris County, Kansas.

Appendix C: Riparian Condition Class and Potential Historical Remnant Forest by Hydrophysiographic Province and Adjacent to Lakes

Flint Hills Hydrophysiographic Province

Twin Lakes Study Area	Acres					
HUC-12	Conservation	Developed	Establishment	Management	Water	Potential Remnant*
110702010101	0.0	11.0	291.4	660.8	8.4	27.3
110702010102	0.1	4.2	272.6	872.9	11.2	378.3
Total	0.2	15.2	564.0	1,533.7	19.5	405.5

Marion Lake Study Area	Acres					
HUC-12	Conservation	Developed	Establishment	Management	Water	Potential Remnant*
110702020103	142.9	19.2	685.2	449.8	29.8	46.6
110702020104	128.0	3.8	254.3	315.6	91.4	0.0
Total	270.9	23.1	939.4	765.4	121.1	46.6

Cottonwood Study Area	Acres					
HUC-12	Conservation	Developed	Establishment	Management	Water	Potential Remnant*
110702030204	3.3	15.5	1,576.5	689.6	130.5	179.4
110702030205	2.5	14.7	1,370.9	677.6	142.3	229.1
110702030305	1.2	6.5	1,253.3	763.2	127.8	259.0
110702030401	3.1	7.8	1,338.5	684.1	101.7	209.2
110702030402	6.7	9.1	1,063.8	737.0	70.3	278.8
110702030403	11.1	11.1	1,361.5	713.4	130.5	278.8
110702030404	19.7	15.6	1,262.1	757.4	116.6	243.2
110702030405	7.0	33.5	2,338.7	1,064.4	251.7	430.0
110702030406	22.3	9.9	1,454.3	835.9	104.6	441.7
Total	76.8	123.7	13,019.7	6,922.7	1,175.9	2,549.2

Eagle Creek Study Area	Acres					
HUC-12	Conservation	Developed	Establishment	Management	Water	Potential Remnant*
110702010403	26.0	4.4	354.1	512.1	17.2	212.4
110702010404	28.3	4.4	498.4	701.9	23.4	262.4
110702010405	7.3	4.0	396.5	421.8	82.4	123.4
Total	61.6	12.8	1,248.9	1,635.8	123.0	598.2

North-Central Hydrophysiographic Province

Milford Lake Study Area	Acres					
HUC-12	Conservation	Developed	Establishment	Management	Water	Potential Remnant*
102500170202	1.7	31.2	370.0	516.7	113.1	75.5
102500170204	6.9	6.5	664.5	868.8	221.7	133.1
102500170303	0.0	1.3	377.5	349.9	101.1	52.2
102500170304	0.0	5.0	288.7	459.9	113.7	32.4
102500170310	0.0	4.9	703.4	577.1	135.1	40.7
102500170409	0.3	17.6	2,411.5	1,650.1	499.0	163.5
102500170508	6.3	4.5	2,095.3	1,512.7	469.9	126.3
102500170602	59.3	6.6	782.0	338.9	42.7	0.0
102500170604	31.9	4.3	1,096.6	532.1	374.0	106.1
102500170607	0.1	0.2	17.4	59.5	12.7	0.9
102500170608	0.0	0.8	14.9	25.8	7.4	0.8
102500170609	0.0	256.7	539.6	681.5	238.4	3.3
Total	106.6	339.6	9,361.5	7,572.9	2,328.8	734.8

Eastern Hydrophysiographic Province

Upper Wakarusa Study Area	Acres					
HUC-12	Conservation	Developed	Establishment	Management	Water	Potential Remnant*
102701040104	110.5	10.0	624.0	1,054.4	33.3	180.6
102701040105	86.1	4.9	315.7	904.4	71.9	267.4
102701040106	18.8	1.3	175.5	452.5	118.0	227.9
102701040107	77.0	2.9	267.8	521.2	24.7	209.5
102701040108	102.5	2.7	191.1	474.5	12.3	239.8
Total	394.8	21.8	1,574.1	3,406.9	260.2	1,125.1

Pomona Lake Study Area	Acres					
HUC-12	Conservation	Developed	Establishment	Management	Water	Potential Remnant*
102901010203	43.6	10.8	698.7	879.3	24.4	216.0
102901010205	69.3	7.9	819.0	925.6	32.4	207.6
102901010207	75.7	6.2	503.3	749.7	34.6	238.9
Total	188.7	24.9	2,021.0	2,554.6	91.3	662.5

Hillsdale Lake Study Area	Acres					
HUC-12	Conservation	Developed	Establishment	Management	Water	Potential Remnant*
102901020101	0.0	14.2	295.5	801.4	47.1	437.7
Total	0.0	14.2	295.5	801.4	47.1	437.7

Middle Neosho Study Area	Acres					
HUC-12	Conservation	Developed	Establishment	Management	Water	Potential Remnant*
110702050101	464.7	8.6	1,171.9	1,069.7	178.0	646.4
110702050109	193.5	25.7	2,290.1	1,375.5	338.1	891.5
110702050201	4.3	9.8	1,298.3	1,465.1	278.0	1,111.2
110702050202	0.7	3.2	1,553.5	730.1	238.0	509.1
110702050204	2.0	11.2	1,164.5	1,217.8	177.1	515.4
110702050205	8.7	17.4	1,925.9	1,376.7	366.1	1,257.1
110702050305	56.9	12.5	664.5	1,363.8	196.3	684.0
110702050403	357.8	18.6	696.1	752.7	42.5	390.1
110702050501	25.5	9.0	912.3	1,076.2	34.7	554.7
110702050505	2.0	11.0	611.4	790.6	66.3	260.7
110702050601	1.4	11.0	1,621.7	1,167.6	286.5	932.4
110702050605	47.1	18.7	1,308.6	1,360.3	286.7	815.1
Total	1,164.7	156.7	15,218.6	13,746.1	2,488.2	8,567.9

South-Central Hydrphyisographic Province						
Cheney Lake Study Area	**Acres**					
HUC-12	**Conservation**	**Developed**	**Establishment**	**Management**	**Water**	**Potential Remnant***
110300140109	29.2	9.9	1,072.5	203.7	32.0	0.0
110300140204	44.8	3.6	379.6	170.3	12.3	0.0
110300140205	43.7	5.1	577.0	183.0	5.9	0.0
110300140301	58.6	2.0	543.7	189.9	24.9	0.0
110300140302	24.4	6.3	299.5	270.2	7.2	0.0
110300140303	36.4	3.5	662.0	403.3	19.1	0.0
110300140304	9.3	4.1	351.5	410.4	18.2	0.0
110300140305	0.9	1.5	122.3	114.7	5.5	0.0
Total	247.4	36.1	4,008.2	1,945.6	125.2	0.0

Lakes

Milford Lake	**Acres**					
Milford Lake	**Conservation**	**Developed**	**Establishment**	**Management**	**Water**	**Potential Remnant***
887 Ft Buffer	0.0	335.5	4585.2	2296.7	857.2	142.3
Clinton Lake	**Acres**					
Clinton Lake	**Conservation**	**Developed**	**Establishment**	**Management**	**Water**	**Potential Remnant***
600 Ft Buffer	35.9	16.3	666.2	1855.3	417.0	405.9
Pomona Lake	**Acres**					
Pomona Lake	**Conservation**	**Developed**	**Establishment**	**Management**	**Water**	**Potential Remnant***
600 Ft Buffer	0.6	1.5	174.6	302.7	108.2	15.4
Cheney Lake	**Acres**					
Cheney Lake	**Conservation**	**Developed**	**Establishment**	**Management**	**Water**	**Potential Remnant***
600 Ft Buffer	2.0	35.7	1259.4	638.7	518.8	0.0

Flint Hills Hydrophysiographic Province

Twin Lakes Study Area	Percentage					
HUC-12	Conservation	Developed	Establishment	Management	Water	Potential Remnant*
110702010101	0.0	1.1	30.0	68.0	0.9	2.8
110702010102	0.0	0.4	23.5	75.2	1.0	32.6
Total	0.0	1.5	53.5	143.2	1.8	35.4

Marion Lake Study Area	Percentage					
HUC-12	Conservation	Developed	Establishment	Management	Water	Potential Remnant*
110702020103	10.8	1.4	51.6	33.9	2.2	3.5
110702020104	16.1	0.5	32.1	39.8	11.5	0.0
Total	26.9	1.9	83.7	73.7	13.8	3.5

Cottonwood Study Area	Percentage					
HUC-12	Conservation	Developed	Establishment	Management	Water	Potential Remnant*
110702030204	0.1	0.6	65.3	28.6	5.4	7.4
110702030205	0.1	0.7	62.1	30.7	6.4	10.4
110702030305	0.1	0.3	58.2	35.5	5.9	12.0
110702030401	0.1	0.4	62.7	32.0	4.8	9.8
110702030402	0.4	0.5	56.4	39.1	3.7	14.8
110702030403	0.5	0.5	61.1	32.0	5.9	12.5
110702030404	0.9	0.7	58.1	34.9	5.4	11.2
110702030405	0.2	0.9	63.3	28.8	6.8	11.6
110702030406	0.9	0.4	59.9	34.4	4.3	18.2
Total	3.3	5.0	547.1	296.0	48.6	108.0

Eagle Creek Study Area	Percentage					
HUC-12	Conservation	Developed	Establishment	Management	Water	Potential Remnant*
110702010403	2.8	0.5	38.8	56.0	1.9	23.3
110702010404	2.3	0.3	39.7	55.9	1.9	20.9
110702010405	0.8	0.4	43.5	46.2	9.0	13.5
Total	5.9	1.3	121.9	158.2	12.8	57.7

North-Central Hydrophysiographic Province

Milford Lake Study Area	Percentage					
HUC-12	Conservation	Developed	Establishment	Management	Water	Potential Remnant*
102500170202	0.2	3.0	35.8	50.0	10.9	7.3
102500170204	0.4	0.4	37.6	49.1	12.5	7.5
102500170303	0.0	0.2	45.5	42.2	12.2	6.3
102500170304	0.0	0.6	33.3	53.0	13.1	3.7
102500170310	0.0	0.3	49.5	40.6	9.5	2.9
102500170409	0.0	0.4	52.7	36.0	10.9	3.6
102500170508	0.2	0.1	51.2	37.0	11.5	3.1
102500170602	4.8	0.5	63.6	27.6	3.5	0.0
102500170604	1.6	0.2	53.8	26.1	18.3	5.2
102500170607	0.2	0.3	19.4	66.1	14.1	1.0
102500170608	0.0	1.7	30.5	52.7	15.1	1.7
102500170609	0.0	15.0	31.4	39.7	13.9	0.2
Total	7.3	22.6	504.3	520.2	145.6	42.5

Eastern Hydrophysiographic Province

Upper Wakarusa Study Area	Percentage					
HUC-12	Conservation	Developed	Establishment	Management	Water	Potential Remnant*
102701040104	6.0	0.5	34.1	57.5	1.8	9.9
102701040105	6.2	0.4	22.8	65.4	5.2	19.3
102701040106	2.4	0.2	22.9	59.1	15.4	29.7
102701040107	8.6	0.3	30.0	58.3	2.8	23.4
102701040108	13.1	0.3	24.4	60.6	1.6	30.6
Total	36.4	1.7	134.2	300.9	26.8	113.0

Pomona Lake Study Area	Percentage					
HUC-12	Conservation	Developed	Establishment	Management	Water	Potential Remnant*
102901010203	2.6	0.7	42.2	53.1	1.5	13.0
102901010205	3.7	0.4	44.2	49.9	1.7	11.2
102901010207	5.5	0.5	36.8	54.7	2.5	17.4
Total	11.9	1.5	123.1	157.7	5.7	41.7

Hillsdale Lake Study Area	Percentage					
HUC-12	Conservation	Developed	Establishment	Management	Water	Potential Remnant*
102901020101	0.0	1.2	25.5	69.2	4.1	37.8
Total	0.0	1.2	25.5	69.2	4.1	37.8

Middle Neosho Study Area	Percentage					
HUC-12	Conservation	Developed	Establishment	Management	Water	Potential Remnant*
110702050101	16.1	0.3	40.5	37.0	6.2	22.3
110702050109	4.6	0.6	54.2	32.6	8.0	21.1
110702050201	0.1	0.3	42.5	47.9	9.1	36.4
110702050202	0.0	0.1	61.5	28.9	9.4	20.2
110702050204	0.1	0.4	45.3	47.3	6.9	20.0
110702050205	0.2	0.5	52.1	37.3	9.9	34.0
110702050305	2.5	0.5	29.0	59.5	8.6	29.8
110702050403	19.2	1.0	37.3	40.3	2.3	20.9
110702050501	1.2	0.4	44.3	52.3	1.7	27.0
110702050505	0.1	0.7	41.3	53.4	4.5	17.6
110702050601	0.0	0.4	52.5	37.8	9.3	30.2
110702050605	1.6	0.6	43.3	45.0	9.5	27.0
Total	45.7	6.0	543.8	519.3	85.2	306.5

South-Central Hydrphyisographic Province

Cheney Lake Study Area	Percentage					
HUC-12	Conservation	Developed	Establishment	Management	Water	Potential Remnant*
110300140109	2.2	0.7	79.6	15.1	2.4	0.0
110300140204	7.3	0.6	62.2	27.9	2.0	0.0
110300140205	5.4	0.6	70.8	22.5	0.7	0.0
110300140301	7.2	0.2	66.4	23.2	3.0	0.0
110300140302	4.0	1.0	49.3	44.5	1.2	0.0
110300140303	3.2	0.3	58.9	35.9	1.7	0.0
110300140304	1.2	0.5	44.3	51.7	2.3	0.0
110300140305	0.4	0.6	49.9	46.8	2.3	0.0
Total	30.8	4.7	481.4	267.5	15.6	0.0

Lakes

Milford Lake	Percentage					
Milford Lake	Conservation	Developed	Establishment	Management	Water	Potential Remnant*
887 Ft Buffer	0.0	4.2	56.8	28.4	10.6	1.8

Clinton Lake	Percentage					
Clinton Lake	Conservation	Developed	Establishment	Management	Water	Potential Remnant*
600 Ft Buffer	1.2	0.5	22.3	62.0	13.9	13.6

Pomona Lake	Percentage					
Pomona Lake	Conservation	Developed	Establishment	Management	Water	Potential Remnant*
600 Ft Buffer	0.1	0.3	29.7	51.5	18.4	2.6

Cheney Lake	Percentage					
Cheney Lake	Conservation	Developed	Establishment	Management	Water	Potential Remnant*
600 Ft Buffer	0.1	1.5	51.3	26.0	21.1	0.0

Appendix D: Riparian Species List by Hydrophysiographic Province and Riparian Community Type

Riverfront Forests

		Hydrophysiographic Province			
Scientific Name	**Common Name**	**East**	**Flint Hills**	**NC**	**SC**
Populus deltoides	Eastern cottonwood	x	x	x	x
Salix nigra	Black willow	x	x	x	x
Fraxinus pennsylvanica	Green ash	x	x	x	x
Acer saccharinum	Silver maple	x	x	x	x
Platanus occidentalis	Sycamore	x	x	x	x
Cornus amomum	Pale dogwood	x	x		
Cornus drummondii	Rough-leaved dogwood	x	x	x	x
Elymus virginicus	Virginia wild-rye	x	x	x	x
Leersia oryzoides	Rice cut grass	x	x	x	x
Carex frankii	Frank's sedge	x	x	x	x
Laportea canadensis	Wood nettle	x	x		x
Glyceria striata	Fowl manna grass	x	x		
Boehmeria cylindrica	False nettle	x	x	x	
Bidens cernua	Nodding beggar-ticks	x	x	x	
Bidens frondosa	Bearded beggar-ticks	x	x	x	x
Solidago gigantea	Late goldenrod	x	x	x	x
Persicaria punctata	Dotted smartweed	x	x	x	x
Symphyotrichum lanceolatum	Panicled aster	x			
Rudbeckia laciniata	Goldenglow	x	x	x	

Mesic Bottomland Forest

Scientific Name	Common Name	Hydrophysiographic Province			
		East	Flint Hills	NC	SC
	Ash-Elm Hackberry				
Fraxinus pennsylvanica	Green ash	x	x	x	x
Celtis occidentalis	Hackberry	x	x	x	x
Quercus macrocarpa	Bur oak	x	x	x	x
Carya cordiformis	Bitternut hickory	x	x	x	
Quercus muehlenbergii	Chinquapin oak	x	x		
Juglans nigra	Black walnut	x	x	x	x
Tilia americana	Basswood	x	x		
Asimina triloba	Paw paw	x	x		
Cornus drummondii	Rough-leaved dogwood	x	x	x	x
Elymus virginicus	Virginia wild-rye	x	x	x	x
Chasmanthium latifolia	Woodland sea-oats	x	x		
Muhlenbergia frondosa	Wirestem muhly	x	x		
Symphoricarpos orbiculatus	Buckbrush	x	x	x	x
Geum canadense	Spring avens	x	x	x	x
Laportea canadensis	Wood nettle	x	x		
Campanula americana	American bellflower	x	x		
	Pecan-Hackberry				
Carya illinoinensis	Pecan	x			
Celtis occidentalis	Hackberry	x			
Acer saccharinum	Silver maple	x			
Platanus occidentalis	Sycamore	x			
Populus deltoides	Eastern cottonwood	x			
Ulmus americana	American elm	x			
Juglans nigra	Black walnut	x			
Cornus drummondii	Rough-leaved dogwood	x			
Elymus virginicus	Virginia wild-rye	x			
Diarrhena americana	American beakgrain	x			
Leersia oryzoides	Rice cut grass	x			
Geum canadense	Spring avens	x			
	Mixed Oak				
Carya cordiformis	Bitternut hickory	x			
Quercus shumardii	Shumard oak	x			
Quercus macrocarpa	Bur oak	x			
Juglans nigra	Black walnut	x			
Quercus muehlenbergii	Chinquapin oak	x			
Platanus occidentalis	Sycamore	x			
Ulmus americana	American elm	x			
Elymus virginicus	Virginia wild-rye	x			
Chasmanthium latifolia	Woodland sea-oats	x			
Carex blanda	Woodland sedge	x			

Wet-Mesic Bottomland Forest

		Hydrophysiographic Province			
Scientific Name	**Common Name**	**East**	**Flint Hills**	**NC**	**SC**
		Cottonwood-Sycamore			
Platanus occidentalis	Sycamore	x	x	x	x
Populus deltoides	Eastern cottonwood	x	x	x	x
Fraxinus pennsylvanica	Green ash	x	x	x	x
Celtis occidentalis	Hackberry	x	x	x	x
Salix nigra	Black willow	x	x	x	x
Carya illinoinensis	Pecan	x	x		
Quercus palustris	Pin oak	x			
Cornus amomum	Pale dogwood	x	x		
Cornus drummondii	Rough-leaved dogwood	x	x	x	x
Elymus virginicus	Virginia wild-rye	x	x	x	x
Leersia oryzoides	Rice cut grass	x	x	x	x
Carex frankii	Frank's sedge	x	x	x	x
Laportea canadensis	Wood nettle	x	x		
Glyceria striata	Fowl manna grass	x	x		
Boehmeria cylindrica	False nettle	x	x	x	
		Pecan-Hackberry			
Carya illinoinensis	Pecan	x			
Celtis occidentalis	Hackberry	x			
Acer saccharinum	Silver maple	x			
Platanus occidentalis	Sycamore	x			
Populus deltoides	Eastern cottonwood	x			
Ulmus americana	American elm	x			
Juglans nigra	Black walnut	x			
Cornus drummondii	Rough-leaved dogwood	x			
Elymus virginicus	Virginia wild-rye	x			
Diarrhena americana	American beakgrain	x			
Geum canadense	Spring avens	x			

Wet Bottomland Forest

		Hydrophysiographic Province			
Scientific Name	**Common Name**	**East**	**Flint Hills**	**NC**	**SC**
Populus deltoides	Eastern cottonwood	x	x	x	x
Salix nigra	Black willow	x	x	x	x
Fraxinus pennsylvanica	Green ash	x	x	x	x
Acer saccharinum	Silver maple	x	x	x	x
Platanus occidentalis	Sycamore	x	x	x	x
Quercus palustris	Pin oak	x			
Cephalanthus occidentalis	Buttonbush	x	x	x	x
Carex grayii	Gray sedge	x			
Carex frankii	Frank's sedge	x	x	x	x
Leersia oryzoides	Rice cut grass	x	x	x	x
Lycopus americanus	Common water horehound	x	x	x	x
Boehmeria cylindrica	False nettle	x	x	x	
Rumex verticellatus	Swamp dock	x	x	x	x
Persicaria punctata	Dotted smartweed	x	x	x	x
Pilea pumila	Clearweed	x	x		
Impatiens capensis	Spotted touch-me-not	x			

Mesic Bottomland Woodlands

Scientific Name	Common Name	Hydrophysiographic Province East	Flint Hills	NC	SC
		Mixed Oak			
Quercus macrocarpa	Bur oak	x			
Fraxinus pennsylvanica	Green ash	x			
Carya illinoinensis	Pecan	x			
Carya cordiformis	Bitternut hickory	x			
Quercus muehlenbergii	Chinquapin oak	x			
Cornus drummondii	Rough-leaved dogwood	x			
Salix nigra	Black willow	x			
Andropogon gerardii	Big bluestem	x			
Panicum virgatum	Switch grass	x			
Elymus virginicus	Virginia wild-rye	x			
Chasmanthium latifolia	Woodland sea-oats	x			
Carex sparganoides	Bur-seed sedge	x			
Carex radiata	Radiate sedge	x			
Spartina pectinata	Prairie cordgrass	x			
Sanicula odorata	Black snakeroot	x			
Symphoricarpos orbiculatus	Buckbrush	x			
Geum canadense	Spring avens	x			
		Bur Oak			
Quercus macrocarpa	Bur oak	x			
Fraxinus pennsylvanica	Green ash	x			
Quercus rubra	Red oak	x			
Cornus drummondii	Rough-leaved dogwood	x			
Panicum virgatum	Switch grass	x			
Schizachyrium scoparium	Little bluestem	x			
Sorghastrum nutans	Indian grass	x			
Elymus virginicus	Virginia wild-rye	x			
Chasmanthium latifolia	Woodland sea-oats	x			
Carex sparganoides	Bur-seed sedge	x			
Carex radiata	Radiate sedge	x			
Spartina pectinata	Prairie cordgrass	x			
Sanicula odorata	Black snakeroot	x			
Symphoricarpos orbiculatus	Buckbrush	x			
Geum canadense	Spring avens	x			

Wet-Mesic Bottomland Woodland

Scientific Name	Common Name	Hydrophysiographic Province East	Flint Hills	NC	SC
Eastern Third of Kansas					
Populus deltoides	Eastern cottonwood	x	x		
Salix nigra	Black willow	x	x		
Fraxinus pennsylvanica	Green ash	x	x		
Quercus palustris	Pin oak	x			
Carya illinoinensis	Pecan	x	x		
Quercus macrocarpa	Bur oak	x	x		
Carex annectans	Yellow-fruited sedge	x	x		
Carex frankii	Frank's sedge	x	x		
Carex vulpinoidea	Fox sedge	x	x		
Juncus torreyi	Torrey sedge	x	x		
Andropogon gerardii	Big bluestem	x	x		
Panicum virgatum	Switch grass	x	x		
Spartina pectinata	Prairie cordgrass	x	x		
Asclepias incarnata	Swamp milkweed	x	x		
Teucrium canadense	American germander	x	x		
Persicaria punctata	Dotted smartweed	x	x		
Verbena hastata	Blue vervain	x	x		
Elsewhere in Study Areas					
Populus deltoides	Eastern cottonwood			x	x
Salix amygdaloides	Peach-leaf willow			x	x
Salix exigua	Sandbar willow			x	x
Carex pellita	Wooly sedge			x	x
Equisetum laevigatum	Smooth horsetail			x	x
Pascopyron smithii	Western wheat grass			x	x
Elymus virginicus	Virginia wild-rye			x	x
Spartina pectinata	Prairie cordgrass			x	x
Sporobolus cryptandrus	Sand dropseed			x	x
Calmovilfa longifolia	Prairie sandreed			x	x
Glycyrrhiza lepidota	Wild licorice			x	x
Phyla lanceolata	Lance-leaf frog fruit			x	x
Muhlenbergia racemosa	Marsh muhly			x	x