A Natural Areas Inventory of Douglas County in Northeast Kansas

Open-File Report No. 184
February 15, 2016

Kelly Kindscher, Leanne M. Martin, Erica M. Staab, and Jennifer M. Delisle

Kansas Natural Heritage Inventory
Kansas Biological Survey
2101 Constant Avenue
Lawrence, KS 66047

A Natural Areas Inventory of Douglas County in Northeast Kansas

Cover Photo: Native Prairie in Douglas County, 2015.

Report submitted: February 15, 2016

Citation:

Kindscher, K., L. M. Martin, E. M. Staab, and J. M. Delisle. 2016. A Natural Areas Inventory of Douglas County in Northeast Kansas. Open-File Report No. 184. Kansas Biological Survey. Lawrence, KS. 53 pp.

Abstract

In 2014, the Kansas Biological Survey initiated a two-year inventory to identify and survey the remaining high-quality natural areas in Douglas County.

The primary natural areas in Douglas County are prairie and forest plant communities. Douglas County has 76 high-quality prairie sites and 27 high-quality forests that are documented in the Kansas Natural Heritage Inventory database. Prairie communities include Unglaciated Tallgrass Prairie, Glaciated Tallgrass Prairie, and Low (Wet) Prairie. Forest communities include Oak-Hickory Forest, Ash-Elm-Hackberry Forest, Cottonwood-Sycamore Floodplain Forest, and Cross Timbers-Post Oak Woodland.

We documented significant changes to prairie and forest habitats. Between 1988, when the Kansas Natural Heritage Inventory began documenting high-quality prairies, and our survey in 2005 29% of the high-quality prairie was lost. This resulted in only 0.5% of the original prairie in the county remaining. During the current survey we found that an additional 18% has been lost over the last 10 years. Similarly, approximately 88% of the original forest in the county has been cleared at some time. Roughly 82% of the forested areas seen today are "new growth" forests that have developed in areas once occupied by prairie. Today, approximately 15% of the county is forested.

Four areas of special interest were identified for further examination in this study: Lakeview, Baldwin Woods, and the riparian corridors of the Kansas and Wakarusa rivers. All of these areas contain natural areas and open space, and offer considerable recreation and conservation opportunities. We highlighted current conservation efforts when applicable and potential opportunities for recreation and conservation for each of these areas.

Conserving high-quality natural areas benefits the citizens of Douglas County for many reasons. Natural areas provide habitat for a rich array of plant and animal species, water-quality improvement, recreational, research, and educational opportunities, economic benefits, appreciation of our natural heritage, and aesthetic enjoyment of the outdoors. We suggest several ways landowners may be able to conserve and enhance their high-quality tracts of land. We also suggest ways that the conservation of public land would benefit Douglas County.

TABLE OF CONTENTS

List of Figures and Tables

Figures

Tables

Chapter 1: Introduction

1.1. Project Purpose

In 2014, the Kansas Biological Survey was funded by the Douglas County Natural & Cultural Heritage Grant Program to reassess the condition of the remaining high-quality natural areas in Douglas County in northeast Kansas. High-quality natural areas are plant communities that closely approximate the native vegetation (e.g., tallgrass prairie, oak-hickory forest) that existed prior to Euro-American settlement. Healthy natural areas are primary reservoirs of biological diversity and sanctuaries for sensitive and declining species. They also provide many beneficial services to humans by buffering the effects of pollution, protecting water quality, preventing soil erosion, improving land values, and providing opportunities for outdoor recreation.

High-quality prairies and forests have been documented and mapped by the Kansas Natural Heritage Inventory since 1988. In a prior study (Kindscher et al. 2005) nearly all remaining prairies and several forest tracts were identified and the reduction in prairie acreage since 1988 was documented. The primary objectives of the current study were to survey native prairies and forests in the county, to assess their ecological viability, and to document losses in prairie acreage since the 2005 survey. As previous forest inventories had not been conducted in a comprehensive manner, we implemented a systematic effort to find additional high-quality forest tracts in the county. We also identified four target areas for special consideration of conservation efforts: Lakeview, Baldwin Woods, and the riparian corridors of the Kansas and Wakarusa rivers.

The specific objectives of this study were to

a) find, identify, and assess through field surveys the remaining high-quality natural areas in Douglas County;
b) document the locations of protected and rare plant species on these areas;
c) document the number of new and previously known sites supporting high-quality prairies and forests;
d) identify sensitive environments, potential parklands, and scenic recreational areas.
e) report results, provide maps of high-quality natural areas, and discuss risks, protection options, and opportunities for restoration and recreation.

Information gathered through this inventory will allow Douglas County to lead in the integration of conservation planning with development planning. Recommendations provided in this report offer many opportunities for partnerships with federal, state, local, and nonprofit entities in the implementation of conservation in the county.

1.2. Survey Area and Landscape Features

The survey area was Douglas County in northeast Kansas (Figure 1.1). The northern portion of the county is located in the Glaciated Region formed by glacial drift deposited during the last two Ice Ages (Lauver 1989; McCauley 1998). The southern portion, the upland area south of the Wakarusa River, is unglaciated and is located in the Osage

Cuestas physiographic province. The county has two large rivers, the Kansas and the Wakarusa (which has been dammed to form Clinton Reservoir).

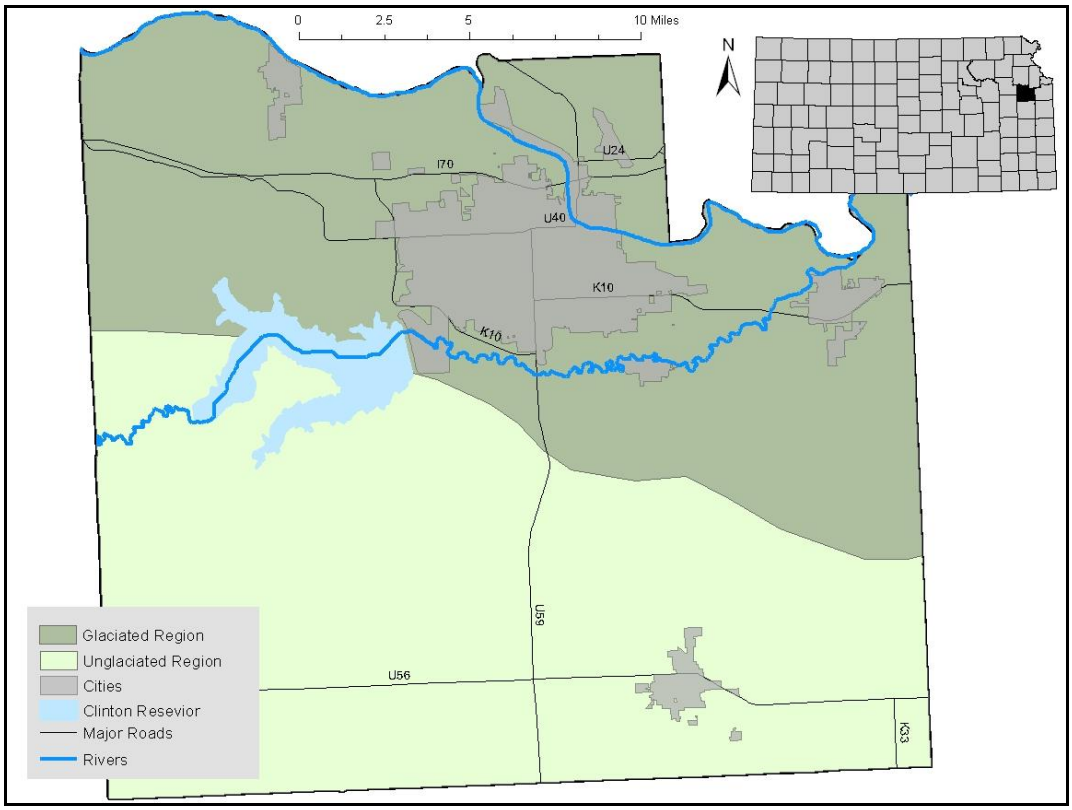

Figure 1.1. Map of Douglas County, Kansas, showing glaciated and unglaciated regions, Clinton Reservoir, and major rivers, cities, and roads.

1.3. Land-use History and Trends

Past land-use patterns. Prior to Euro-American settlement, the area was inhabited by the Kansa and other Native American tribes. Most of the land was prairie, a diverse mix of native grasses and wildflowers, which was primarily maintained by fires either set by Native Americans or started by lightning. When Euro-American settlement began in the 1850s, federal land surveyors estimated prairie to cover approximately 87% of the county (Kansas Biological Survey 2015). The remaining land was covered primarily with forest and small patches of wetland and marsh. Forested lands were limited to moist soils in riparian areas along streams and rivers, and steep, moist, north-facing, sometimes rocky, slopes such as was found at Baldwin Woods, the bluffs along the south side of present-day Clinton Reservoir (Figure 1.2) and other places naturally protected from fire.

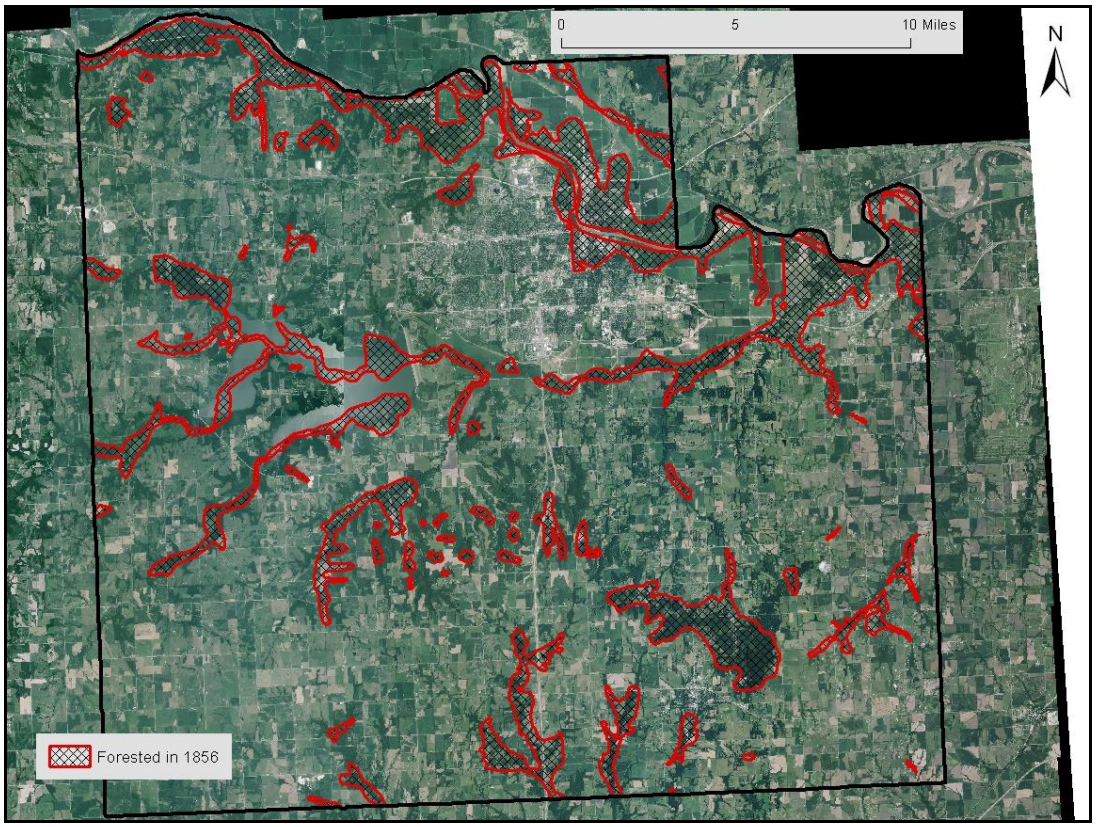

Figure 1.2. Areas forested in Douglas County in 1856, shown overlaying 2014 aerial photograph.

European-heritage immigrants settled first near rivers for access to timber, transportation, and commerce but then expanded to upland prairies, which they tilled for crops and used for pasture. Riparian forests were cut for timber and farmland development. Over time, livestock grazing and suppression of fire on prairies led to woody growth replacing these grasslands. Conversion of grassland to farmland further reduced prairie acreage. With continued fire suppression and changing land use today, forest and brush cover of all types have increased. Despite observations of these changes to prairie and forest cover since the 1850s, however, changes to both types of habitat have not been previously quantified in a systematic manner for Douglas County.

The trend in land cover change between the 1850s and early 1900s is evident from aerial photography dated from 1937, the oldest imagery available for the county (Figure 1.3). Although this black and white image is difficult to see at the scale shown in this figure, we were able to use it to determine which areas were forested in 1937. At that time, the rural population in Douglas County was much higher, with farms on almost every quarter section of land (160 acres) or smaller. Nearly all prairie had been plowed by that time, most forests had been logged, and there was little wooded cover.

More recently, creek and river channels, specifically the Kansas River and Mud Creek, have been controlled with levees to reduce flooding (Lauver 1989), and the small acreage of wetlands has been drained or significantly modified (Lauver 1989; Kindscher 1992).

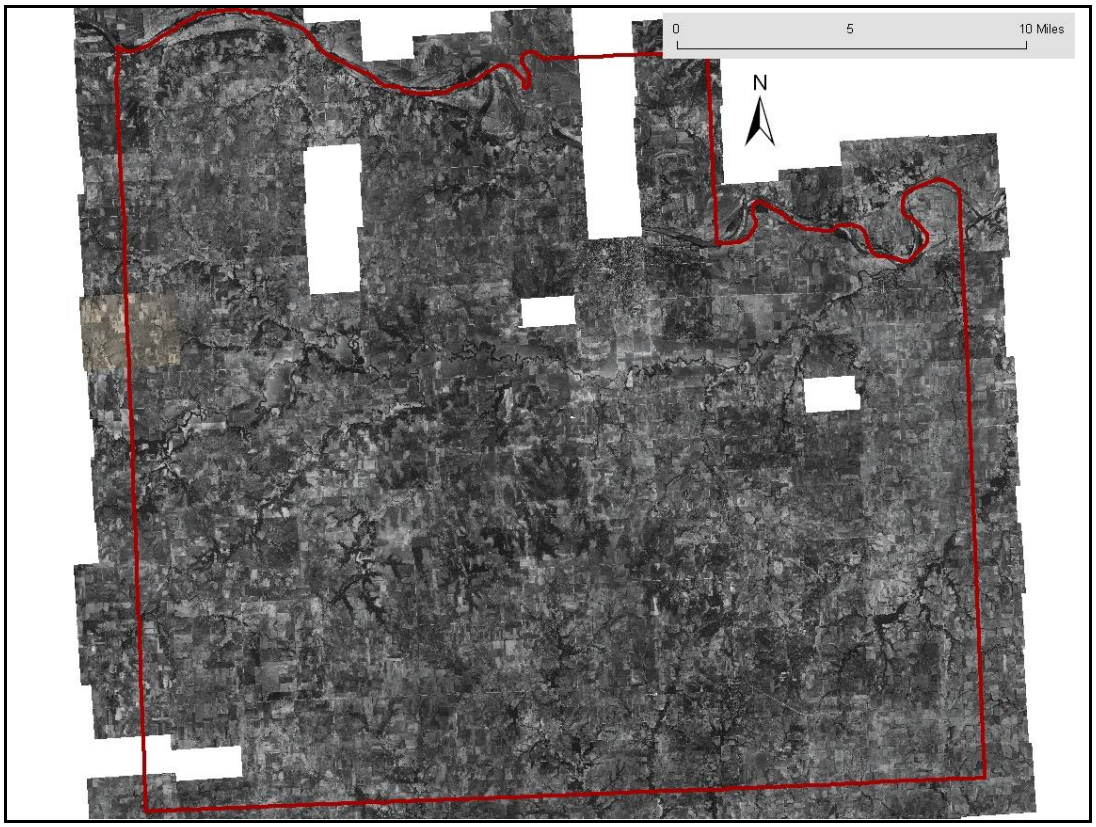

Figure 1.3. 1937 aerial photo of Douglas County showing a significantly reduced area of tree cover. This image has been stitched together from multiple aerial images; white areas occur where imagery was not available.

Current land-use trends. At present, land in the United States is being converted to cropland, housing, offices, shopping centers, and industrial uses at an accelerating rate. Some estimates indicate that the amount of land being claimed for urban and suburban uses has increased by nearly 300% since 1955, while the U.S. population has increased by 75%. Conversion of natural areas to human uses reduces habitat for wildlife and limits ecosystem benefits, and has become one of the most serious threats to native plant and animal species (Ewing et al. 2005). Development in northeast Kansas is consistent with this national land-use trend.

1.4. Potential Natural Communities in Douglas County

Several natural community types were present in Douglas County prior to Euro-American settlement (Table 1.1). Of these original, native plant communities the most common types were Glaciated Tallgrass Prairie, found in the north half of Douglas County, and Unglaciated Tallgrass Prairie, found in the southern half (Figure 1.1; Figure 1.4). Low (Wet) Prairie was found along creeks and streams. Forest communities were characterized by proximity to rivers or moist habitats and by dominant tree species. The most common forest type was Oak-Hickory Forest (Figure 1.5). Other forest communities included Ash-Elm-Hackberry Floodplain Forest, Cottonwood-Sycamore

Floodplain Forest, and Cross Timbers Woodland-Post Oak Woodland. Wetland and marsh community types also were found in the county.

Figure 1.4. Showy wildflowers (gayfeather in the foreground; compassplant in the background) in Unglaciated Tallgrass Prairie in Douglas County, 2015.

Table 1.1. Pre-settlement terrestrial and wetland plant communities in Douglas County (adapted from Lauver et al. 1999; Jennings et al. 2006).

Ash-Elm-Hackberry Floodplain Forest	Mixed Oak Floodplain Forest
Bur Oak Floodplain Woodland	Mixed Oak Ravine Woodland
Cottonwood–Black Willow Floodplain Forest	Oak-Hickory Forest
Cottonwood-Sycamore Floodplain Forest	Eastern Cattail Marsh
Freshwater Marsh	Pondweed Aquatic Wetland
Glaciated Tallgrass Prairie	Unglaciated Tallgrass Prairie
Wet Prairie	

Figure 1.5. Oak-Hickory Forest in Douglas County, 2015 showing large trees and a diversity of species.

Chapter 2: Methods

2.1. Natural Areas Inventory

The planning phase of this project began in the spring of 2014; field data were collected during both the 2014 and 2015 spring growing seasons. The majority of high-quality prairies in Douglas County had been mapped previously (Kindscher et al. 2005) so our current efforts focused on documenting changes in the number, size, or quality of previously known prairies and to locate any new sites. No systematic effort to identify and map all potential high-quality forests had been conducted before. In previous surveys we focused our work on the Baldwin Woods area, the Kansas River bluffs, and Clinton Reservoir that were less impacted by human use due to the steep slopes and rugged terrain. Our efforts with the current survey focused on more accessible areas that had not been assessed previously. We developed a method using digital imagery, recent and historical aerial photography, and historical public land surveys to predict where high-quality forest might occur.

Potential prairie sites of five acres or more, forest sites of 10 acres or more, and sites that were smaller but had the potential to provide habitat for rare species were surveyed. Natural communities that met the quality criteria used by the Kansas Natural Heritage Inventory were identified and assessed by crews comprised of at least two field workers including a botanist or ecologist. We obtained landowner permission before accessing

any potential sites and offered to send property owners the lists of plant species identified on their property. Most property owners granted us access to their properties.

We collected the following information at each site:

1) latitude and longitude obtained by GPS and a general description of the area;
2) landscape description of the site and the surrounding area;
3) description of the vegetative community and ranking (according to standard Heritage methodology; see section 2.3a);
4) the names of all plant species found on the site if not previously documented (the taxonomy used was from Freeman 2012);
5) any occurrences of rare, threatened, or endangered species; and
6) a map of the site drawn on an aerial photograph.

Data were entered into the Kansas Natural Heritage Inventory database and into plant species databases. Boundaries of natural areas were digitized using ArcMap 10.1 software using current aerial photographs as base maps.

Forest Inventory. Forests were surveyed in April and May 2015, when ephemeral woodland wildflowers were observed most readily. Presence of these species in the understory can be used as an indicator of forest condition, with a greater diversity of conservative species indicating higher quality forests. Conservative species do not tolerate disturbances well, and are therefore typically only found on high-quality sites with low disturbance levels. By late May, most spring ephemerals (such as Dutchman's breeches, fawn-lily, and jack-in-the-pulpit) have died back and their presence cannot be detected easily.

Prior to starting field surveys we conducted an analysis of forest cover to locate potential high-quality forest tracts. Figure 2.2 shows an example of how this targeting process worked in the Baldwin Woods area. We began by identifying areas with greater than 50% forest cover in all of the following data sets: a digitized map of forests from the 1856 public land survey (Kansas Biological Survey 2015), a 1937 aerial photo (University of Kansas Libraries, GIS & Numeric Data Lab Douglas County Public Works Department), a GIS layer showing current forested areas of 40 acres or greater (Kansas Forest Service 2011), and a 2014 aerial photo of Douglas County (FSA National Agricultural Imagery Program). By overlaying these digital layers in a Geographic Information System we were able to determine areas that most likely were forested continuously since 1856 (Figures 2.1 and 2.2 A). We predicted that areas mapped as forest in 1856 that were forested in both 1937 and 2014 had never been clear-cut and therefore might retain old-growth characteristics.

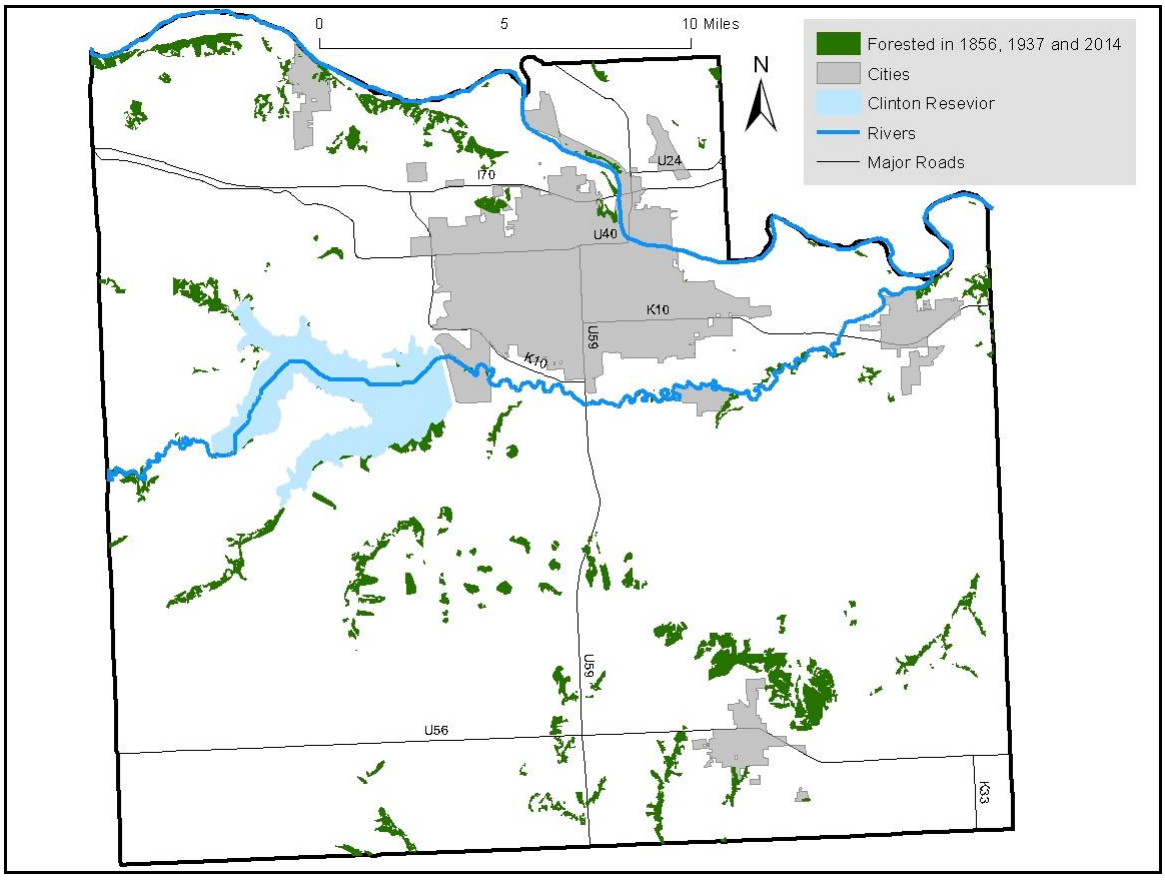

Figure 2.1. Areas most likely to have been forested continuously from1856–2014.

We predicted that the remaining tracts were the most likely to be high-quality forests of considerable size that contained conservative species (Figure 2.2 C). Forest tracts that had been surveyed previously were not selected for additional survey work.

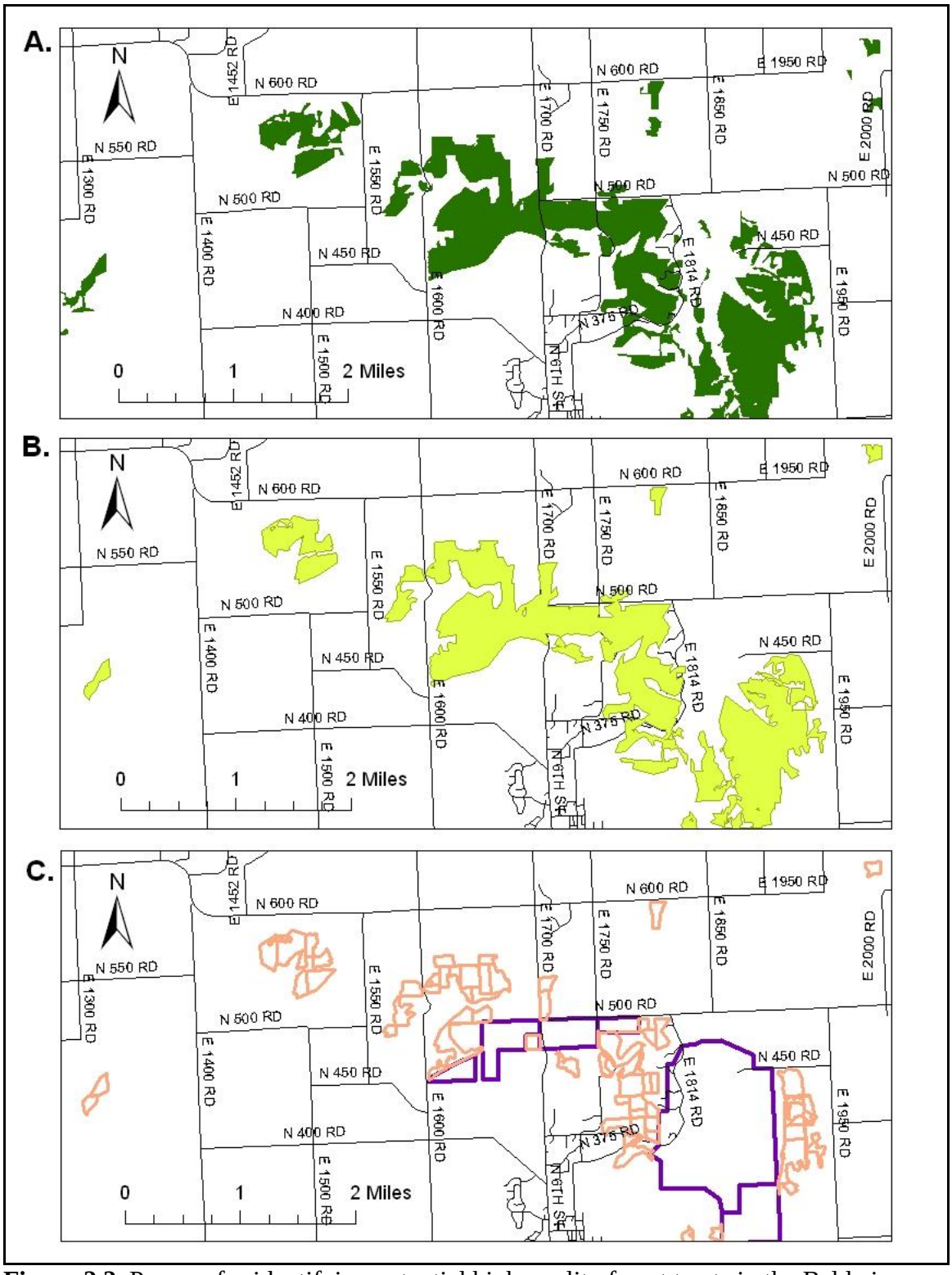

Figure 2.2. Process for identifying potential high-quality forest tracts in the Baldwin Woods area. A. Areas forested continuously from 1856 to 2014. B. Forest tracts of at least 10 acres and wider than 100 m, with at least 50% tree cover. C. Areas targeted for field survey (pink); areas outlined in purple had been surveyed previously.

We utilized ecological information about understory plants and trees to assess the quality of forests during our survey work. From past work and observations, we know that areas that have been clear-cut or significantly altered do not regain their biodiversity (including conservative wildflowers) for many decades, if at all. Therefore, identifying conservative wildflowers during our inventories allowed us to assess whether the forest was likely a historical remnant. Figure 2.3 shows a fern and three woodland wildflowers that along with other species, indicated high-quality forest tracts. Tree size also can indicate presence of an old-growth forest. For example, some old-growth trees in Douglas County have been determined to be over 300 years old. When they are cut it would take a long time for mature trees to replace them; therefore, the presence of mostly young trees indicates that the forest is newly grown, whereas mostly old trees indicate an old-growth forest. Additionally, when a forest is clear-cut and then allowed to re-develop without being re-planted, the tree species composition will differ from that which occurred originally. Rather than being dominated by oaks and hickories, younger forests are dominated by early-successional species such as hackberry, elm, and walnut or, if grazed or severely disturbed, by less desirable and thorny species including honey locust, black locust, Osage orange, and eastern red cedar.

Figure 2.3. Indicators of higher quality forest: maidenhair fern (*Adiantum pedatum*) and three woodland wildflowers—American bellflower (*Campanula americana*), bloodroot (*Sanguinaria canadensis*), and blue phlox (*Phlox divaricata*). These and other wildflowers are seen on highest quality forests.

Prairie Inventory. The prairies of Douglas County have been inventoried through several efforts undertaken since 1988. An important focus of this project was to re-evaluate the status and quality of all prairies of five acres or greater known to occur in the county. We also wanted to locate prairie sites that had been missed by previous surveys. Sites less than five acres are not considered viable because adjacent land practices such as herbicide use and drift, fertilizer use and run-off, and dense tree cover and shade, can severely impact their ability to persist for the long term. Prairie sites situated adjacent to roads were assessed via road-side surveys conducted in June and July, 2014. Prairies not visible from roads were resurveyed on foot in May and June 2015 after obtaining landowner permission.

2.2. Natural Areas Assessment

We used standard Natural Heritage procedures (Freeman and Delisle 2004) to assess the viability of each prairie and forest included in this survey. These assessments evaluate the ecological integrity of the site relative to its historical community type. It does not take into consideration its current economic utility. Sites were ranked using three key factors: landscape context, size, and condition. Considering all of these factors together determines whether or not a prairie or forest is viable, or able to persist into the future. Normally, landscape context and size are weighted more heavily than condition. The rationale is that landscape context and size cannot increase, or can do so only slightly with time, whereas condition is a more variable attribute and can be increased fairly quickly with appropriate management. Also, the assessed condition of a prairie remnant may vary with season, observer, or environmental conditions. Each prairie and forest was assigned a final letter grade (A–D, with A being the best and D being the worst) that summarized the three key factors. The grade of X was used to indicate a site that had been extirpated (e.g., developed for housing or converted to cropland or other uses).

Landscape Context. Landscape context refers to the general condition of the landscape in which a site occurs, considering such issues as disturbance regimes, fragmentation, topography, and biological diversity. Landscape context is ranked A–D. Generally speaking, A-grade landscapes have not been converted to human land uses (like cropland or housing) and are dominated by natural communities. Natural processes, species interactions, and species migrations can occur across all natural communities and experience no complete barriers. Surrounding vegetation is greater than 80% natural. B-grade landscapes have experienced some land conversion, but natural communities remain well-connected. Natural processes and species interactions and migrations can occur across many natural communities and experience few barriers. Surrounding vegetation is 50–80% natural. C-grade landscapes are fragmented by cultural land, including cropland or developed areas. Barriers severely affect many natural processes, species interactions, and migrations, and many species are unable to maintain viable populations. Surrounding vegetation is 20–50% natural. D-grade landscapes are surrounded almost entirely by cultural land. Natural processes and species migrations are severely compromised and cannot occur at natural scales. Only a subset of the historic biological diversity is viable within natural communities.

Size. Determining the size of a natural community may appear straight-forward, but several issues complicate this process: patch size and minimum distance separating two occurrences.

Patch size denotes the size and landscape position of a natural community (Lauver et al. 1999). Four patch types usually are recognized: matrix, large-patch, small-patch, and linear. Matrix communities occur on the dominant landforms in an ecoregion and form extensive and often contiguous cover, usually greater than 1,000 acres. Large-patch communities generally occur on subdominant landform features and form large but interrupted cover, usually 20–1,000 acres. Small-patch communities occur on specialized landforms and microhabitats, and generally are less than 20 acres. Linear communities are long, narrow communities usually associated with riverine features.

Size standards have been established for many natural communities to distinguish viable from nonviable occurrences and, for viable occurrences, to rank them (A–D, with A being the best and D being the worst). Each community occurrence must meet the minimum size set for its type to be considered viable. For example, for Glaciated Tallgrass Prairie, a matrix community type, occurrences less than 1,000 acres usually are not considered viable (able to support ecosystem functions necessary to maintain high levels of native biodiversity for more than 100 years).

A second factor complicating the size issue is how far apart two occurrences of the same community type can be before they are considered distinct occurrences. Several evaluation guidelines are available to assist in determining the minimum distance of separation for terrestrial natural communities. Basically, two tracts are treated as distinct if they are separated by:

1) a substantial barrier to natural processes and/or to native species, such as a busy highway, developed area, or large body of water;
2) cultural vegetation that limits connection of patches;
3) a different community type coverage greater than 0.5 mile wide if the communities frequently do not occur in a mosaic, or 1–2 miles wide if frequently in a mosaic;
4) a tract subjected to management that is significantly different from that employed on the separated tracts; or
5) a major break or change in ecological land unit.

Condition. Condition refers to the impacts that human disturbance has had on a site. Condition can be estimated by any of several available methods. Most Natural Heritage programs use subjective field assessments, which are based on estimates of native species richness, abundance of exotic species, and ecological processes. As with landscape context, condition may be ranked from A–D, with A being the best (least affected by human disturbance) and D being the worst (severely affected by human disturbance).

The determination of condition at a site was a primary purpose of our fieldwork. We therefore report condition ranks in the results of this report. The only exception to reporting condition ranks is when we report on loss of prairie in the county. In that case

we rely on the overall viability ranking, or the combination of landscape context, size, and condition, as explained above. For each newly documented forest site visited, we noted the ecological and physical characteristics, working in teams of two or more to put together an accurate plant species list for each site. For each prairie site that was previously documented, we determined whether the prairie still existed and assigned an appropriate condition rank. We generated an updated or new species list for prairies only if landowners were interested in joining us and learning to identify plant species during our prairie survey; if we were surveying a new prairie; or if a species list had not been generated for a prairie that was previously documented. We compiled plant species lists for 29 prairies. Plant species that could not be identified in the field were brought back to the Kansas Biological Survey and the R. L. McGregor Herbarium for identification.

2.3. Rare and Significant Plant Species

State Natural Heritage programs throughout the NatureServe Network determine conservation status ranks for all plant and animal species in their jurisdictions (NatureServe 2005). Each species is ranked based on the following factors: total number and condition of populations; population size; range extent and area of occupancy; short- and long-term trends in the above factors; scope, severity, and immediacy of threats to the species; number of protected and managed populations; intrinsic vulnerability, and environmental restrictions.

State conservation status ranks of species are based on a 1–5 scale, ranging from critically imperiled (S1) to demonstrably secure (S5). Locations of plants ranked S1 and S2 (imperiled) are documented in the Heritage database. In Kansas, two of these species, Western prairie fringed orchid (*Platanthera praeclara*), and Mead's milkweed (*Asclepias meadii*) are of particular interest because they are listed as threatened under the U.S. Endangered Species Act.

Western prairie fringed orchid. This orchid occurs on tallgrass prairies, in prairie swales, and in fens in the eastern Great Plains and western Midwest (U.S. Fish & Wildlife Service 1995). It is a perennial herb with open, spike-like clusters of showy white flowers that are produced from mid-June to late June. Individual plants may produce flowers once every 2–4 years, or even less often. Each flower has a distinctive three-lobed, fringed lip. In Kansas, north of the Kansas River the orchid inhabits moderate to steep slopes and swales of tallgrass prairie on glacial drift. South of the Kansas River the species occurs primarily on level to hilly, unglaciated upland prairies covered with a thin, discontinuous mantle of loess. On the slopes of prairies, Western prairie fringed orchid often grows in moist soils or where seeps occur. Historically, it also occurred in wet-mesic prairies in the floodplains of rivers. Scattered populations have been documented at 22 sites in 16 counties in eastern Kansas (Freeman and Hall 1991). Six of those populations are known to have been destroyed; 12 have not been seen in more than 40 years and may no longer be present.

The Western prairie fringed orchid is threatened by conversion of habitat. Other factors that may contribute to the species' decline are drainage of prairie wetlands and

encroachment of prairies by woody plants. Seasonal fires, in combination with high rainfall, may promote flowering in this species; lack of these conditions may have contributed to its rarity.

Mead's milkweed. This milkweed occurs on prairies in the Midwest and eastern Great Plains (U.S. Fish & Wildlife Service 2003). It is a smooth, rhizomatous, perennial herb with a distinctive single nodding head of greenish-cream-colored, fragrant flowers produced at the end of each flowering stem (Figure 2.4). Flowers are produced from mid-May to early June. Slender, hairy, erect pods mature from mid-June through late September. Slender, vegetative plants often arise from the rhizomes in the vicinity of flowering or fruiting stems.

Mead's milkweed has declined due to destruction and alteration of habitat by humans. Because of its rhizomes, plants can survive annual mowing, a common practice on native prairie in eastern Kansas. Unfortunately, haying removes fruits before they can mature and release seeds, which prevents new plants from growing in most populations. Consequently, populations on most prairies with a long history of haying show less genetic variability than do populations on sites managed by fire (Tecic et al. 1998).

Figure 2.4. Mead's milkweed growing on a Douglas County prairie.

Most of the remaining populations of Mead's milkweed occur in Kansas, where more than 200 populations have been documented in the eastern two tiers of counties in the Osage Cuestas and in the southern Glaciated Region (Kansas Natural Heritage Inventory

2015). Large populations include several thousand stems, but most populations in Kansas have fewer than 50.

The viability of a population is ranked by the number of stems present, where A = ≥ 200 stems; B = 100–199; C = 25–99; and D = < 25. Populations with many stems are assumed to have higher levels of genetic diversity and thus higher levels of reproductive success. Most populations occur on dry-mesic to mesic tallgrass prairies that are hayed annually, but a few sites are known to be grazed lightly during the winter. Plants grow most frequently on the middle and upper slopes of ridges and hills that have shallow, well-drained, limestone or (infrequently) sandstone soils.

Chapter 3: Results

3.1. Natural Areas

Prairie Communities. During the 2014 and 2015 project seasons we assessed the condition of 84 prairies in the county. Prairies fell into three natural community types: Unglaciated Tallgrass Prairie (70 sites), Glaciated Tallgrass Prairie (12 sites), and Low (Wet) Prairie (2 sites). Eighty-one of the sites had been identified in previous surveys and three were newly documented during this survey. These prairies are distributed throughout the county but are somewhat concentrated in the western and southern parts (Figure 3.1). We were not able to assess the condition of eight previously-known sites because landowner permission could not be obtained.

There has been an overall decline in the number and condition of prairies in the county since our last assessment in 2005 (Table 3.1). The number of prairies in excellent condition (A-grade) has stayed virtually constant, but many of the prairies that had been in good condition (B-grade) have declined to fair (C-grade). Three prairies have become so severely degraded (D-grade) that they no longer can be considered prairie. Two prairies have been converted to row crop agriculture. Five have been reduced in size due to partial conversion to other uses; four of those have been reduced to below the five-acre minimum necessary to be considered viable. C-condition prairies have poor viability due to the combination of small size relative to their historic size, fair condition, and the negative influences of a non-native landscape and are therefore considered ‘lost’. All losses combined amount to a reduction of 257 acres of prairie during the last 10 years. If we assume that all prairies not visited remain in a condition of A or B, there are 76 prairies remaining for a total of 1,352 acres of high-quality prairie in the county. This includes 214 acres missed in previous surveys.

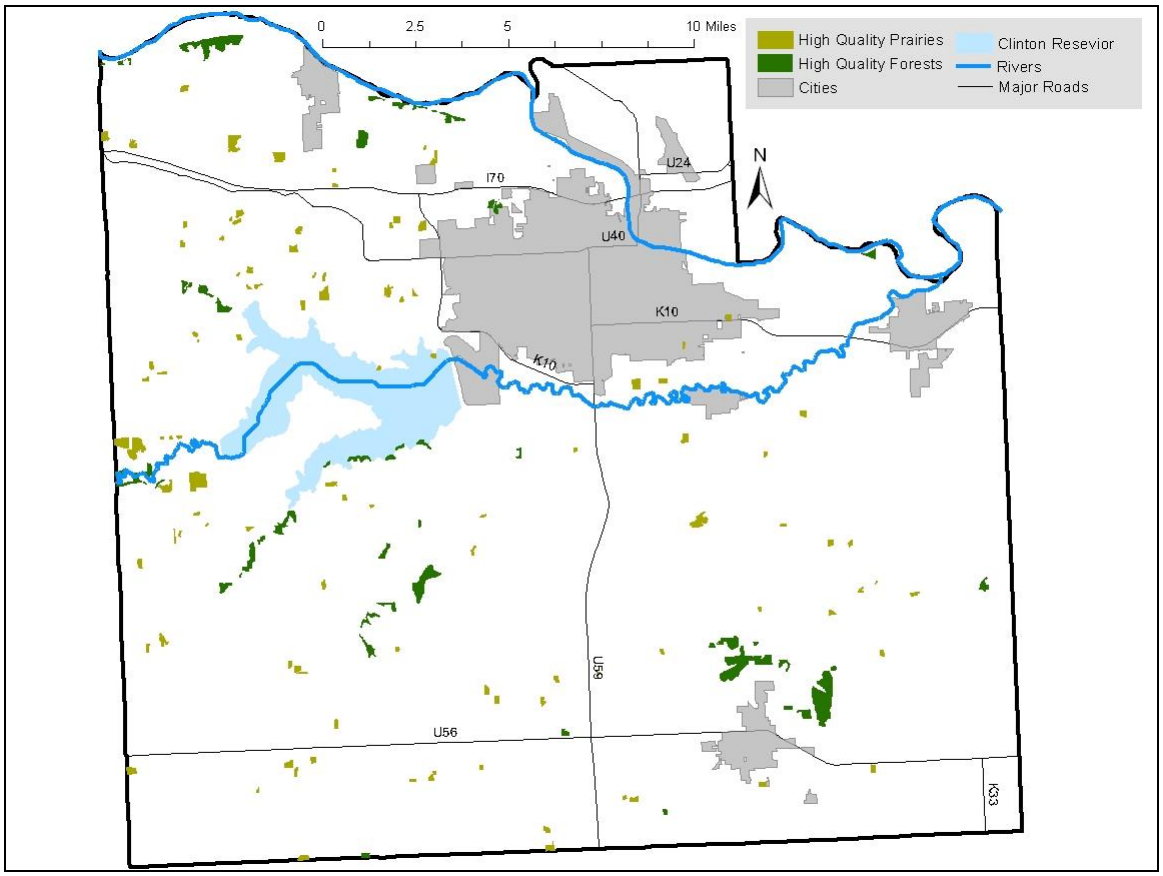

Figure 3.1. Remaining parcels of high-quality prairie and forest in Douglas County, Kansas.

Table 3.1. Comparison of condition ranks of revisited prairie sites from 2005 to 2015.

Condition Rank	2005 Survey	2014-2015 Survey
A	35	36
B	39	29
C	7	11
D[1]	NA	3
X[2]	NA	2
Total	81	81

[1] Sites ranked A, B, or C in 2005 that are no longer considered prairie.
[2] Sites ranked A, B, or C in 2005 that have been converted to row crop agriculture. There are no D or X condition sites listed in 2005 because they were not viable and therefore not revisited in our 2014–2015 survey.

Forest Communities. We visited 40 forest sites comprising 1,736 acres during the 2014 and 2015 project seasons. Thirty-six of these sites (1,223 acres) were newly surveyed and four (513 acres) were revisits to previously-known sites. No forest sites were in excellent condition. Eight of the newly surveyed sites were in good or fair condition; the remaining sites were in poor condition. The sizes of two previously-known sites were expanded to include adjacent parcels that had not been assessed earlier. A total of 331

acres of high-quality forest habitat was identified during this survey. The eight new sites were comprised of three different community types, including three Oak-Hickory Forests, three Mixed Oak Floodplain Woodlands, and two Mixed Oak Ravine Woodlands (Table 3.2). The addition of these sites brings the total number of high-quality forest sites documented in Douglas County to 27, comprising 2,530 acres (Table 3.2). These forest tracts are located mostly in the uplands along the Kansas and Wakarusa rivers, and in the Baldwin Woods area near Baldwin City (Figure 3.1).

Table 3.2. Number of high-quality forest sites surveyed, 1988–2015.

Community	1988–2005	New in 2015	Total
Ash-Elm-Hackberry Floodplain Forest	1	0	1
Cottonwood-Sycamore Floodplain Forest	3	0	3
Cross Timbers–Post Oak-Blackjack Oak Woodland	3	0	3
Maple-Basswood Forest	0	0	0
Oak-Hickory Forest	12	3	15
Mixed Oak Floodplain Woodland	0	3	3
Mixed Oak Ravine Woodland	0	2	2
All Forest Community Sites	19	8	27

3.2. Rare and Significant Plant Species

Western prairie fringed orchid. This species was not seen on any prairie visited during this survey. In the last 10 years, it has been observed on only one prairie in the county.

Mead's milkweed. Nine newly-discovered populations of Mead's milkweed were identified during this survey: one A-ranked population, one B-ranked population, and seven D-ranked populations. All of these occurred on prairies that had been surveyed previously. With its small stature, slender leaves, and green nodding flower head, Mead's milkweed can be extremely difficult to detect. During this survey a population of nearly 300 stems was discovered on a prairie that had been visited during a previous natural area survey. It is highly unlikely that new populations have established on their own because this species is very conservative and occurs in heavily fragmented habitats where dispersion of propagules is unlikely. It is likely that other undocumented populations exist on other high-quality prairies, highlighting the continued need for prairie inventory and conservation in the county.

Since 1986, 46 populations of Mead's milkweed have been found in the county; three of those have been extirpated over the last 25 years. The majority of remaining populations have low viability rankings. Only three populations were A grade, four were B grade, six were C grade, and the 30 remaining populations were D grade.

Mead's milkweed is found almost exclusively on high-quality native prairies and almost always on prairies being managed as hay meadows. The majority of prairies on which Mead's milkweed was found during this survey were in excellent (12 prairies) or good (7 prairies) condition. One prairie was in fair condition, but we did not find Mead's milkweed on any prairies in poor condition.

Conservative Species. We recorded the coefficient of conservatism (CoC value) for all plant species identified during our survey (Appendices A and B). A coefficient of conservatism is an integer from 0–10 that is assigned to each native plant species in a given geographic region, often a state or province. Coefficients of conservatism express two basic ecological tenets: plants differ in their tolerance of the type, frequency, and amplitude of human disturbance, and plants vary in their fidelity to remnant natural plant communities (Taft et al. 1997). These two principles exhibit an inverse relationship: the lower a species' tolerance of human-mediated disturbance, the higher its likelihood of occurring only in a natural plant community. Low coefficient values (0–3) denote taxa often found in highly disturbed habitats and without a strong affinity for natural communities. High coefficient values (7–10) denote species that tolerate only limited disturbance and usually are found in natural communities. With these principles as a guide, the CoC value applied to each species represents a relative rank based on observed behavior and patterns of occurrence in Kansas natural communities.

Plants with high coefficients of conservatism, referred to as *conservative species*, occur almost exclusively on our highest-quality sites. For example, the high-quality prairie indicators inland New Jersey tea (*Ceanothus americanus*) and azure aster (*Symphyotrichum oolentangiense*) are very rarely found in other habitats. Finding one of these species often means that other conservative species might be present, and they often indicate that some of our rarest prairie species such as Mead's milkweed might also be present.

Non-native Plant Species. Non-native, invasive plants rapidly establish themselves in new habitats, especially habitats that have experienced localized or generalized disturbance. The species listed in Tables 3.3 and 3.4 are those that have most often invaded our prairies and forests. Sericea lespedeza (*Lespedeza cuneata*), a state-listed noxious weed, was found at seven prairie and two forest sites. The low incidence of this highly invasive species may indicate that it is not currently a major threat to these high-quality sites. However, we would need to assess habitat surrounding high-quality sites to determine the full extent of threat from sericea lespedeza. In forests, multiflora rose (*Rosa multiflora*), amur honeysuckle (*Lonicera mackii*), and Japanese honeysuckle (*Lonicera japonica*) pose the greatest potential threats.

Table 3.3. Non-native plant species found at prairie sites more than once during this study.

Species Name	Common Name	No. of Sites Where Found
Poa pratensis	Kentucky blue grass	20
Dianthus armeria	Deptford pink	19
Potentilla recta	sulfur cinquefoil	15
Bromus japonicus	Japanese brome	13
Tragopogon dubius	western salsify	13
Trifolium pratense	red clover	13
Bromus inermis	smooth brome	11
Medicago lupulina	black medic	11
Melilotus officinalis	yellow sweet-clover	11
Schedonorus arundinaceus	tall mountain-fescue	11
*Lespedeza cuneata**	sericea bush-clover	7
Leucanthemum vulgare	common ox-eye daisy	7
Phleum pratense	common timothy	6
Hypericum perforatum	common St. John's-wort	4
Rumex crispus	curly dock	4
*Carduus nutans**	musk-thistle	3
Dactylis glomerata	common orchard grass	3
Prunella vulgaris	common selfheal	3
Rosa multiflora	multiflora rose	3
Verbascum thapsus	flannel mullein	3
Melilotus albus	white sweet-clover	2
Trifolium campestre	low hop clover	2

*designated as a state noxious weed as determined by the Kansas State Board of Agriculture.

Table 3.4. Non-native plant species found at forest sites more than once during this study.

Species Name	Common Name	No. of Sites Where Found
Alliaria petiolata	common garlic-mustard	34
*Rosa multiflora**	multiflora rose	27
Maclura pomifera	Osage-orange	16
Lonicera maackii	amur honeysuckle	11
Lamium purpureum	dead nettle	10
Euonymus fortunei	Chinese spindle-tree	8
Lonicera japonica	Japanese honeysuckle	8
Stellaria pallida	pale chickweed	8
Allium vineale	field garlic	7
Dactylis glomerata	common orchard grass	4
Hemerocallis fulva	orange day-lily	3
Humulus japonicus	Japanese hop	3
Melilotus officinalis	yellow sweet-clover	3
Phalaris canariensis	common canary grass	3
Rumex crispus	curly dock	3
Bromus inermis	smooth brome	2
Bromus japonicus	Japanese brome	2
Conium maculatum	poison-hemlock	2
Dipsacus fullonum	fuller's teasel	2
Hesperis matronalis	dame's rocket	2
Lespedeza cuneata	sericea bush-clover	2
Ligustrum obtusifolium	obtuse-leaf privet	2
Melilotus sp.	sweet clover	2
Persicaria maculosa	lady's-thumb smartweed	2
Trifolium pratense	red clover	2
Trifolium repens	white clover	2

*designated as a state noxious weed as determined by the Kansas State Board of Agriculture.

Chapter 4: Discussion

4.1. Status of Natural Areas in Douglas County

We documented the presence of many high-quality prairies and forests during our survey work. Some of these natural areas contain highly conservative plant species including the

federally threatened Mead's milkweed. We also documented significant changes to prairie and forest habitats. These changes include the loss of old-growth forest, the succession of forest into areas previously occupied by prairie, and the loss of prairie acreage since 2005.

Loss and re-growth of forest since 1856. We found that the acreage, location, and condition of forests have changed substantially in Douglas County since 1856. There were an estimated 40,634 acres of forested area in 1856, comprising approximately 13.4% of the county. By 1937, approximately 5,256 acres of the pre-settlement forest had been cleared, and much of the remaining forested acres were likely degraded by hogs and cattle, as evidenced by remnant hog wire and barbed wire fencing still attached to trees. By 2014 the number of forested acres increased to 45,403 acres, or 15% of the county. [Note that Nowak et al. (2014) estimated the total at 24% of the county based on analyzing 500 random points from Google Earth imagery, whereas our estimate is based on digitizing current forest cover in a GIS program.] However, the forests are not in the same areas or of the same quality as the forests from 1856 (Figure 4.1).

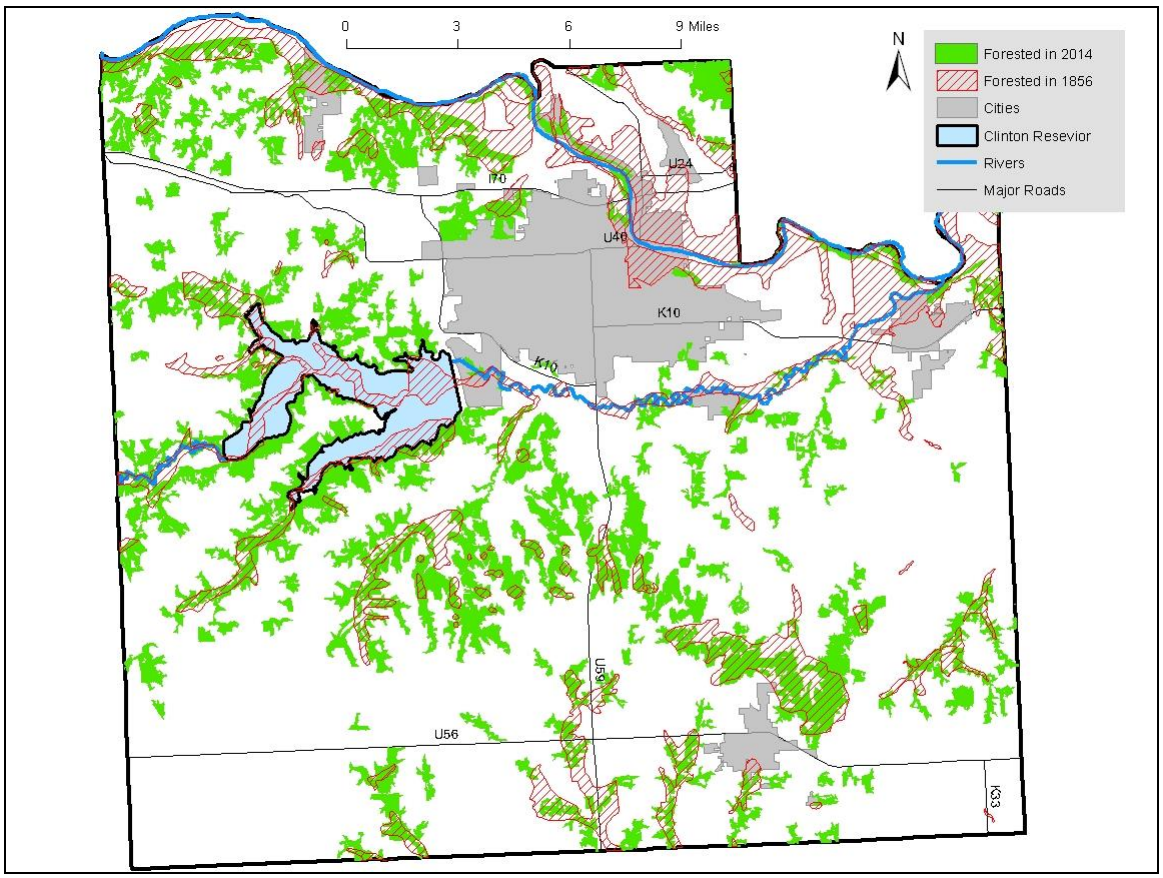

Figure 4.1. Distribution of current forest in relation to forest cover in 1856.

Of the 40,634 acres that were forested in 1856, only 8,842 acres have remained in forest since that time. This indicates that 88% of the historical forest had been cleared at some time. Much of the area that had been cleared is now under cultivation or has been developed, but some has re-grown to forest cover. These new-growth forests do not have

the same characteristics of the original forests, and are characterized by different tree species and understory vegetation. The dominant oaks and hickories have been replaced by shorter-lived trees of lower quality, such as elm, hackberry, honey locust, and eastern red cedar (Nowak et al. 2014, this study). In comparison to the more slowly growing oaks and hickories, these tree species are adapted to grow where there is more land disturbance and more sunlight. They produce many seeds and grow quickly, and they generally are small in size, not large old-growth trees. The spring ephemeral wildflowers of the understory have been overgrown or replaced in many cases by buckbrush, honeysuckles, euonymus, and other invasive or weedy species. The diversity of forest floor wildflowers has significantly decreased, and it is now difficult to find areas of forest where showy wildflowers carpet the ground. Typically, these areas also do not serve as habitat for many of our rare animal species such as the Southern Flying Squirrel (*Glaucomys volans*), a Species of Greatest Conservation Need in Kansas.

Approximately 82% of the forested areas we see today are "new growth" forests that have developed in areas once occupied by prairie (Figure 4.1). New forests have become established because landscape-scale fires have been eliminated since settlement. Also, brush and trees have spread where landscape and farm management changes, suburban growth, availability of seeds, and other factors have inadvertently encouraged their growth. Our historical landscape included populations of native grassland birds (such as prairie chickens), abundant wildflowers and many species that are uncommon today. For example, grassland birds are now threatened throughout their range, including Douglas County, indicating that habitat changes have had significant impacts on our natural heritage. Once gone, restoration of these habitats and species is difficult, and may be impossible in many cases.

Loss of Native Tallgrass Prairie. The Kansas Natural Heritage Inventory has been conducting extensive survey work in Douglas County to document all high-quality, tallgrass prairie since 1988. The program found 110 sites in 1988, with a combined area of 1,963 acres. By 2005, 21 (19%) of these prairies had been lost to development, conversion to commodity crop production, or other uses, resulting in a reduction in area to 1,395 acres, a loss of 29% in a period of 17 years. This acreage

Loss of prairie chickens – silent spring

The Greater Prairie-Chicken (*Tympanuchus cupido*) is native to the prairies of much of Kansas, but it has been absent from Douglas County for about 8–10 years. Since then we've had a silent spring, with the booming of their spring mating ritual no longer heard. Prairie chickens were last seen near Globe in the southwest part of the county. Populations of prairie chickens east of the Flint Hills have been winking out for decades. The population in Douglas County had become isolated from other populations, making it vulnerable to genetic inbreeding effects and population fluctuation. Experts suspect the underlying reason for the decline east of the Flint Hills is habitat change: loss of prairie, tree invasion, rural development, and other factors. Perhaps it was surprising that prairie chickens held on as long as they did in Douglas County as there has been very little suitable habitat for at least several decades. Will they return? Could they be brought back? For long term survival, prairie chickens require a large area of prairie habitat.

represents approximately 0.5% of the original 285,158 acres of prairie that existed in the county prior to Euro-American settlement. Through the current survey we have documented the loss of 257 additional acres of prairie since 2005. The actual total loss may be higher if any of the eight unsurveyed prairies are now degraded or developed. This is an 18% reduction in prairie acres in 10 years. While the rate of loss depends on many factors such as commodity crop prices and development pressure, it is clear that the loss of native prairie is continuing. If the current trajectory continues, today's grade-school children will see all high-quality native prairie in the county disappear during their lifetimes.

Natural areas on lands in public and nonprofit ownership. Several tracts of native prairie and forest in the county are owned by public or nonprofit entities, including the U.S. Army Corps of Engineers, Kansas Department of Wildlife, Parks and Tourism, the University of Kansas Endowment Association, Baker University, county and city governmental entities, and nonprofit organizations (Figure 4.2). Others are in private ownership (not shown in Figure 4.2).

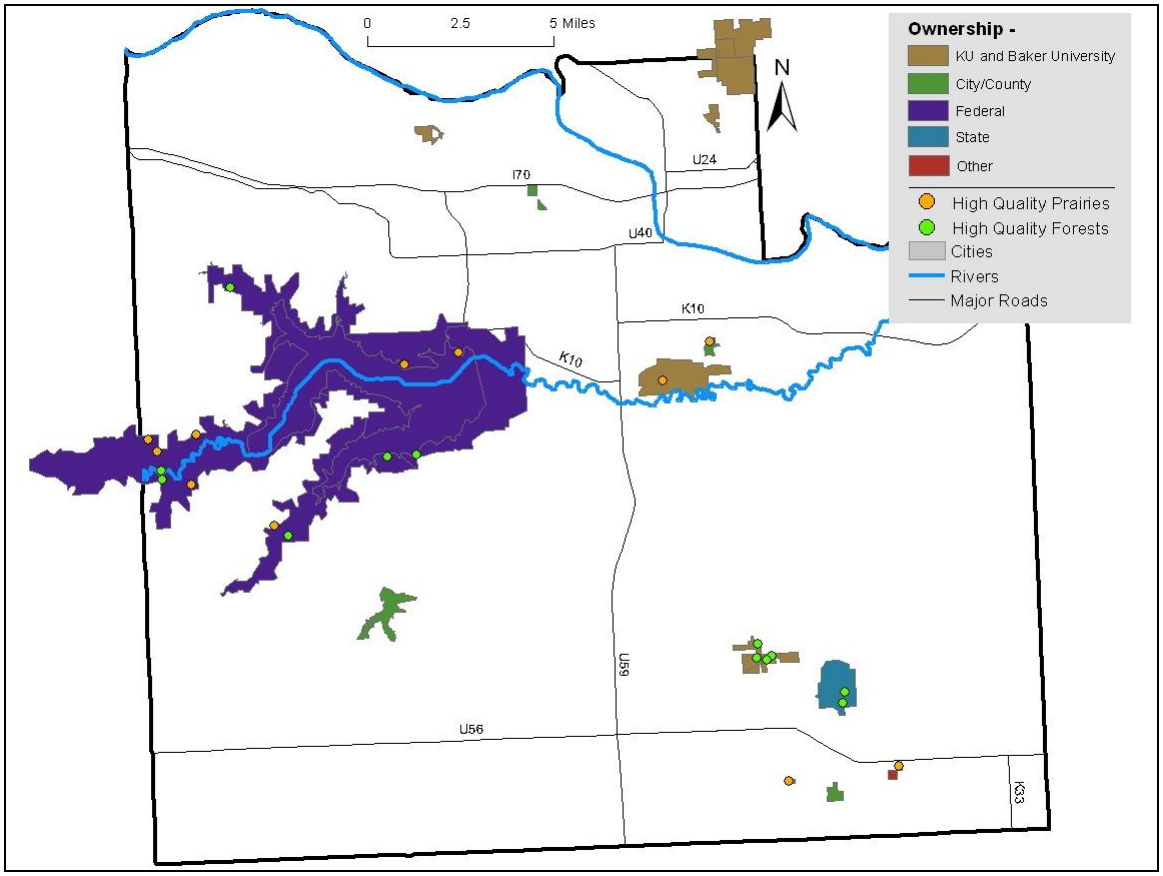

Figure 4.2. High-quality prairies and forests on lands in public and nonprofit ownership in Douglas County. Private conservation easements not shown.

These prairies and forests do not all receive the same level of protection. Few are managed explicitly for conservation and the maintenance of biodiversity, and many are

vulnerable to management actions that could threaten their viability. They can be grouped as follows:

1) Federal: The U.S. Army Corps of Engineers owns Clinton Reservoir and the surrounding property, most of which is managed by the Kansas Department of Wildlife, Parks and Tourism. These lands contain several small tracts of high-quality prairie and significant forest tracts that surround the lake, especially along the south side. Management is primarily for recreation including hiking and hunting with no explicit protection for high-quality natural areas.
2) State: The Kansas Department of Wildlife, Parks and Tourism owns and manages Douglas County State Lake, which contains significant tracts of Oak-Hickory Forest and Cross Timbers Woodland. Management is primarily for recreation including hiking and hunting with no explicit protection for high-quality natural areas.
3) Universities and their affiliates: The KU Endowment Association owns several tracts of high-quality forest in the Baldwin Woods area that are managed by the University of Kansas Field Station. These areas are maintained primarily for research and biodiversity protection. Baker University owns the wetland areas adjacent to the South Lawrence Trafficway immediately south of Lawrence. This area contains two small parcels of moderate-quality Low Prairie, a natural community type uncommon in the county. Most of the area is not native prairie but is undergoing restoration to its former natural state. The area is open to the public.
4) County/City: Douglas County and the City of Lawrence own and manage several natural areas. Prairie Park Nature Center and the Ivan Boyd Prairie Preserve contain small tracts of high-quality prairie that are managed for public education and biodiversity protection. The City of Baldwin owns Pioneer Cemetery, which contains a tract of high-quality prairie that is being managed by Baker University.
5) Private: Three high-quality prairies that occur on private land are protected with conservation easements held by the Kansas Land Trust. These easements ensure that the prairies are not built upon, farmed, or significantly degraded over time. Three forested tracts also are protected under conservation easements held by the Kansas Land Trust and the Kansas Department of Wildlife, Parks and Tourism.

The county and the cities of Lawrence, Eudora, Lecompton, and Baldwin maintain many additional recreational parks (not shown on map), but these are not known to contain tracts of high-quality natural areas.

4.2. Risks to Natural Areas

Our data show that native, high-quality plant communities (native tallgrass prairie and oak-hickory forest) continue to decline in both acreage and quality. Agricultural operations at the time of settlement resulted in the plowing of prairies and clearing of forests. The loss of these areas now is related to development, but the process leading to their destruction is less direct. For the most part, houses and strip malls are not replacing native tracts of prairie or forests. Rather, it is the speculation for development that

changes long-term ownership and management, leading to the eventual destruction of native prairies. Lands in Douglas County are in transition as land owners are growing older, and an increasing number no longer live on the land (in contrast to the time when farmers owned and farmed most of the land in the county). When land changes hands, landowners may not know how to manage what they have purchased, or they may have a variety of reasons to change land management practices. Prairies on the west edge of Lawrence are particularly vulnerable due to the westward growth of the city of Lawrence. By 2005, development along the western leg of the South Lawrence Trafficway led to destruction of two known prairies (Kindscher et al. 2005) (see text box). Additional high-quality remnants in this area are threatened due to increased development along the Trafficway. At least four prairies, all of which contain populations of Mead's milkweed, lie within the potential path of new highway alignments. In addition, when roads or access to lands increase (such as the increased access to lands along the South Lawrence Trafficway and its new interchanges), the opportunities for development increase. In some cases, land is purchased because the new owners are hopeful that these lands will greatly increase in value for development. When lands become too valuable, they are less likely to remain as native prairies or forest. The problem for conserving our natural heritage in Douglas County is that no consideration is given to natural areas. Similar to the Elkins Prairie, when the South Lawrence Trafficway was planned and a $100 million or more investment in road infrastructure was approved, there was no consideration for the prairie or other natural areas. It would seem that some funding for natural area and open space protection should accompany or be implemented to balance the subsidy for growth.

This pattern continues as additional funding is provided for road improvements on the western leg of the South Lawrence Trafficway and its intersections. The native prairie remnants in the vicinity and slightly further to the west are now under increasing threat for management changes and eventual loss. These areas need to be given special attention. Through an open space program, some of these areas could be preserved to provide high quality open space in future development plans.

Loss of our natural heritage – one prairie at a time

The Elkins Prairie was a high-quality native prairie located along US Highway 40 on the west edge of Lawrence. The prairie contained a great diversity of conservative plant species and was a favorite place for KU and K–12 classes to learn about the native flora of Eastern Kansas. The prairie was especially unique because it was one of the few remaining prairies anywhere in the world known to contain both Western prairie fringed orchid and Mead's milkweed, two plant species so rare as to receive federal protection.

Land values escalated when the western leg of the South Lawrence Trafficway was proposed to be located adjacent to the prairie at this intersection. The Elkins family agreed to sell the land for three times its current agricultural value. Shortly after it was purchased the prairie was plowed by the new landowners for what they called "higher use" - development plans that were implemented years later.

Private property owners have the right to do what they want with the land. Even federally-protected plants are not protected on private property.

Chapter 5. Description of Four Target Areas: Lakeview, Baldwin Woods, Kansas River, Wakarusa River

In addition to prairies and forests, large blocks of habitat and corridors (wide strips of habitat connecting two separate natural areas) are very important to conserving the natural history and biodiversity of Douglas County. Four areas of significance were identified for further consideration in this study: Lakeview, Baldwin Woods, and the riparian corridors of the Kansas and the Wakarusa Rivers (Figure 5.1). All of these areas contain natural areas and open space, and offer considerable recreation and conservation opportunities. They will be discussed separately below.

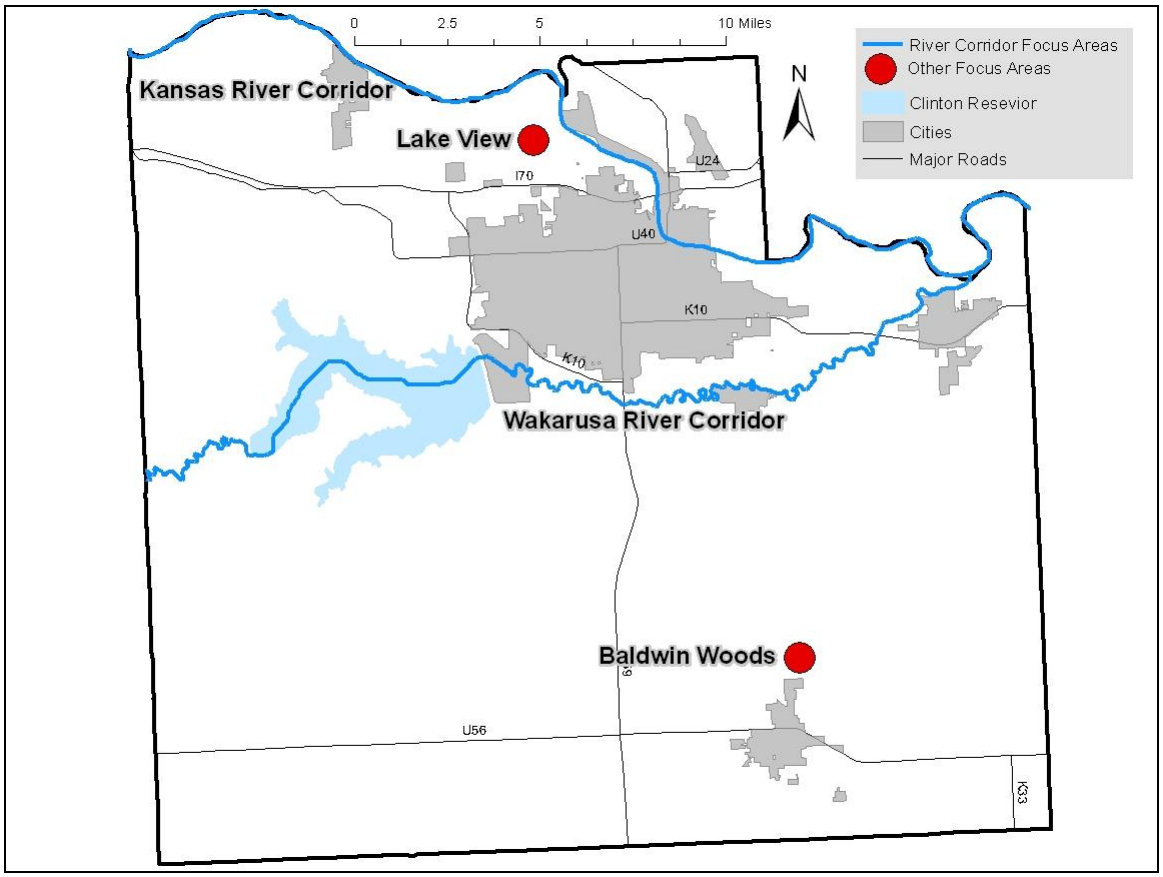

Figure 5.1. Four target areas receiving additional consideration in this study.

Lakeview. The Lakeview area is located in the northern part of Douglas County and is named for the oxbow lake that was formed by a previous channel of the Kansas River (Figure 5.2). It includes the area immediately adjacent to the floodplain and the river bluffs and hills immediately to the south, which contain extensive areas of oak-hickory forest. The area is of note for its long-term history of the Lakeview Clubhouse which opened as a lakeside resort in the 1890s. Lakeview continues today as a small community of houses surrounded by private property that includes many acres of high-quality native forest.

Lakeview is defined in this report as the area that was forested in 1856 relative to the oxbow lake mentioned above (Figure 5.2). This area contained 3,517 acres of forested area in 1856. Between 1856 and 2014, 2,872 acres were lost; in 2014 only 645 acres or 18%, of this historically forested area remained. Consequently, Lakeview followed the trend found in the rest of the county, with only a small amount of continuously forested area remaining in 2014. The total amount of forested area in Lakeview in 2014 was 1,005 acres, or 29% of the Lakeview area. Thirty-four percent, or 360 acres, of this total forested area is re-growth and cannot be considered old-growth.

During our work on this project we had three meetings with the Lakeview community, inviting members and neighbors to discuss our project and the special significance of their land and natural features. During these meetings we also discussed conservation easements that are being considered by at least three of the area landowners.

Two significant entities influencing conservation in the area include the Lakeview Clubhouse and Association, and the Land Institute, which is managing 65 acres of land that were donated to them for conservation purposes and their use in agricultural research. In addition, the mix of property owners in the area includes several who support conservation of the woodlands in the area. Working with all of these partners on conservation could result in additional protection and management that will benefit the forest habitat and other lands in the area.

Baldwin Woods. Baldwin Woods refers to an area north of Baldwin City that was forested in 1856. Following Euro-American settlement, parts of the area were comprised of woodlots for local residents (Figures 5.1, 5.3). The region stretches east to the forested areas around Douglas County State Lake, and west to the lands owned and managed by the University of Kansas Field Station as evident in the 1856 forest cover. It remains the largest area of upland forest in Douglas County and contains some of the best remaining areas of oak-hickory forest, with an unusually rich diversity of plants and animals, many of which are on the western edge of their ranges (Wells and Morley 1964). Baldwin Woods contains some of the western-most stands of white oak forest in the state, and rangewide.

In 1980, the Baldwin Woods area was designated as a National Natural Landmark because it is recognized as a ". . . significant example of the natural heritage of the Nation (National Park Service 2012)." Furthermore, the Baldwin Woods area is the only significant landscape feature in the greater Kansas City area (Kansas City and the surrounding two counties) identified by the Nature Conservancy's Ecoregional Planning process (The Nature Conservancy 2000), significant for its outstanding forest remnants and rare plants and animals.

Baldwin Woods is an important focus area because a large proportion, an estimated 47% of its 3,856 acres, has been forested continuously since 1856. Because we defined the Baldwin Woods focus area by the entire forested extent in 1856, all of the Baldwin Woods focus area was historically forested. Between 1856 and 2014, roughly 2,058 acres of forested area was lost, accounting for a 53% reduction in the extent of original

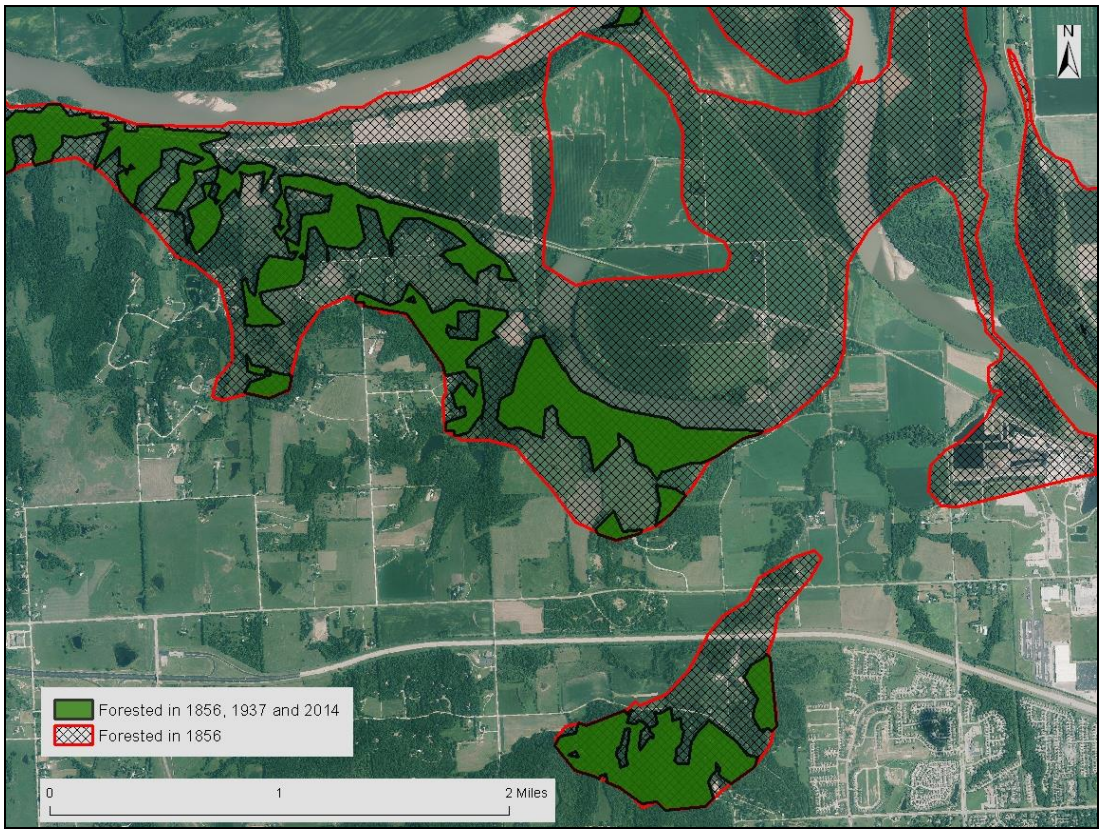

Figure 5.2. Lakeview focus area showing areas forested in 1856 and areas that have been forested continuously from 1856 to 2014.

forest. In spite of this, a remarkable amount of continuously forested area still remains in comparison to the county as a whole. In 2014, Baldwin Woods contained an estimated 2,241 acres of forest, with approximately 443 of these acres having re-grown since 1937. Therefore, we estimate that 19% of this total forested area is regrowth. This brings the total percent of forested area in Baldwin woods to roughly 58% of its total area.

Fragmentation of the area by continued development in the larger Baldwin City area is a major concern, so efforts for more conservation and protection of land would be extremely beneficial. Funds to purchase lands on the west side of the area recently have been provided by the Kansas Forest Service, Douglas County Heritage Conservation Council program and the Conservation Fund; this property will be managed by the University of Kanas Field Station. Recreation opportunities already exist with trails at both Douglas County State Lake and at the University of Kansas tracts, but there is no comprehensive plan to connect trails or any of these areas with a hike/bike trail to Baldwin City or other protected areas such as Black Jack Park or Black Jack Battlefield Trust site. Through coordinated management and planning of these forests, there is great potential for making this both a more secure conservation area of forested habitat, and a more utilized recreational destination.

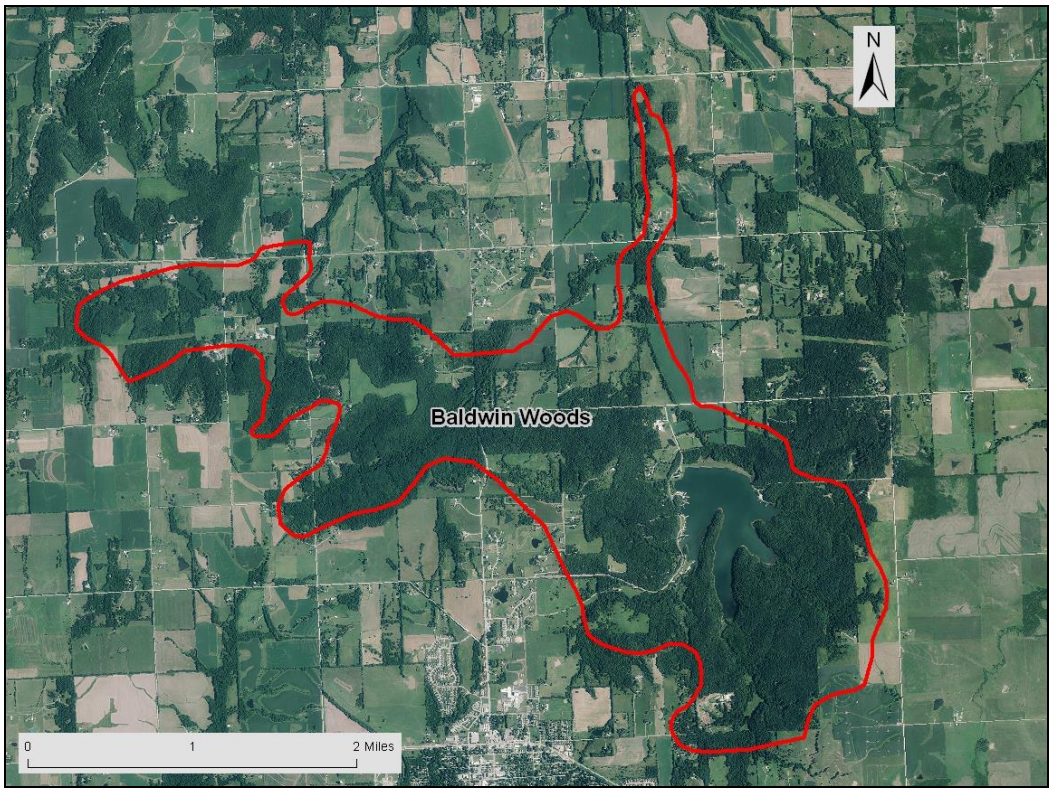

Figure 5.3. Baldwin Woods focus area. The entire area outlined in red was forested in 1856.

Kansas River riparian corridor. The Kansas River forms much of the north border of Douglas County (Figure 5.4). The river, which has its origins in the High Plains in eastern Colorado, is very sandy with numerous sandbars and high-quality sandy soils adjacent to it. Riparian forests also are found adjacent to the river channel where they experience periodic flooding. In some areas in the western half of the county, north-facing oak-hickory forests are found along the river bluffs just south of the river. These riparian forests provide important wildlife habitat but they are generally small and not high-quality. Consequently, they were not mapped as high-quality forests by our field crews. They could be important for open space habitats and for protection of water quality for downstream city water supplies. The corridors could also provide recreational opportunities for hike/bike trails, especially extending from existing trails from the City of Lawrence and also around the towns of Lecompton and Eudora. Canoe and other river access points have been established at Lecompton, Lawrence, and Eudora to encourage use of the river. One potential partner for use of the river and its riparian corridors is Friends of the Kaw, a nonprofit organization focused on the conservation of the biological diversity of the river and its use for recreation.

Wakarusa River riparian corridor. The Wakarusa River runs east through the center of nearly the entire length of the county (Figure 5.4). With its source at the edge of the Flint Hills near Eskridge, Kansas, the Wakarusa River was formed by glacial activity. Much of the floodplain was wet prairie or wetlands, but the heavy clay soils were productive and could be farmed if they were drained. Most of the floodplain is now cropland or part

of Clinton Reservoir. The Wakarusa River riparian corridor contains the Baker Wetlands, which has two small native wet prairie remnants. It is primarily managed as a wetland restoration project and has recently been increased in size due to funding by the Kansas Department of Transportation to Baker University as a wetland mitigation project for the South Lawrence Trafficway.

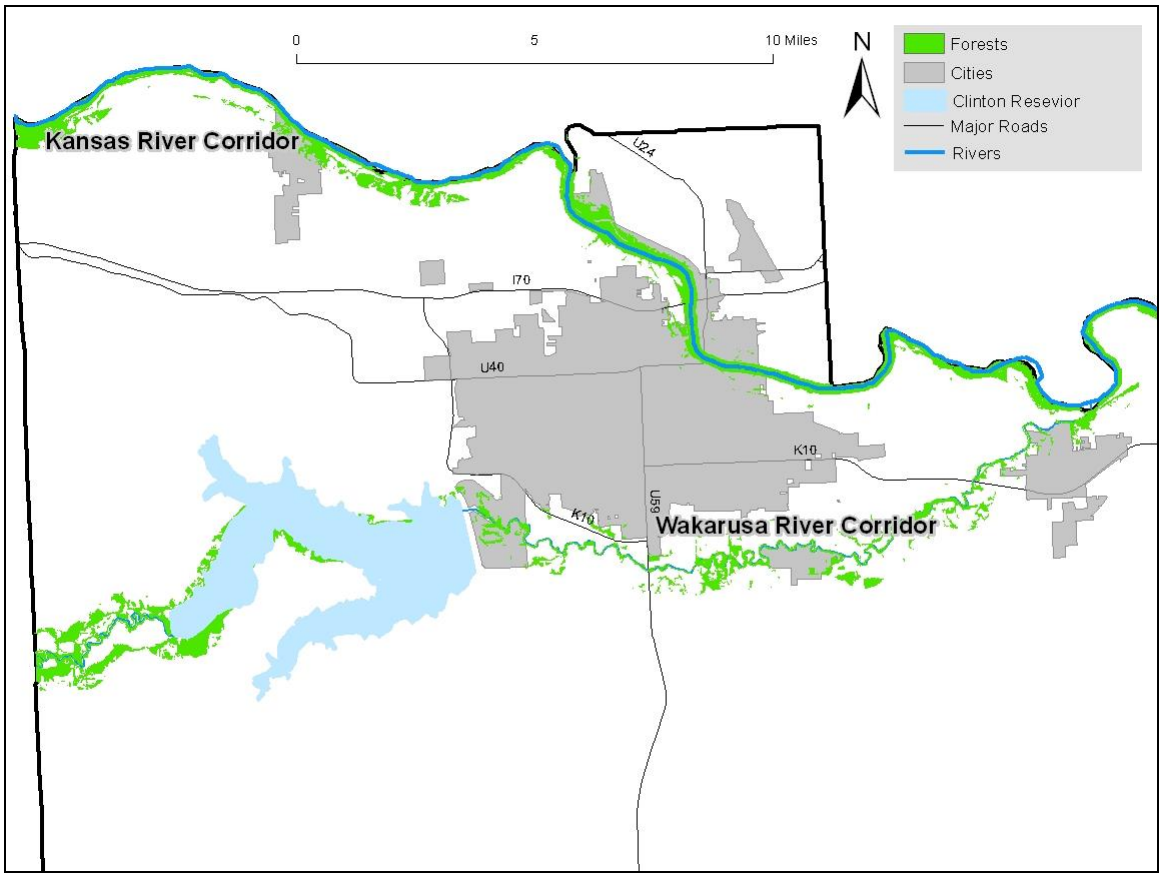

Figure 5.4. The Kansas River and Wakarusa River focus areas showing currently forested areas within 0.5 miles of the river corridors.

The Wakarusa River, known as Wakarusa Creek until the 1940s, is much smaller than the Kansas River but carries enough water to maintain Clinton Reservoir. Associated with the river corridor are both riparian forests and nearby areas of oak-hickory forests, notable features along the south edge of Clinton Reservoir. There is considerable access along public trails on the lands associated with the reservoir and the Baker Wetlands. It is possible that other trails and protected green spaces could be created in the riparian areas in other parts of the county, connecting these features and possibly tying into the Kansas River where the riparian areas meet near Eudora.

Chapter 6: Natural Areas and Open Space

6.1. Benefits of High-quality Natural Areas and Open Space

The residents of Douglas County should take great pride in the remnants of viable, high-quality prairie and tracts of high-quality forest remaining in the county. These native prairies and forests are an integral part of our cultural heritage. They are our last examples of the pre-settlement vegetation and represent the landscape occupied by Native Peoples for millennia (the Kansa and more recently the Delaware and others). These areas provide the context for understanding what greeted Euro-American (immigrant) settlers as they arrived in Kansas.

High-quality native prairies and forests provide many benefits to the public including flood control, water-quality improvement, recreational opportunities, and aesthetic enjoyment of the outdoors. Our remaining natural areas also provide habitat for some of the state's sensitive and declining species including pollinators (bees as well as monarchs and other butterflies), which are experiencing severe declines due to loss of habitat.

Natural areas and open space are important locally for educational and research opportunities. Schools, from grade schools to graduate school classes at the University of Kansas, take field trips to these areas as they provide many educational and research opportunities. Researchers at the University of Kansas have recently provided compelling evidence that spending time in nature increases human creativity (Atchley et al. 2012), indicating that inherent value lies in maintaining open spaces for our children and adult residents.

Creating open space for businesses, employees, and homeowners makes sense from an economic perspective. Businesses and employees are attracted to communities with more amenities such as open space and natural areas. For cities such as Lawrence, open spaces integrated into more densely populated areas provide the most efficient human access to "green space" because of their proximity to the greatest number of residents (Stahle 2010). A study of Ramsey County, Minnesota (St. Paul area) showed that residential property values increased when near parks, trails, streams, and lakes, accounting for an average of 10–20% of a property's market value (Sander and Polasky 2009). Likewise, a study of newer middle-income suburban subdivisions in Cedar Rapids, Iowa showed that homes in "clustered" developments with well-integrated permanently preserved open spaces benefited from higher home values than in standard subdivisions. In these "conservation subdivisions," a significant portion of a home's value was attributed to the open space, with streams in particular contributing 9.6% of the value, and making individual lot size less significant to home price (Bowman et al. 2009).

The Kansas landscape may not suggest the immediately obvious recreational opportunities offered by the mountains of Colorado or the seashore of California. However, the particular beauty of our prairies and forests can be promoted as amenities for their own unique character. Thus, these natural areas and open spaces can increase the economic vitality of the cities and greater landscapes of Douglas County.

6.2. Natural Areas and Conservation Planning Recommendations

6.2.a. Conservation of Privately Held High-quality Natural Areas

Our inventory of Douglas County lands revealed that high-quality prairies and forests still exist but they continue to decrease in number, size, and quality over time. Most of the remaining areas of high-quality native prairie and forest are owned by private landowners, and it is thanks to them and their management practices that these native communities still exist. Various means exist to encourage good management for biological diversity, including funding through U.S. Department of Agriculture programs, state programs, and local monies, for both direct management and conservation of these high-quality native tracts. There are other ways that these areas can continue to be part of our natural heritage. These are discussed below, but it should be recognized that collaboration by partners needs to be a central theme of future efforts, especially in the four focus areas—Baldwin Woods, Lakeview, and the Kansas and Wakarusa river corridors, as discussed above.

Conservation Easements. A conservation easement is a voluntary legal agreement between a landowner and a conservation organization that allows the landowner to limit the type or amount of development on their property while retaining private ownership and many uses of the land. Any land whose conservation is in the public interest - prairies, woodland, wetlands, farmland, ranchland, scenic areas, riparian areas, historic lands, and undisturbed natural areas - can be protected by an easement. An easement provides a landowner with assurance that their land will be protected from certain uses that could change the character of the land they love. This agreement can be made to legally accompany the land into the future. The agreement also can allow for public access, but it does not need to. In addition, an easement can be a valuable tool for estate planning because it is likely to reduce the taxes paid by the beneficiary of the land; therefore some conservation easements are donated. Currently there are more than 12 conservation easements in the county; easement holders include the Kansas Land Trust and the Kansas Department of Wildlife, Parks and Tourism. Additional information provided to landowners regarding the benefits of easements could encourage their use. Funds for programs to pay landowners for conservation easements on additional high-quality parcels of forest and prairie would significantly help conserve these tracts. Some federal funds are available for conservation easements, and some states also provide funding. An Open Space program for Douglas County could significantly aid in promoting and securing easements. Douglas County has already provided funding to help secure two conservation easements in the county. One easement protects a tract of land as part of Baldwin Woods, and another preserves cropland in the Kansas River floodplain that also protects the City of Eudora water supply.

Buffer Areas Adjacent to High-Quality Areas. The remaining high-quality natural areas in Douglas County exist as remnants of a landscape once dominated by native prairie. These habitat remnants are highly vulnerable to disturbances from the surrounding landscape such as invasion by exotic species and herbicide drift, and often are not large enough to support animal species known to be area-sensitive. Small remnants can only

support small populations of such area-sensitive plants and animals, making them vulnerable to local extinction.

These factors can be mitigated somewhat by creating buffers around high-quality natural areas. Lower-quality prairies and forests adjacent to high-quality areas can increase the overall size of a remnant protecting it from adjacent disturbances and making it more suitable for area-sensitive species. Buffers to natural areas, such as an area of restored prairie surrounding a high-quality native prairie remnant, are very important to both animal and plant species. Buffers benefit many animal species because they are more secure when their habitats are larger, allowing them to move around in a larger space to find food, shelter, and mates. Buffers also may eliminate edges that harbor invasive species that may threaten existing plant species in high-quality habitat. For example, a native prairie remnant surrounded by a fence line containing trees and shrubs may become degraded over time as trees spread and shade out the prairie. These trees and shrubs often produce tremendous amounts of seed. The seeds inevitably fall in the prairie, in turn leading to more woody shrubs and trees on the prairie. These woody species are difficult to manage once established and may eventually lead to the loss of the prairie and/or its wildflowers. Therefore, eliminating the tree row and replanting more prairie it its place could be of great benefit to plant species on the prairie. In addition, the viability of small populations of the rare Mead's milkweed could be improved by reintroducing additional Mead's plants on replanted prairie buffers. It is not uncommon for a Mead's milkweed stand to have only 5–10 flowering stems in a given year; these small populations are functionally endangered.

Corridors of Habitat. Restoring corridors, or strips of habitat connecting natural areas, is another way to improve the ecological functioning of high-quality habitat. Corridors allow animals to travel more safely between habitat patches to find food, shelter, and mates. Plants also may disperse among habitats when connected by corridors. Restoration of native plant populations through contiguous corridors could dramatically improve waterway health and overall ecological functions of agricultural and suburban areas (Rayburn and Schulte 2009). In Iowa, an Integrated Roadside Vegetation Management Program planted more than 50,000 acres of federal, state, county, and city roadsides to native grasses, wildflowers, and other select types of vegetation (http://www.iowadot.gov/lrtf/irvm.html). This type of program can be used here in Kansas and Douglas County to further connect our natural areas with corridors for pollinators and wildlife, particularly those that are adjacent to roadways, and to provide recreation corridors.

Conservation Programs and Incentives. Programs can be developed by state and local governments to provide funding to landowners to restore areas adjacent to higher-quality natural communities. Protecting habitat such as low diversity prairies could provide significant benefits as both buffers to high-quality prairies or as corridors among high-quality prairies. Where clusters of prairies and forests occur, lands that connect them could be appropriate places to encourage and fund restoration in voluntary programs. Programs for technical assistance and funding exist for re-establishing prairie vegetation and for planting more wildflowers and pollinator plants through seeding, both through the Kansas Department of Wildlife, Parks and Tourism and the USDA Natural Resources

Conservation Service. In addition, the Kansas Forest Service has a program for timber stand improvement for forested lands.

Unfortunately, sites that could provide buffers or corridors, or large tracts of lands that could connect clusters of prairies or forests, have never been documented systematically in Douglas County. Surveying these sites could expand opportunities for protecting larger, contiguous tracts of land that would represent the historical and natural heritage of Douglas County.

6.2.b. Conservation Planning for Public Land

An Open Space program resulting in public access to land would be of significant benefit to Douglas County. It could play a significant role in protecting or conserving many of the high quality natural areas and promote further conservation in the four target areas. There has been discussion of this in the past, and the work of ECO2, a Douglas County based land-use task force coordinated by the Lawrence Chamber of Commerce and others, was a positive development. However, with the economic downturn in 2008, work on the open space portion of this program was mostly set aside. One positive development was the establishment of the Heritage Conservation Council of Douglas County, which "promotes the conservation of our cultural and natural heritage to honor our past, enrich our present, and inspire our future" (http://www.douglascountyks.org/hcc/who-we-are). The Heritage Conservation Council makes recommendations to the Douglas County Commission on how best to establish a framework to conserve our natural & cultural heritage for future generations and to enhance economic benefits of tourism, local agriculture, and other endeavors based on such conservation efforts.

In addition, there is currently discussion about and revisions being made to Horizon 2020, the comprehensive plan for the City of Lawrence and Douglas County, see: https://www.lawrenceks.org/assets/pds/planning/documents/Horizon2020.pdf. This document discusses the importance and need for natural areas, open space, corridors, and greenways. It also discusses the importance of the Lawrence Parks and Recreation Comprehensive Master Plan, which encourages many of these same things.

Even more opportunity for planning can occur with the riparian corridors of the Kansas and Wakarusa rivers mentioned above. Hike-bike trail projects are one specific recreational corridor project that could both encourage conservation and provide public access. Currently, a county-wide bike trail plan encourages recreation (see https://www.lawrenceks.org/mpo/bicycle_planning) but not the goal of simultaneously protecting corridors as habitat. As mentioned above, there is great opportunity for both conservation and recreation along the Kansas and Wakarusa River corridors. Other counties and cities in Kansas have already implemented some of these projects, which could serve as a model for Douglas County.

Riparian Hike-Bike Trail Projects in Kansas. Barton County, Kansas, incorporated the Great Bend Riverside Hike & Bike Path into their Arkansas River Great Bend Flood Control Project to create an eight-mile levee trail alongside a flood control ditch,

connected by a path to the city's community center. The Manhattan Linear Park Trail also makes use of a levee along the Kansas River for part of its ring around the university town. The Shunga Trail project crosses Topeka in the Shunganunga Creek valley, connecting several city parks and neighborhoods and passing within a block of the Washburn University campus. In Atchison, the ten-mile Independence Creek Hiking/Biking Trail links recreational and historic attractions along the town's riverfront. Johnson County and the municipalities within the county have made extensive use of riparian routes for hike-bike paths with paved trails along Indian Creek, Tomahawk Creek, Mill Creek, Mahaffie Creek, Turkey Creek, and Kill Creek, to name a few. Many of these trails connect neighborhoods and cities within the county.

Unfortunately, there are no funding mechanisms in place to make these planning recommendations happen—only language that indicates they would be good for Douglas County. For this reason, we believe it is time for the development of a comprehensive Open Space Program for Douglas County. This program could include not only the natural areas identified in our study but also the public open space to connect them and to provide recreational opportunities. Many of these lands are also areas in the floodplain or provide other benefits. Attention would also be given to protecting prime farmland and historic areas, especially when these are close to the towns in Douglas County. Funding mechanisms and potential partnerships to implement the plan would be identified.

Conclusion

Douglas County's pre-settlement landscape consisted of prairies, forests and wetlands. This project documented high-quality forest and prairie parcels remaining in the county. Alarmingly, we also documented the continued high rate of loss of high-quality prairie and substantial changes to high-quality old-growth forests in the county. Though several high-quality and open space areas are already protected in the county, the development of natural resources and changing land ownership continue to threaten some of the county's high-quality prairies and forests. We believe that there is great opportunity for partners to work together in protecting habitats through conservation and restoration initiatives. Also the development and implementation of a comprehensive Open Space program would be an effective way to insure that conservation opportunities could be obtained in the four focal areas—Baldwin Woods, Lakeview, and the Kansas and Wakarusa river corridors. With an Open Space program, a significant number of high-quality parcels and open space areas will be available for the preservation of cultural and natural heritage, and development of recreational amenities and high quality of life that is desired by the current and future citizens of Douglas County.

Literature Cited and Data Sources

Atchley, R.A., D. L. Strayer, and P. Atchley. 2012. Creativity in the wild: Improving creative reasoning through immersion in natural settings. PLoS ONE 7: 1-3.

Bowman, Troy, J. Thompson, and J. Colletti. 2009. Valuation of open space and conservation features in residential subdivisions. Journal of Environmental

Management 90(1): 321-330.
Ewing, R., J. Kostyack, D. Chen, B. Stein, and M. Ernst. 2005. Endangered by Sprawl: How Runaway Development Threatens America's Wildlife. National Wildlife Federation, Smart Growth America, and NatureServe. Washington, D.C., January 2005.
Freeman, C.C. 2012. Coefficients of conservatism for Kansas vascular plants and selected life history attributes. Kansas Biological Survey, University of Kansas.
Freeman, C. C. and J. M. Delisle. 2004. Vegetation of the Fort Riley Military Reservation, Kansas. Kansas Biological Survey, Lawrence, Open-file Report 119:1–110.
Freeman, C. C. and S. M. Hall. 1991. Status survey for western prairie fringed orchid (*Platanthera praeclara* Sheviak & Bowles) on the Fort Riley Military Reservation.
FSA National Agricultural Imagery Program (NAIP). USDA FSA APFO Aerial Photography Field Office. Salt Lake City, Utah. Access: http://kansasgis.org/catalog/index.cfm?data_id=332&show_cat=1?data_id=329&show_cat=10?data_id=332&show_cat=99?data_id=332&show_cat=99?data_id=332&show_cat=99?data_id=332&show_cat=99.
Jennings, M. D., D. Faber-Langendoen, R. K. Peet, O. L. Loucks, D. C. Glenn-Lewin, A. Damman, M. G. Barbour, R. Pfister, D. H. Grossman, D. Roberts, and D. Tart. 2006. Description, documentation, and evaluation of associations and alliances within the US National Vegetation Classification, Version 4.5. Ecological Society of America, Vegetation Classification Panel. Washington DC. Page 119.
Kansas Biological Survey. 2015. Kansas Historic Forest. Digital data layer of forest boundary as shown in the US General Land Office paper maps.
Kansas Forest Service. 2011. Kansas Forest Action Plan. Kansas State University, Manhattan.
Kansas Natural Heritage Inventory. 2015. Kansas Biological Survey, Lawrence.
Kindscher, K. 1992. Environmental features report for Horizon 2020. Manuscript. Kansas Biological Survey, Lawrence.
Kindscher, K, W. H. Busby, J. M. Delisle, J. A. Dropkin, and C. C. Freeman. 2005. A Natural Areas Inventory of Douglas, Johnson, Leavenworth, Miami, and Wyandotte Counties in Northeast Kansas. Open-File Report No. 124. Kansas Biological Survey. Lawrence, KS.
Lauver, C. L., K. Kindscher, D. Faber-Langendoen, and R. Schneider. 1999. A classification of the natural vegetation of Kansas. Southwestern Naturalist 44:421–443.
Lauver, C. L. 1989. Final report on the natural areas inventory of Douglas County, Kansas, with a progress report on the inventory of other Kansas counties. Report no. 38. Kansas Biological Survey, Lawrence.
The Nature Conservancy. 2000. Ecoregional Conservation in the Osage Plains/Flint Hills Prairie. Minneapolis, Minnesota.
McCauley, J. R. 1998. Development and general geology of the Kansas River corridor. Chapter 1 of The Kansas River corridor—Its geologic setting, land use, economic geology, and hydrology, by L. L. Brady, compiler, D. A. Grisafe, J. R. McCauley, G. C. Ohlmacher, H. A. M. Quinodoz, and K. A. Nelson. Open-file report no. 98-

2. Kansas Geological Survey, Lawrence. Electronic version posted January 13, 1998, at http://www.kgs.ku.edu/Publications/KR/kr_geol.html; accessed August 24, 2005.

National Park Service. 2012. National Natural Landmarks Program. Baldwin Woods. http://www.nature.nps.gov/nnl/site.cfm?Site=BAWO-KS; accessed January 25, 2016.

NatureServe. 2014. NatureServe conservation status. NatureServe explorer: an online encyclopedia of life. Version 7.1. NatureServe, Arlington, VA. Available at http://www.natureserve.org/explorer/ranking.htm, accessed October 23, 2015.

Nowak, D. J., A. R. Bodine, R. E. Hoehn III, A. Ellis, K. Bomberger, D. E. Crane, T. A. Endreny, T. Taggert, and E. Stephan. 2014. Assessing urban forest effects and values: Douglas County, Kansas. Resource Bull. NRS-91. Newtown Square, PA: US Department of Agriculture, Forest Service, Northern Research Station.

Rayburn, A. P. and L. A. Schulte. 2009. Landscape change in an agricultural watershed in the U.S. Midwest. Landscape and Urban Planning 93(2) 30: 132–141.

Sander, H. A. and S. Polasky. 2009. The value of views and open space: Estimates from a hedonic pricing model for Ramsey County, Minnesota, USA. Land Use Policy 26(3): 837–845.

Ståhle, Alexander. 2010. More green space in a denser city: Critical relations between user experience and urban form. Urban Design International 15(1): 47–67.

Taft, J. B., G. S. Wilhelm, D. M. Ladd, and L. A. Masters. 1997. Floristic quality assessment for vegetation in Illinois: a method for assessing vegetation integrity. Erigenia 15: 3–23.

Tecic, D. L., J. L. McBride, M. L. Bowles, and D. L. Nickrent. 1998. Genetic Variability in the Federal Threatened Mead's Milkweed, Asclepias meadii Torrey (Asclepiadaceae), as Determined by Allozyme Electrophoresis. Annals of the Missouri Botanical Garden 85(1): 97–109.

University of Kansas Libraries, GIS & Numeric Data Lab Douglas County Public Works Department. Douglas County Historical Rectified Aerial Photos 1937. 1937 Douglas County Aerial Photography Set. Access: http://kansasgis.org/catalog/index.cfm?data_id=265&show_cat=1. http://www.fs.fed.us/openspace/OS_Strategy_final_web.pdf

U.S. Fish & Wildlife Service. 1995. *Platanthera praeclara* (Western prairie fringed orchid) recovery plan. U.S. Fish & Wildlife Service, Ft. Snelling, MN.

U.S. Fish & Wildlife Service. 2003. Mead's milkweed (*Asclepias meadii*) recovery plan. U.S. Fish & Wildlife Service, Fort Snelling, MN.

Wells, P. V. and G. E. Morley. 1964. Composition of Baldwin Woods: an oak-hickory forest in eastern Kansas. *Transactions of the Kansas Academy of Science*. vol. 67(1) pages 65–69.

Appendix A

Prairie plant species found during this study. CoC values are described in Section 3.2.b. A CoC value of "NA" indicates that species is non-native.

Species Name	Common Name	CoC Value	No. of Sites Where Found
Achillea millefolium	western yarrow	1	22
Agrostis hyemalis	winter bent grass	2	2
Allium canadense	Canadian onion	2	2
Allium vineale	field garlic	NA	1
Ambrosia artemisiifolia	annual bur-sage	0	1
Ambrosia psilostachya	western ragweed	3	7
Ambrosia trifida	giant ragweed	0	2
Amorpha canescens	leadplant	7	24
Amorpha fruticosa	bush wild-indigo	6	5
Andropogon gerardii	big bluestem	4	25
Andropogon virginicus	broom-sedge bluestem	0	1
Antennaria neglecta	field pussy's-toes	2	14
Apios americana	American potato-bean	6	1
Apocynum cannabinum	hemp dogbane	0	20
Arnoglossum atriplicifolium	pale Indian-plantain	3	5
Arnoglossum plantagineum	tuberous Indian-plantain	6	11
Artemisia ludoviciana	Louisiana sagewort	2	8
Asclepias amplexicaulis	blunt-leaf milkweed	7	5
Asclepias hirtella	prairie milkweed	7	6
Asclepias meadii	Mead's milkweed	10	8
Asclepias stenophylla	narrow-leaf milkweed	7	6
Asclepias sullivantii	smooth milkweed	5	11
Asclepias syriaca	common milkweed	1	4
Asclepias tuberosa	butterfly milkweed	6	19
Asclepias verticillata	whorled milkweed	1	15
Asclepias viridiflora	green milkweed	6	15
Asclepias viridis	spider milkweed	1	24
Astragalus crassicarpus	ground-plum milk-vetch	7	10
Baptisia alba	white wild-indigo	5	2
Baptisia bracteata	plains wild-indigo	6	21
Barbarea vulgaris	bitter wintercress	NA	1

Species Name	Common Name	CoC Value	No. of Sites Where Found
Bouteloua curtipendula	side-oats grama	5	6
Brassica sp.	mustard	-	1
Brickellia eupatorioides	eastern brickellbush	2	16
Bromus inermis	smooth brome	NA	11
Bromus japonicus	Japanese brome	NA	13
Buchnera americana	American bluehearts	9	1
Calystegia sepium	common hedge-bindweed	0	1
Camassia scilloides	Atlantic camas	8	3
Carduus nutans	musk-thistle	NA	3
Carex brevior	short-beak sedge	5	4
Carex bushii	Bush's sedge	4	9
Carex gravida	heavy sedge	4	3
Carex meadii	Mead's sedge	7	9
Ceanothus americanus	American ceanothus	9	7
Ceanothus herbaceus	inland ceanothus	8	16
Celastrus scandens	American bittersweet	4	1
Cercis canadensis	eastern redbud	2	2
Chaerophyllum tainturieri	southern chervil	2	2
Chamaecrista fasciculata	showy partridgepea	2	2
Chenopodium sp.	goosefoot	-	1
Cirsium altissimum	tall thistle	2	3
Cirsium undulatum	wavy-leaf thistle	4	4
Comandra umbellata	umbellate bastard toad-flax	6	18
Conyza canadensis	tall horseweed	0	6
Coreopsis palmata	finger coreopsis	7	8
Cornus drummondii	rough-leaf dogwood	1	9
Croton monanthogynus	one-seed croton	1	1
Cyperus lupulinus	slender-stem flat-sedge	3	1
Dactylis glomerata	common orchard grass	NA	3
Dalea candida	white prairie-clover	7	26
Dalea multiflora	round-head prairie-clover	7	5
Dalea purpurea	purple prairie-clover	7	25
Delphinium carolinianum	Carolina larkspur	6	19
Descurainia pinnata	pinnate tansy-mustard	1	1
Desmanthus illinoensis	Illinois bundle-flower	2	13
Desmodium illinoense	Illinois tick-clover	5	20

Species Name	Common Name	CoC Value	No. of Sites Where Found
Desmodium sessilifolium	sessile-leaf tickclover	7	19
Dianthus armeria	Deptford pink	NA	19
Dichanthelium acuminatum	pointed dichanthelium	3	15
Dichanthelium linearifolium	slim-leaf dichanthelium	7	8
Dichanthelium oligosanthes	Scribner's dichanthelium	4	24
Dichanthelium sphaerocarpon	round-seed dichanthelium	5	1
Draba cuneifolia	wedge-leaf draba	3	1
Echinacea atrorubens	Topeka coneflower	8	3
Echinacea pallida	pale purple coneflower	7	19
Eleocharis sp.	spike-rush	-	2
Elymus canadensis	Canadian wild-rye	5	10
Elymus virginicus	Virginia wild-rye	3	3
Erigeron annuus	annual fleabane	0	10
Erigeron philadelphicus	Philadelphia fleabane	3	6
Erigeron strigosus	daisy fleabane	4	18
Eryngium yuccifolium	button snake-root eryngo	7	13
Eupatorium altissimum	tall joe-pye-weed	2	9
Euphorbia corollata	flowering spurge	5	20
Euphorbia dentata	eastern toothed spurge	0	2
Euthamia gymnospermoides	sticky euthamia	3	7
Fimbristylis puberula	hairy fimbry	8	1
Fragaria virginiana	woodland strawberry	2	14
Galium aparine	catch-weed bedstraw	0	1
Galium obtusum	blunt-leaf bedstraw	5	1
Galium pedemontanum	foothill bedstraw	NA	1
Gentiana puberulenta	downy gentian	8	11
Geranium carolinianum	Carolina cranes-bill	0	4
Geum canadense	white avens	1	1
Glandularia canadensis	rose vervain	3	8
Gleditsia triacanthos	common honey-locust	0	2
Glycyrrhiza lepidota	American licorice	3	1
Grindelia squarrosa	curly-cup gumweed	0	1
Helianthus annuus	common sunflower	0	1
Helianthus grosseserratus	saw-tooth sunflower	4	12
Helianthus maximilianii	Maximilian's sunflower	3	2
Helianthus mollis	ashy sunflower	7	9

Species Name	Common Name	CoC Value	No. of Sites Where Found
Helianthus pauciflorus	stiff sunflower	5	16
Helianthus salicifolius	willow-leaf sunflower	6	3
Helianthus tuberosus	Jerusalem-artichoke	2	3
Hesperostipa spartea	porcupine grass	8	14
Hieracium longipilum	long-beard hawkweed	5	17
Hordeum jubatum	fox-tail barley	1	1
Hordeum pusillum	little barley	0	1
Hypericum perforatum	common St. John's-wort	NA	4
Hypericum punctatum	spotted St. John's-wort	6	2
Hypoxis hirsuta	hairy yellow star-lily	5	3
Juniperus virginiana	eastern red-cedar	1	3
Koeleria macrantha	prairie June grass	6	11
Lactuca ludoviciana	western lettuce	3	1
Lactuca serriola	prickly lettuce	NA	1
Lepidium densiflorum	common pepperweed	0	2
Lespedeza capitata	round-head bush-clover	6	20
Lespedeza cuneata	sericea bush-clover	NA	7
Lespedeza violacea	violet bush-clover	5	15
Lespedeza ×manniana	lespedeza	-	1
Leucanthemum vulgare	common ox-eye daisy	NA	7
Liatris aspera	button gayfeather	6	9
Liatris punctata	eastern dotted gayfeather	5	5
Liatris pycnostachya	thick-spike gayfeather	7	19
Lilium michiganense	Michigan lily	8	2
Linum sulcatum	grooved flax	6	7
Lithospermum canescens	hoary gromwell	7	7
Lithospermum incisum	plains gromwell	5	3
Lobelia spicata	pale-spike lobelia	6	13
Lomatium foeniculaceum	fennel-leaf desert-parsley	6	3
Lycopus americanus	American water-horehound	3	1
Lythrum alatum	winged loosestrife	4	4
Maclura pomifera	Osage-orange	NA	1
Medicago lupulina	black medic	0	11
Melilotus albus	white sweet-clover	NA	2
Melilotus officinalis	yellow sweet-clover	NA	11
Mimosa quadrivalvis	cat-claw mimosa	6	14

Species Name	Common Name	CoC Value	No. of Sites Where Found
Mirabilis albida	white four-oclock	5	1
Mirabilis linearis	narrow-leaf four-o'clock	5	1
Mirabilis nyctaginea	wild four-o'clock	0	1
Monarda fistulosa	wild bergamot bee-balm	3	7
Muhlenbergia sp.	muhly	-	1
Myosotis verna	spring forget-me-not	2	7
Nothoscordum bivalve	yellow false-garlic	3	1
Oenothera biennis	common evening-primrose	0	1
Oenothera speciosa	white evening-primrose	2	10
Oenothera curtiflora	velvetweed	1	4
Oenothera filiformis	longflower beeblossom	2	2
Onosmodium bejariense	western marbleseed	4	2
Oxalis dillenii	gray-green wood-sorrel	0	6
Oxalis stricta	yellow wood-sorrel	2	1
Oxalis violacea	violet wood-sorrel	4	9
Packera plattensis	prairie ragwort	5	3
Panicum virgatum	switch grass	4	10
Pedicularis canadensis	Canadian lousewort	7	9
Pediomelum argophyllum	silver-leaf scurf-pea	8	3
Pediomelum esculentum	bread-root scurf-pea	7	14
Pediomelum tenuiflorum	narrow-leaf scurf-pea	3	14
Penstemon cobaea	cobaea beardtongue	5	7
Penstemon digitalis	smooth beardtongue	4	3
Penstemon sp.	beardtongue	-	4
Penstemon tubaeflorus	tube beardtongue	3	1
Phleum pratense	common timothy	NA	6
Phlox divaricata	blue phlox	3	1
Phlox pilosa	prairie phlox	7	16
Physalis heterophylla	clammy ground-cherry	4	6
Physalis longifolia	long-leaf ground-cherry	2	2
Physalis pumila	prairie ground-cherry	4	11
Physalis virginiana	Virginia ground-cherry	6	1
Plantago virginica	pale-seed plantain	1	7
Poa pratensis	Kentucky blue grass	NA	20
Polygala verticillata	whorled milkwort	3	1
Polytaenia nuttallii	Nuttall's prairie-parsley	6	19

Species Name	Common Name	CoC Value	No. of Sites Where Found
Potentilla recta	sulfur cinquefoil	NA	15
Potentilla simplex	old-field cinquefoil	3	3
Prunella vulgaris	common selfheal	NA	3
Prunus americana	American plum	3	2
Pycnanthemum tenuifolium	narrow-leaf mountain-mint	4	15
Quercus muehlenbergii	chinquapin oak	5	1
Ratibida columnifera	upright prairie-coneflower	4	4
Ratibida pinnata	gray-head coneflower	3	13
Rhus aromatica	fragrant sumac	3	1
Rhus copallinum	dwarf sumac	3	2
Rhus glabra	smooth sumac	1	9
Rosa arkansana	Arkansas rose	4	17
Rosa multiflora	multiflora rose	NA	3
Rosa setigera	prairie rose	3	1
Rubus flagellaris	American dewberry	5	7
Rudbeckia hirta	black-eyed-Susan	2	19
Ruellia humilis	fringe-leaf ruellia	3	22
Ruellia strepens	limestone ruellia	4	1
Rumex acetosella	sheep sorrel	NA	1
Rumex crispus	curly dock	NA	4
Salvia azurea	blue sage	4	21
Schedonorus arundinaceus	tall mountain-fescue	NA	11
Schizachyrium scoparium	little bluestem	5	19
Scirpus pendulus	drooping bulrush	3	4
Scleria triglomerata	whip nut-rush	8	9
Setaria parviflora	knot-root bristle grass	3	4
Silene antirrhina	sleepy catchfly	0	2
Silene noctiflora	night-flowering catchfly	0	1
Silene stellata	starry catchfly	5	3
Silphium integrifolium	whole-leaf rosinweed	3	8
Silphium laciniatum	compassplant	4	19
Sisyrinchium campestre	prairie blue-eyed-grass	6	15
Solanum carolinense	Carolina horse-nettle	1	12
Solidago canadensis	Canadian goldenrod	2	21
Solidago missouriensis	Missouri goldenrod	5	12
Solidago rigida	stiff goldenrod	3	12

Species Name	Common Name	CoC Value	No. of Sites Where Found
Solidago speciosa	showy-wand goldenrod	7	4
Sorghastrum nutans	yellow Indian grass	5	15
Spartina pectinata	prairie cord grass	4	16
Sphenopholis obtusata	prairie wedgescale	4	4
Sporobolus compositus	rough dropseed	3	11
Sporobolus heterolepis	prairie dropseed	8	11
Symphoricarpos orbiculatus	buckbrush	1	6
Symphyotrichum drummondii	Drummond's aster	2	1
Symphyotrichum ericoides	heath aster	5	19
Symphyotrichum laeve	smooth blue aster	7	2
Symphyotrichum lanceolatum	lance-leaf aster	3	2
Symphyotrichum oolentangiense	azure aster	8	18
Symphyotrichum pilosum	hairy aster	0	6
Symphyotrichum praealtum	willow-leaf aster	3	11
Tephrosia virginiana	Virginia hoary-pea	7	1
Teucrium canadense	American germander	1	6
Toxicodendron radicans	poison-ivy	0	6
Tradescantia bracteata	bracted spiderwort	5	13
Tradescantia ohiensis	Ohio spiderwort	5	18
Tragia betonicifolia	betony noseburn	5	2
Tragopogon dubius	western salsify	NA	13
Tridens flavus	purpletop	1	1
Trifolium campestre	low hop clover	NA	2
Trifolium pratense	red clover	NA	13
Trifolium reflexum	buffalo clover	10	1
Triodanis leptocarpa	slender-fruit venus'-looking-glass	3	1
Triodanis perfoliata	clasping-leaf venus'-looking-glass	2	4
Triosteum perfoliatum	clasping-leaf horse-gentian	4	4
Tripsacum dactyloides	eastern gamma grass	3	24
Ulmus rubra	slippery elm	3	5
Verbascum blattaria	moth mullein	NA	1
Verbascum thapsus	flannel mullein	NA	3
Verbena simplex	narrow-leaf vervain	2	3
Verbena stricta	hoary vervain	1	2

Species Name	Common Name	CoC Value	No. of Sites Where Found
Vernonia baldwinii	western ironweed	2	19
Viola nephrophylla	northern bog violet	3	1
Viola pedatifida	prairie violet	6	15
Yucca filamentosa	Adam's-needle	NA	1
Zizia aurea	common golden-alexanders	5	8

Appendix B

Forest plant species found during this study. CoC values are described in Section 3.2.b. A CoC value of "NA" indicates that species is non-native.

Species Name	Common Name	CoC Value	No. of Sites Where Found
Acalypha virginica	Virginia copperleaf	0	2
Acer negundo	boxelder	1	17
Acer saccharinum	silver maple	2	8
Adiantum pedatum	northern maiden-hair fern	8	1
Aesculus glabra	Ohio buckeye	5	19
Agastache nepetoides	catnip giant-hyssop	4	5
Agrimonia parviflora	small-flower agrimony	4	1
Agrimonia pubescens	downy agrimony	5	20
Alliaria petiolata	common garlic-mustard	NA	34
Allium canadense	meadow garlic	2	5
Allium sp.	onion	-	1
Allium vineale	field garlic	NA	7
Ambrosia artemisiifolia	common ragweed	0	3
Ambrosia trifida	giant ragweed	0	4
Ampelopsis cordata	heart-leaf raccoon-grape	2	4
Amphicarpaea bracteata	American hogpeanut	3	23
Andropogon gerardii	big bluestem	4	1
Androsace occidentalis	western rock-jasmine	0	1
Anemone caroliniana	Carolina anemone	5	1

Species Name	Common Name	CoC Value	No. of Sites Where Found
Anemone virginiana	tall thimbleweed	4	6
Antennaria neglecta	field pussy's-toes	2	2
Antennaria parlinii	plantain-leaf pussy's-toes	5	1
Aplectrum hyemale	puttyroot	8	1
Apocynum cannabinum	hemp dogbane	0	6
Aquilegia canadensis	American columbine	7	4
Arenaria serpyllifolia	thymeleaf sandwort	NA	1
Arisaema dracontium	dragonroot Jack-in-the-pulpit	7	15
Arisaema triphyllum	Jack-in-the-pulpit	6	27
Arnoglossum atriplicifolium	pale Indian-plantain	3	13
Asclepias incarnata	swamp milkweed	4	2
Asclepias purpurascens	purple milkweed	6	8
Asclepias viridis	spider milkweed	1	2
Asimina triloba	common pawpaw	4	30
Berberis vulgaris	European barberry	NA	1
Botrychium virginianum	rattlesnake fern	4	23
Bromus inermis	smooth brome	NA	2
Bromus japonicus	Japanese brome	NA	2
Bromus pubescens	Canadian brome	4	18
Campanula americana	American bellflower	4	7
Campsis radicans	common trumpet-creeper	2	1
Cardamine concatenata	cut-leaf toothwort	6	17
Carex austrina	golden-fruit sedge	5	1
Carex blanda	woodland sedge	1	16
Carex brevior	short-beak sedge	5	2
Carex davisii	Davis' sedge	4	7
Carex grisea	narrow-leaf sedge	3	1
Carex jamesii	James' sedge	5	4
Carex lupulina	hop sedge	6	2
Carex muehlenbergii	Muhlenberg's sedge	6	1
Carex oligocarpa	straight-fruit sedge	6	3
Carex radiata	radiate sedge	6	2
Carex rosea	rosy sedge	7	7

Species Name	Common Name	CoC Value	No. of Sites Where Found
Carex sp.	sedge	-	5
Carex sparganioides	bur-reed sedge	7	2
Carya cordiformis	bitter-nut hickory	4	27
Carya ovata	shag-bark hickory	5	37
Ceanothus herbaceus	inland ceanothus	8	1
Celastrus scandens	American bittersweet	4	9
Celtis occidentalis	common hackberry	1	35
Cephalanthus occidentalis	common buttonbush	4	3
Cercis canadensis	eastern redbud	2	31
Chaerophyllum procumbens	spreading chervil	0	26
Chaerophyllum tainturieri	hairyfruit chervil	2	1
Chasmanthium latifolium	broad-leaf wood-oat	4	5
Chenopodium simplex	maple-leaf goosefoot	2	1
Circaea lutetiana	broadleaf enchanter's nightshade	6	8
Cirsium altissimum	tall thistle	2	6
Cirsium vulgare	bull thistle	NA	1
Claytonia virginica	Virginia springbeauty	3	1
Conium maculatum	poison-hemlock	NA	2
Cornus drummondii	rough-leaf dogwood	1	28
Cryptotaenia canadensis	honewort	4	15
Cystopteris protrusa	southern bladder fern	6	2
Cystopteris tennesseensis	Tennessee bladder fern	6	13
Dactylis glomerata	common orchard grass	NA	4
Danthonia spicata	poverty oat grass	5	2
Dasistoma macrophylla	big-leaf mullein-foxglove	4	13
Delphinium sp.	larkspur	-	3
Delphinium tricorne	dwarf larkspur	6	2
Desmanthus illinoensis	Illinois bundle-flower	2	2
Desmodium paniculatum	panicled tick-clover	4	5
Desmodium sp.	tick-clover	-	3
Diarrhena obovata	American beakgrain	6	1
Dicentra cucullaria	Dutchman’s-breeches	7	19
Dichanthelium acuminatum	tapered rosette grass	3	1

Species Name	Common Name	CoC Value	No. of Sites Where Found
Dichanthelium latifolium	broad-leaf dichanthelium	7	9
Dipsacus fullonum	fuller's teasel	NA	2
Ellisia nyctelea	water-pod	0	13
Elymus canadensis	Canada wild-rye	5	3
Elymus villosus	hairy wild-rye	5	1
Elymus virginicus	Virginia wild-rye	3	25
Enemion biternatum	false rue-anemone	3	15
Equisetum laevigatum	smooth scouring-rush	3	2
Erigeron annuus	annual fleabane	0	2
Erigeron philadelphicus	Philadelphia fleabane	3	3
Erythronium albidum	white fawn-lily	6	26
Erythronium mesochoreum	prairie fawn-lily	7	8
Euonymus alatus	winged burningbush	NA	1
Euonymus atropurpureus	eastern wahoo	5	1
Euonymus fortunei	Chinese spindle-tree	NA	8
Eupatorium altissimum	tall joe-pye-weed	2	2
Eupatorium sp.	joe-pye-weed	-	3
Euphorbia cyathophora	painted spurge	3	1
Eutrochium purpureum	joe-pye-weed	4	11
Festuca subverticillata	nodding fescue	4	19
Fraxinus americana	white ash	7	5
Fraxinus pennsylvanica	green ash	0	28
Galium aparine	catch-weed bedstraw	0	28
Galium circaezans	forest bedstraw	3	24
Galium concinnum	shining bedstraw	5	17
Geum canadense	white avens	1	23
Gleditsia triacanthos	common honey-locust	0	23
Gymnocladus dioica	Kentucky coffeetree	4	21
Hackelia virginiana	Virginia bracted-stickseed	3	20
Helianthus hirsutus	hairy sunflower	6	22
Hemerocallis fulva	orange day-lily	NA	3
Hesperis matronalis	dame's rocket	NA	2
Humulus japonicus	Japanese hop	NA	3
Hydrophyllum virginianum	Virginia waterleaf	5	9

Species Name	Common Name	CoC Value	No. of Sites Where Found
Hylodesmum glutinosum	pointedleaf tick-clover	3	13
Hypericum perforatum	St. John's-wort	NA	2
Hypericum punctatum	spotted St. John's-wort	6	1
Impatiens capensis	spotted touch-me-not	4	21
Juglans nigra	black walnut	3	32
Juncus tenuis	path rush	0	2
Juniperus virginiana	eastern red-cedar	1	34
Lactuca floridana	Florida lettuce	3	10
Lamium purpureum	dead nettle	NA	10
Laportea canadensis	Canadian wood-nettle	4	20
Leersia virginica	white grass	3	3
Lespedeza cuneata	sericea bush-clover	NA	2
Lespedeza violacea	violet bush-clover	5	1
Liatris aspera	button gayfeather	6	1
Ligustrum obtusifolium	obtuse-leaf privet	NA	2
Lilium michiganense	Michigan lily	8	22
Lobelia appendiculata	ear-flower lobelia	7	1
Lobelia siphilitica	great lobelia	4	1
Lobelia spicata	pale-spike lobelia	6	1
Lonicera japonica	Japanese honeysuckle	NA	8
Lonicera maackii	amur honeysuckle	NA	11
Maclura pomifera	Osage-orange	NA	16
Maianthemum racemosum	spikenard	6	3
Medicago lupulina	black medic	NA	1
Melilotus albus	white sweet-clover	NA	1
Melilotus officinalis	yellow sweet-clover	NA	3
Melilotus sp.	sweet clover	NA	2
Menispermum canadense	Canadian moonseed	4	29
Mimulus alatus	sharp-wing monkey-flower	5	1
Mimulus ringens	monkey flower	5	2
Mirabilis nyctaginea	wild four-o'clock	0	4
Monarda fistulosa	bee balm	3	1
Morus rubra	red mulberry	5	16
Muhlenbergia schreberi	nimblewill	0	1

Species Name	Common Name	CoC Value	No. of Sites Where Found
Muhlenbergia sobolifera	rock muhly	5	1
Nelumbo lutea	American lotus	5	2
Ophioglossum engelmannii	limestone adder's-tongue	3	1
Osmorhiza longistylis	long-style sweet-cicely	3	14
Ostrya virginiana	American hop-hornbeam	5	16
Oxalis stricta	yellow wood-sorrel	2	7
Oxalis violacea	violet wood-sorrel	4	6
Packera obovata	round-leaf ragwort	4	1
Panicum capillare	fall panicum	0	1
Parthenocissus quinquefolia	Virginia creeper	1	33
Perilla frutescens	beefstakeplant	NA	1
Persicaria lapathifolia	pale smartweed	2	2
Persicaria longiseta	Asian smartweed	NA	1
Persicaria maculosa	Lady's-thumb smartweed	NA	2
Persicaria punctata	dotted smartweed	3	3
Persicaria virginiana	jumpseed	2	30
Phalaris arundinacea	reed canary grass	0	3
Phalaris canariensis	common canary grass	NA	3
Phlox divaricata	blue phlox	3	34
Physalis longifolia	long-leaf ground cherry	2	1
Phytolacca americana	pokeweed	0	1
Pilea pumila	dwarf clearweed	2	3
Plantago rugelii	Rugel's plantain	0	2
Platanus occidentalis	common sycamore	4	27
Poa pratensis	Kentucky blue grass	NA	1
Poa sylvestris	woodland blue grass	4	14
Podophyllum peltatum	common may-apple	4	32
Polygonatum biflorum	giant Solomon's seal	5	31
Populus deltoides	cottonwood	0	3
Prunella vulgaris	common selfheal	NA	1
Prunus serotina	wild cherry	3	18
Prunus virginiana	choke cherry	2	3
Quercus alba	white oak	7	2
Quercus macrocarpa	bur oak	4	28

Species Name	Common Name	CoC Value	No. of Sites Where Found
Quercus muehlenbergii	chinquapin oak	5	28
Quercus rubra	northern red oak	6	33
Quercus stellata	post oak	4	2
Quercus velutina	black oak	5	4
Ranunculus abortivus	early wood buttercup	1	4
Ratibida pinnata	gray-head prairie-coneflower	3	2
Rhus aromatica	aromatic sumac	3	1
Rhus glabra	smooth sumac	1	4
Ribes missouriense	Missouri gooseberry	3	37
Rosa multiflora	multiflora rose	NA	27
Rosa setigera	prairie rose	3	8
Rubus occidentalis	black raspberry	2	3
Rubus sp.	blackberry	-	9
Rudbeckia laciniata	cutleaf coneflower	5	2
Ruellia strepens	limestone ruellia	4	7
Rumex altissimus	pale dock	0	1
Rumex crispus	curly dock	NA	3
Rumex sp.	dock	-	1
Sambucus canadensis	American elderberry	2	14
Sanguinaria canadensis	bloodroot	7	1
Sanicula canadensis	Canadian blacksnakeroot	2	13
Sanicula odorata	fragrant sanicle	2	23
Scrophularia marilandica	Maryland figwort	5	1
Silene stellata	starry catchfly	5	16
Silphium integrifolium	rosinweed	3	1
Silphium perfoliatum	compass plant	3	1
Smilax herbacea	smooth carrionflower	3	11
Smilax tamnoides	bristly greenbrier	2	32
Solanum ptychanthum	black nightshade	1	1
Solidago canadensis	Canada goldenrod	2	6
Solidago gigantea	giant goldenrod	3	11
Solidago sp.	goldenrod	-	1
Solidago speciosa	showy goldenrod	7	1

Species Name	Common Name	CoC Value	No. of Sites Where Found
Solidago ulmifolia	elm-leaved goldenrod	4	23
Staphylea trifolia	American bladdernut	6	16
Stellaria media	common chickweed	NA	1
Stellaria pallida	pale chickweed	NA	8
Symphoricarpos orbiculatus	buckbrush	1	38
Symphyotrichum drummondii	Drummond's aster	2	9
Symphyotrichum laeve	smooth aster	7	2
Symphyotrichum lanceolatum	lance-leafed aster	3	7
Taraxacum officinale	common dandelion	NA	1
Teucrium canadense	American germander	1	4
Thalictrum dasycarpum	purple meadow-rue	4	19
Tilia americana	basswood	6	11
Toxicodendron radicans	poison ivy	0	30
Trifolium pratense	red clover	NA	2
Trifolium repens	white clover	NA	2
Triodanis perfoliata	Venus'-looking-glass	2	1
Triosteum perfoliatum	clasping-leaf horse-gentian	4	6
Typha angustifolia	narrow-leaf cat-tail	0	1
Ulmus americana	American elm	2	7
Ulmus rubra	slippery elm	3	34
Urtica dioica	stinging nettle	1	7
Verbascum thapsus	flannel mullein	NA	1
Verbena urticifolia	nettle-leaf vervain	2	5
Verbesina alternifolia	wing-stem crownbeard	4	30
Vernonia baldwinii	Baldwin's ironweed	2	3
Veronica arvensis	corn speedwell	NA	1
Viola pubescens	yellow violet	5	28
Viola sororia	common blue violet	2	21
Vitis aestivalis	fall grape	5	4
Vitis cinerea	graybark grape	5	2
Vitis riparia	riverbank grape	2	19
Vitis sp.	wild grape	-	1
Zanthoxylum americanum	common prickly-ash	3	12
Zizia aurea	common golden-alexanders	5	10

Acknowledgments

Work for this project, "A Systematic Inventory for Natural Areas and Habitat for Douglas County," was carried out under a grant from the Douglas County Natural & Cultural Heritage Grant Program. Special thanks to Jan Shupert-Arick of the Heritage Grant Program and to Mary Miller, a Planner for the City of Lawrence.

Many individuals worked on the County Inventory, from field workers to office support personnel. They include botanists Craig Freeman, Caleb Morse, and Hillary Loring, of the Kansas Biological Survey and the R. L. McGregor Herbarium at the University of Kansas, and Bill Busby zoologist, Kansas Biological Survey. KU students Cary Bowen, Amy Isenburg, and Jessica Lackey also assisted with the project.

We are grateful to the dozens of landowners who gave us permission to visit their properties, without whom this inventory would not have been possible.