Missouri River Floodplain
Landform Modeling & Ownership Database Development

Final Report

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From: The Missouri Resource Assessment Partnership (MoRAP)
University of Missouri, Columbia

Project Manager: David D. Diamond
Director
Missouri Resource Assessment Partnership
4200 New Haven Road
Columbia, MO 65201
Phone: 573/876-1862
FAX: 573/876-1863
Diamondd@missouri.edu

Technical Lead: Ronnie Lea
rdldbb@mizzou.edu

TO: Audubon Missouri
Attn: Roger Still
2620 Forum Blvd. Suite C1
Columbia, MO 65203
Phone: 573/447-2249
Fax: 573/447-2428
rstill@audubon.org

Table of Contents

Abstract

This project sought to assemble and create spatial data to aid in the identification of potential areas of herbaceous wetland and bottomland forest restoration within the Missouri River corridor between St. Joseph and Kansas City, Missouri. Data layers created and acquired include elevation (absolute and relative), soil, parcel boundaries, land use/land cover, landscape context, and abiotic site type information. By considering a number of the datasets together we identified areas that are potentially suitable for wetland restoration. Holbrook et al. (2006) suggested that relatively low topographic locations that have soils of slow infiltration are most prone to surface ponding and are the most ideal locations for wetland restoration. Such locations within the river flood plain frequently occupy old river channels that have been filled by sediment over time. It is possible to identify locations such as these using the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) hydrologic soil type and the relative elevation (river level) data we created. The hard-copy report contains maps that depict data layers, but the results are best used via viewing in a GIS.

Background

This report addresses the desire of the Audubon Missouri to develop information relevant to bird conservation and management within the St. Joe/Kansas City River Corridor Important Bird Area (IBA). This IBA extends from just south of St. Joseph downstream to the outskirts of Kansas City, about 77 kilometers. The IBA is an important habitat for bird species of concern such as the Bald Eagle, American Bittern, and King Rail, has wetlands of conservation concern, and serves as a stopover or winter habitat for high numbers of migratory land birds.

Most of the land within the Missouri River Floodplain is in cropland, and thus restoration of natural communities is an important goal (see Figure 5). Successful restoration requires an understanding of abiotic site potential, which in the case of croplands within the floodplain, is largely controlled by elevation, landform, and soils. Thus, lower lying areas that are poorly drained are better candidates for herbaceous or shrub-dominated wetland restoration, whereas higher, better drained areas are more likely candidates for bottomland forest restoration. Finally, since croplands within the floodplain are privately owned, landowner contact and incentive initiatives are required to maintain, improve, and restore the natural communities. The goals of this project were to:

(1) model the abiotic site types within the floodplain on both the Kansas and Missouri side of the Missouri River and suggest appropriate management and restoration targets (e.g. where would wetlands versus "drier" deciduous woodlands best be restored based on the abiotic habitats? How much potential for restoration exists in this IBA and where is it located?), and

(2) create a parcel boundary map (without specific owners identified) for the floodplain to suggest where efforts might best be spent (e.g. where are the larger parcels, and how

do the parcel boundaries intersect with the current vegetation and the with geolandforms models?).

In addition to these two original goals, we also provided an evaluation of landscape patterns within the floodplain. These data can be used to evaluate landscape context and provide one more index to restoration potential in terms of distance of restorable land to existing public lands, urban areas, and existing natural and semi-natural vegetation.

GIS DATA ACQUISITION AND DEVELOPMENT

Study Area Boundary

The polygon for the Missouri River floodplain boundary was obtained from the United States Geological Survey (USGS) Columbia Environmental Research Center (CERC) River Studies group and was used to mask the elevation data to the river valley (see Figure 1). The study area consists of the Missouri River valley from north of St. Joseph, MO at river mile 476, to Kansas City, MO at river mile 378. This study area encompasses all of the St. Joseph/Kansas City River Corridor IBA that is within the Missouri River valley. The study area covers 61,055 ha (236 square miles) and includes part of the Missouri counties of Andrew, Buchanan, Holt and Platte and the Kansas counties of Atchison, Doniphan, Leavenworth, and Wyandotte.

Figure 1. Study area locator map.

Study Area Buffer – 7500 meters

The study area boundary polygon was buffered to create a mask for the 2005 MoRAP Land Use/Land Cover (LULC) and Abiotic Habitat Site Type (ABHST) data. The study area was buffered by 7500 meters to ensure that LULC and ABHST data would be included for all public lands that intersected and extended beyond the study area. The LULC and ABHST can be used to provide contextual information by including areas adjacent to the study area.

Digital Elevation Model (DEM)

Digital elevation data was obtained from the United States Army Corps of Engineers (USACE), Kansas City District and was collected for them by Horizons, Inc of Rapid City, SD in 1998. Horizons, Inc created the elevation information from 25 foot postings of mass points "interpolated" from the breakline, TIN spot, and random spot elevation mapping. USACE delivered the data to MoRAP as text files that required processing in order to create the raster elevation data.

The procedure to create the elevation data set required the mass point and break line files to create a raster data set. There were 18 map sheets of elevation data for the study area. In order for the mass point and break line files to be readable by ESRI ArcGIS the suffix of the break line and mass point files were changed from .brk and .pts to .txt. The .txt text files were then opened using Word Pad and the header information was deleted, so that the text file could be converted to a data base file (.dbf). The text file was then imported into Microsoft Access to assign each elevation point a unique identifier, convert the x, y, and z values from feet to meters, and save the text file as a .dbf. Each point must have a unique id in order to be read by ArcGIS and converted to a raster. The mass point and break line .dbf files for each of the 18 map sheets were opened in ArcGIS and vector point files were created by using the x and y values that had been converted to meters. Using ArcGIS 3D Analyst tools, the elevation values within the break line and mass point vector point files were used to generate a Triangulated Irregular Network (TIN) elevation surface. In a TIN model, the world is represented as a network of linked triangles drawn between irregularly spaced points with x, y, and z values (ESRI ArcGIS Desktop 9.1 Help). To create a smoother elevation surface, the TIN elevation dataset was converted to a 32 bit floating point raster dataset with a 5 meter cell size using the natural neighbors sampling method, which can efficiently handle large numbers of input points. Over 1,276,000 points were used to create the elevation surface.

Hillshade

The hillshade was applied to the DEM for visualization purposes and should be used in place of the DEM when viewing elevation data (see Appendix 1). The hillshade function obtains the hypothetical illumination of a surface by determining illumination values for each cell in a raster. It does this by setting a position for a hypothetical light source and calculating the illumination values of each cell in relation to neighboring cells. It can greatly enhance the visualization of a surface for analysis or graphical display, especially when using transparency (ESRI ArcGIS Desktop 9.1 Help).

Solar Insolation

The solar insolation dataset was derived from the DEM and can be useful in determining whether or not a location will be wetter or drier based on the amount of sun exposure it receives (see Appendix 2). Solar insolation was calculated using a program called Shortwave, developed by Kumar, Skidmore, and Knowles (1997). This program calculates the shortwave radiation received at the surface of the earth over a period of time. For the given day(s), it calculates the sunset and sunrise times and integrates solar radiation from sunrise to sunset each day.

Local Elevation (Land Position)

The local elevation dataset was created to identify local high and low elevation to determine where water may pool (see Appendix 3). Local elevation was calculated using the DEM as the input for the program Landpos. The program was created by Frank Biasi of The Nature Conservancy in 2000. Landpos calculates land position based on the inverse distance weighted elevation of each cell in relation to its neighbors. The mean elevation was determined at various radii. The DEM elevation was subtracted from the mean at each radius and divided by the distance. A maximum radius of 89 cells (445 meters) was used with 44 other radius levels in between.

The Landpos program was unable to determine the highs and lows due to the subtle elevation change or lack of substantial local relief within the Missouri River floodplain. Therefore it was not used in analysis, but is included in the data package.

Relative Elevation

The idea of relative elevation came about after the local elevation program did not provide satisfactory results for the study area. The study area is relatively flat with little relief in most places, thus the local elevation program was not able to show the subtle changes in elevation. Therefore, a relative elevation dataset was created by subtracting the elevation of the river level in the DEM from the elevation value of each pixel to determine relative highs and lows. Relative elevation was also created by subtracting the elevation of the 10 year flood stage provided by the USACE from the DEM. By identifying relative high and low elevations within the study area, one can highlight areas where water would naturally flow. The relative elevation datasets were divided into 10 classes using quantiles.

River Elevation

The elevation of the center of the river was extracted from the DEM at an interval of 1 river mile and saved to a point file. The river channel elevation points were then used to interpolate the river elevation to a raster dataset, using inverse distance weighted, throughout the study area. Finally, the river channel raster was subtracted from the elevation of each pixel to determine the relative elevation within the study area. By using the river channel elevation we ensured that the relative elevation was calculated using only information derived from the DEM (see Figure 2), in contrast to the data that used the elevation of the 10 year flood stage, which was derived from hydrologic modeling.

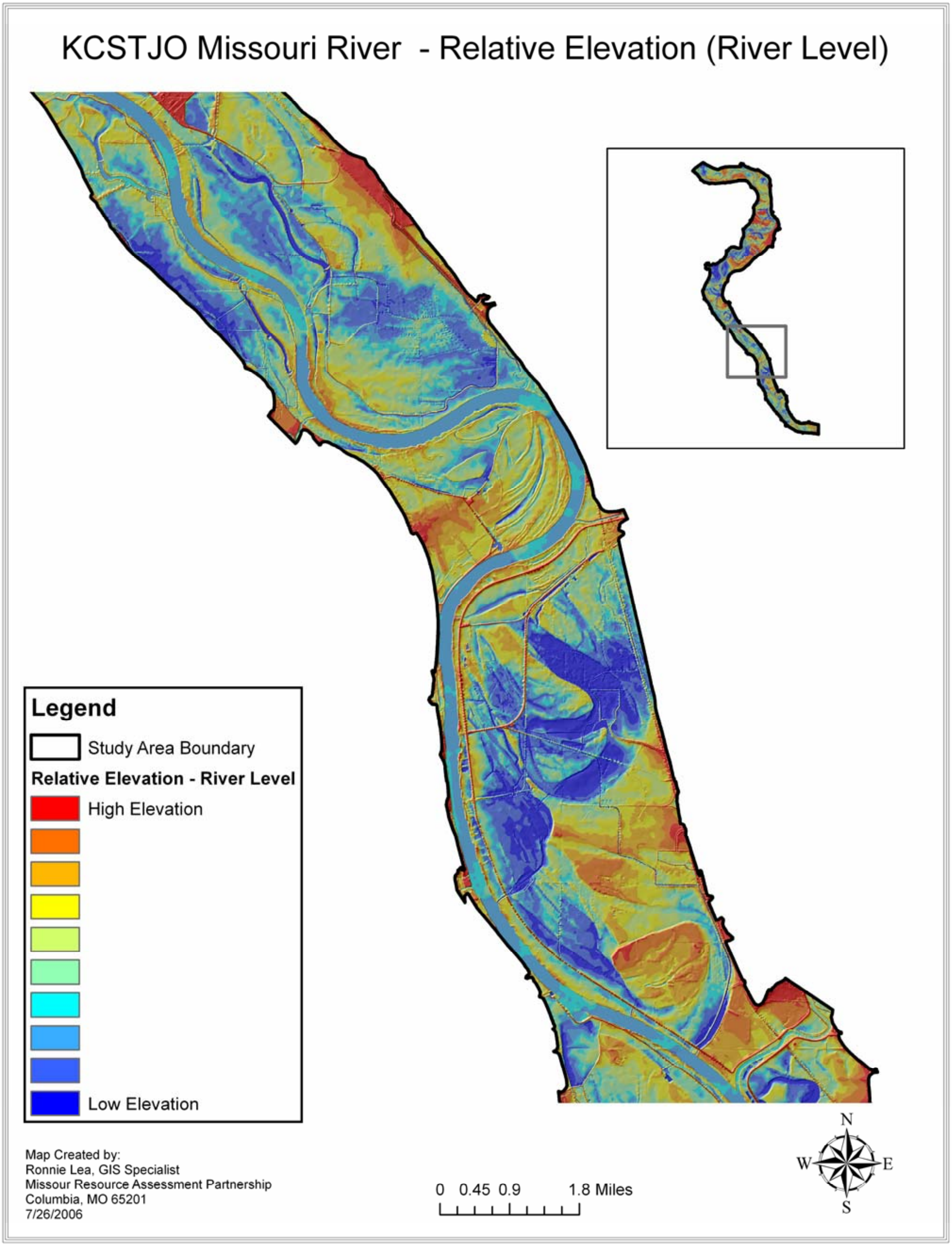


Figure 2. Relative elevation created by subtracting land surface elevation from river surface elevation.

Flood Stage

The flood stage data were originally generated via hydrologic modeling by the USACE, and were acquired from the River Studies group at the USGS CERC. These data contained flood stage elevations for 2, 5, 10, 20, 50, 100, 200, and 500 year floods (U.S. Army Corps of Engineers 1999). The 10 year flood stage elevation was selected for evaluation as an example after consultation with USGS staff. The flood stage elevation was interpolated to a raster file throughout the study area using points in the center of the river channel at an interval of one river mile. The flood stage elevation was subtracted from the elevation of each pixel to create a relative elevation file (see Appendix 5).

Relative Elevation: River Elevation vs. Flood Stage

Values for elevation of a given pixel versus current river level and versus the 10 year flood stage elevation vary quite markedly (e.g. an area may be ‘low’ relative to the current river elevation and ‘high’ relative to the elevation of the 10 year flood stage see Table 1.1). Evaluation of this variation is beyond the scope of this project, but may be related to river channel down-cutting, deposition of sediment between the levees, variation in the width between the levees (these latter two variables might influence the volume between the levees at flood stage), mistakes in the estimation of the current elevation of the river, or errors in the USACE hydrologic model. We elected to use the difference between current river level and the elevation of each pixel for presentation here, because restoration potential of a given site is mainly controlled by the local landforms (e.g. high or low; concave or convex) and soil permeability, and these are better depicted by elevation relative to the river level from the DEM (Holbrook et al. 2006).

Table 1.1. Comparison of relative elevation derived from River Level elevation and 10 year Flood Stage elevation by area and percentage of relative high and low elevation by county within study area.

Relative Elevation - River Level

County	High ha	High % County	Med_High ha	Med_High % County	Med_Low ha	Med_Low % County	Low ha	Low % County	Sum
Holt	1088.9	22.3%	1532.9	31.4%	1334.8	27.3%	926.1	19.0%	4882.7
Andrew	847.7	24.2%	1234.1	35.3%	915.8	26.2%	499.0	14.3%	3496.6
Buchanan	6159.8	35.2%	3392.0	19.4%	3096.1	17.7%	4839.1	27.7%	17487.0
Platte	2527.6	15.9%	4250.2	26.7%	4786.4	30.1%	4360.2	27.4%	15924.5
Wyandotte	313.1	23.7%	420.7	31.9%	381.9	29.0%	202.7	15.4%	1318.4
Atchison	238.1	6.6%	473.9	13.2%	1002.1	28.0%	1869.8	52.2%	3584.0
Leavenworth	409.0	10.4%	1133.2	28.8%	1665.1	42.3%	728.8	18.5%	3936.1
Doniphan	3038.6	30.2%	2738.7	27.2%	2653.9	26.4%	1624.0	16.2%	10055.1

Relative Elevation - Flood Stage

County	High ha	High % County	Med_High ha	Med_High % County	Med_Low ha	Med_Low % County	Low ha	Low % County	Sum
Holt	479.2	9.8%	1157.1	23.7%	1764.9	36.1%	1481.5	30.3%	4882.7
Andrew	712.3	20.4%	1090.9	31.2%	1084.5	31.0%	608.9	17.4%	3496.6
Buchanan	7939.6	45.4%	4767.1	27.3%	2801.9	16.0%	1978.4	11.3%	17487.0
Platte	1600.7	10.1%	3161.3	19.9%	4477.8	28.1%	6684.6	42.0%	15924.5
Wyandotte	127.1	9.6%	121.8	9.2%	329.1	25.0%	740.5	56.2%	1318.4
Atchison	530.3	14.8%	1228.6	34.3%	1572.8	43.9%	252.3	7.0%	3584.0
Leavenworth	140.5	3.6%	403.7	10.3%	1153.4	29.3%	2238.5	56.9%	3936.1
Doniphan	2857.1	28.4%	2557.8	25.4%	2809.2	27.9%	1831.0	18.2%	10055.1

USDA NRCS Soil Survey Geographic (SSURGO) Database

The SSURGO data was obtained from the Soil Data Mart (http://soildatamart.nrcs.usda.gov/) for the counties within the study area. SSURGO data depicts information about soils on the landscape. The SSURGO database was created by soil scientists as part of a National Cooperative Survey. The digital data used for this project were published in 2005 (USDA NRCS 2005), but the on-the-ground soil surveys are of various ages. The database contains numerous relational tables with a vast array of soil information. The Soil Data Viewer 5.0 (http://soildataviewer.nrcs.usda.gov/) was used to ensure that tables were properly related to one another and the appropriate information was extracted. The two available soil characteristics that best highlighted water holding properties were soil hydrologic group and soil drainage class. These datasets can be used in conjunction with relative elevation to identify relatively low spots that have slow infiltration rates and are poorly drained, which are ideal candidates for wetland restoration.

Soil Hydrologic Group

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to 1 of 4 groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms. The soils in the United States are placed into four groups, A, B, C, and D, and three dual classes, A/D, B/D, and C/D (see Figure 3 and Appendix 6). Definitions of the classes are as follows:

The 4 hydrologic soil groups are:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for artificially drained areas and the second is for undrained areas. Only soils that are rated D in their natural condition are assigned to dual classes, thus we included these soils in group d when calculating statistics for figure 3 (USDA NRCS 2006).

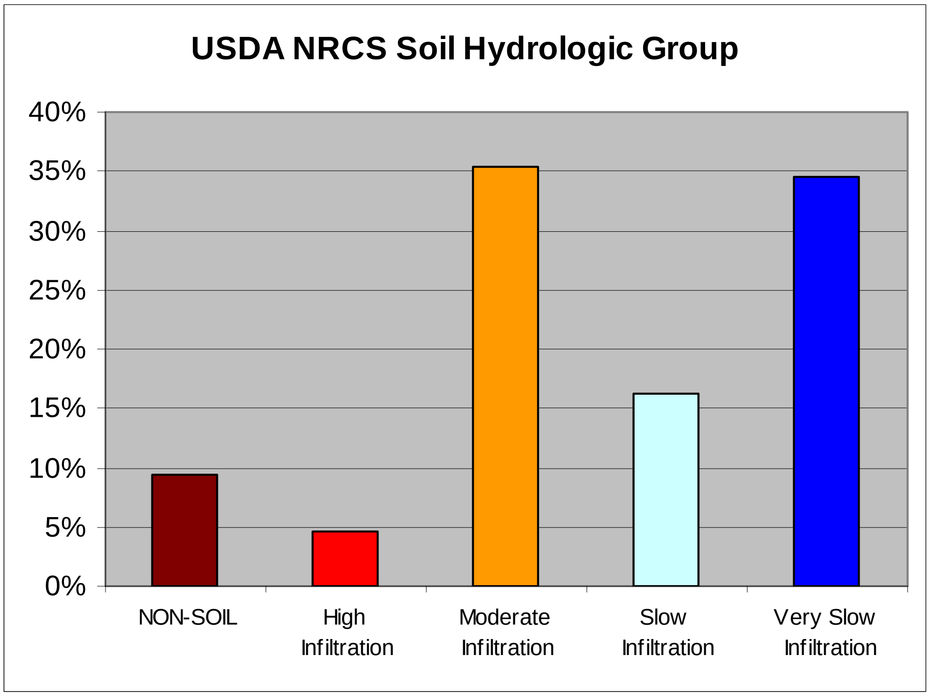


Figure 3. Distribution of soil hydrologic group type within study area.

Soil Drainage Class

Drainage class (natural) refers to the frequency and duration of wet periods under conditions similar to those under which the soil formed (see Figure 4 and Appendix 7). Alterations of the water regime by human activities, either through drainage or irrigation, are not a consideration unless they have significantly changed the morphology of the soil. Seven classes of natural soil drainage are recognized -- excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained, and very poorly drained (USDA NRCS 2006).

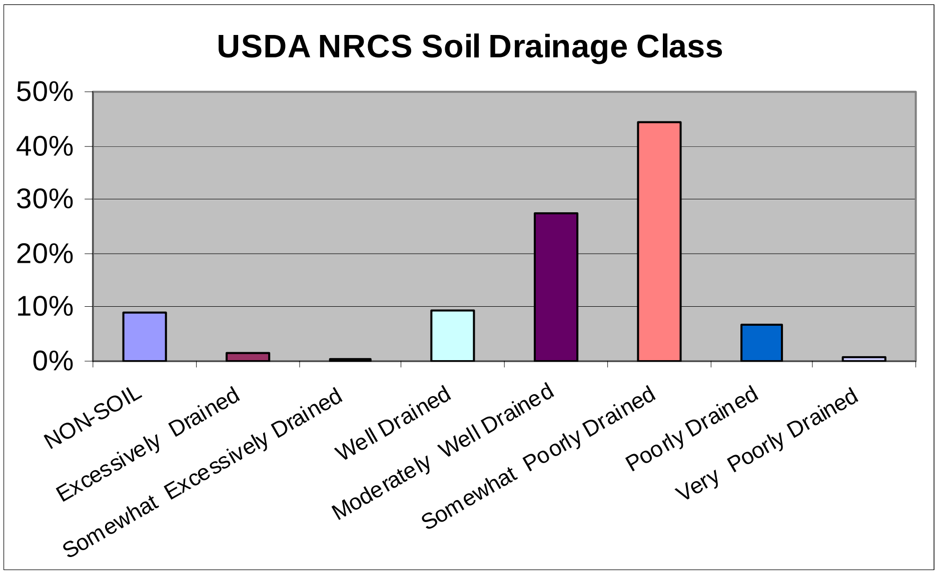


Figure 4. Distribution of soil drainage class in study area.

Public Lands

The public lands data can help provide contextual information regarding the proximity of public lands to that of a potential restoration area (see Tables 1.2 and 1.3 and Appendix 8). The Public Lands data consists of Missouri public lands updated in 2003 by MoRAP from the 1997 version as well as the Public Areas Database (PAD) for Kansas. The dataset consists of polygons of all publicly owned lands within the state. Only public lands that intersected the study area are included.

Table 1.2. Area of publicly owned lands that is located within the study area.

Public Lands within Study Area	
ha	2105.4
% Study Area	3.4%

Table 1.3. Five largest public areas within the study area boundary as well as their total area.

Public Area Name	Owner	State	Area within Study Area (ha)	Full size of Public Area (ha)
Dupree (Arthur) Memorial Conservation Area	Missouri Department of Conservation	MO	86.9	86.9
Little Bean Marsh Conservation Area	Missouri Department of Conservation	MO	177.9	177.9
Worthwine Island Conservation Area	Missouri Department of Conservation	MO	257.2	257.2
Fort Leavenworth	Department of Defense	KS	569.0	1573.6
Benedictine Bottoms	Other	MO	866.8	895.7

USDA NRCS Common Land Units (CLU)

CLU's provide farm tract and field boundaries digitized from aerial photographs (see Appendix 9). The CLU datasets used for this project were published in 2006 and obtained from the USDA NRCS Geospatial Data Gateway (http://datagateway.nrcs.usda.gov). Only CLU's that intersect the study area are included. This dataset will help determine where field boundaries are and potentially identify the size and number of tracts or fields that may encompass a restoration area.

Abiotic Habitat Site Types (ABHST)

The ABHST for a larger region was masked using the study area buffer and can be used to visualize the abiotic site types outside of the river valley, such as the bluffs along the river valley (see Appendix 10). To model abiotic site types, we used neighborhood analyses of 30 meter resolution digital elevation models (DEMs). The key variables assigned to each pixel included solar insolation, which integrates slope percent, shading, and exposure, and relative land position. We used a program called Shortwave to calculate solar insulation, and a program developed initially by Frank Biasi of The Nature Conservancy to calculate relative land position within a 9-cell neighborhood. Finally, we placed the pixels into classes (one to four) for solar insolation and land position, and then combined these to identify seven different abiotic site types. Flat uplands were modeled as an eighth site type when local relief within a 9-cell neighborhood was less than 15m, and the pixel was not identified as a floodplain or well-defined river valley bottom, which is the ninth abiotic site type.

2005 MoRAP Land Use/Land Cover (LULC)

The land use/land cover data for the state of Missouri was masked using the study area buffer and can be used to provide information on current land cover and land use within the study area to assist in the identification of restoration areas (see Figure 5 and Appendix 11). Land cover classification for Missouri was created by MoRAP based on circa 2000-2004 30 meter satellite imagery, and published in 2005. There are 14 classes of LULC that were mapped:

Impervious	Evergreen Forest
High Density Urban	Mixed Forest
Low Density Urban	Deciduous Woody/Herbaceous
Barren or Sparsely Vegetated	Evergreen Woody/Herbaceous
Cropland	Woody-Dominated Wetland
Grassland	Herbaceous-Dominated Wetland
Deciduous Forest	Open Water

Ancillary data for stream networks, the National Wetlands Inventory, and the Wetlands Restoration Program lands were used in a post hoc fashion to improve the mapping of open water, woody-dominated wetland, and herbaceous-dominated wetland.

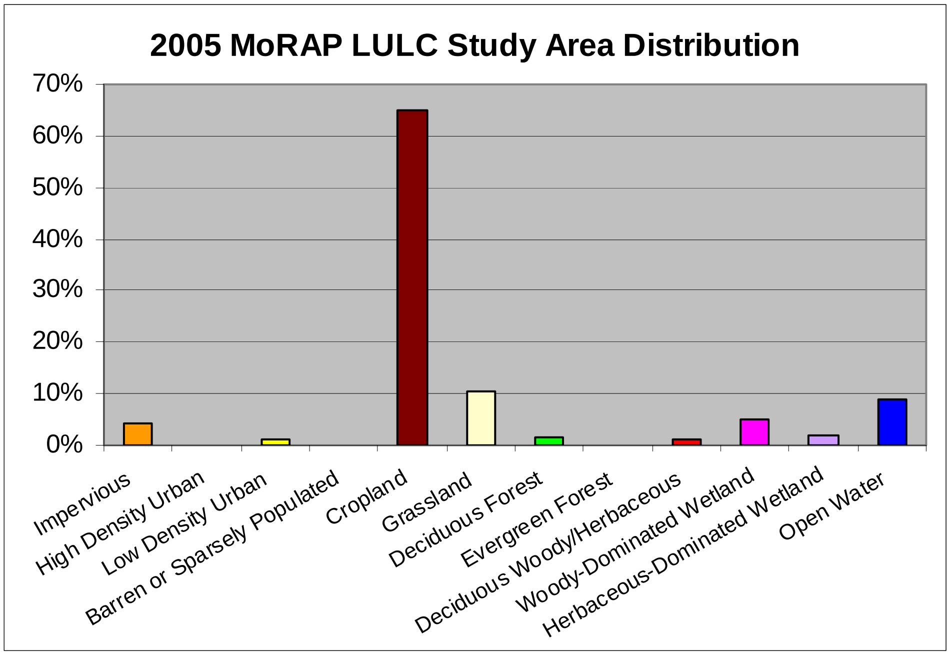


Figure 5. Distribution of LULC within the study area according to the 2005 MoRAP LULC.

Context – Distance Grids

Distance from Natural Vegetation

All natural and semi-natural land cover classes from the 2005 MoRAP LULC (grassland and all forest and wetland types) were selected and a distance grid was created illustrating the distance from patches of natural vegetation. The distances were then grouped into 5 classes (see Figure 6 and Appendix 12):

1 – 0-50 meters
2 – 50 – 100 meters
3 – 100 – 250 meters
4 – 250 – 500 meters
5 – + 500 meters

The closer to natural vegetation the higher the rank, based on the rationale that it is generally more effective to build on existing natural vegetation to create larger blocks, rather than to create new restoration areas distant from other natural or semi-natural vegetation.

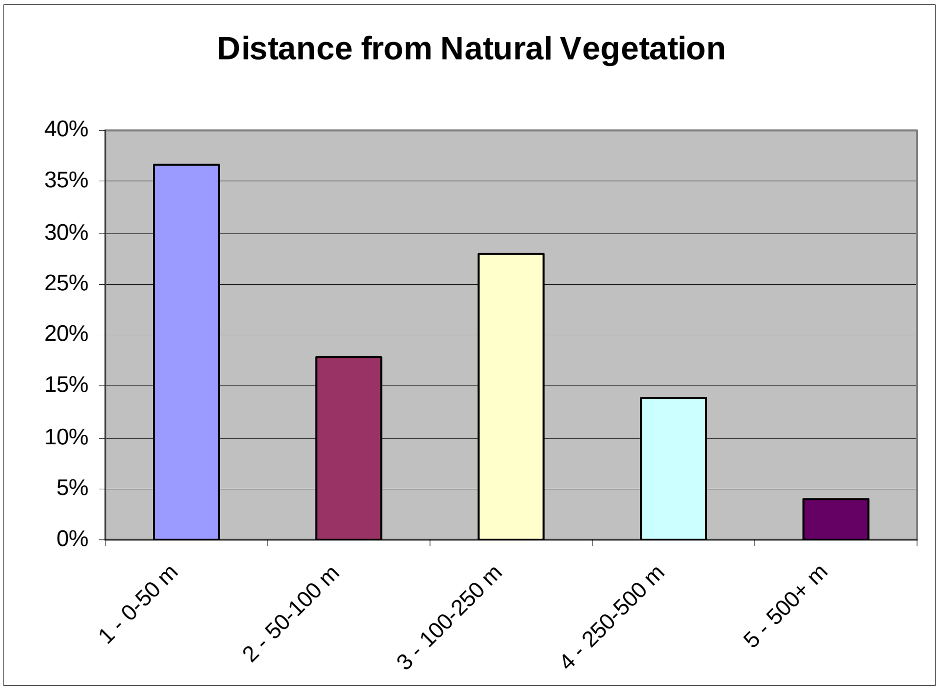


Figure 6. Distribution of distance from natural vegetation within study area.

Distance from Public Lands

Public lands within the study area were used to create a distance from public lands grid. The distances were then grouped into 5 classes (see Figure 7 and Appendix 13):
1 – 0-50 meters
2 – 50 – 100 meters
3 – 100 – 250 meters
4 – 250 – 500 meters
5 – + 500 meters
The closer to public lands the better the ranking, based on the rationale the areas adjacent to current public lands would be ideal locations to for restoration areas because larger blocks can be created, and because public lands are generally actively managed for wildlife habitat.

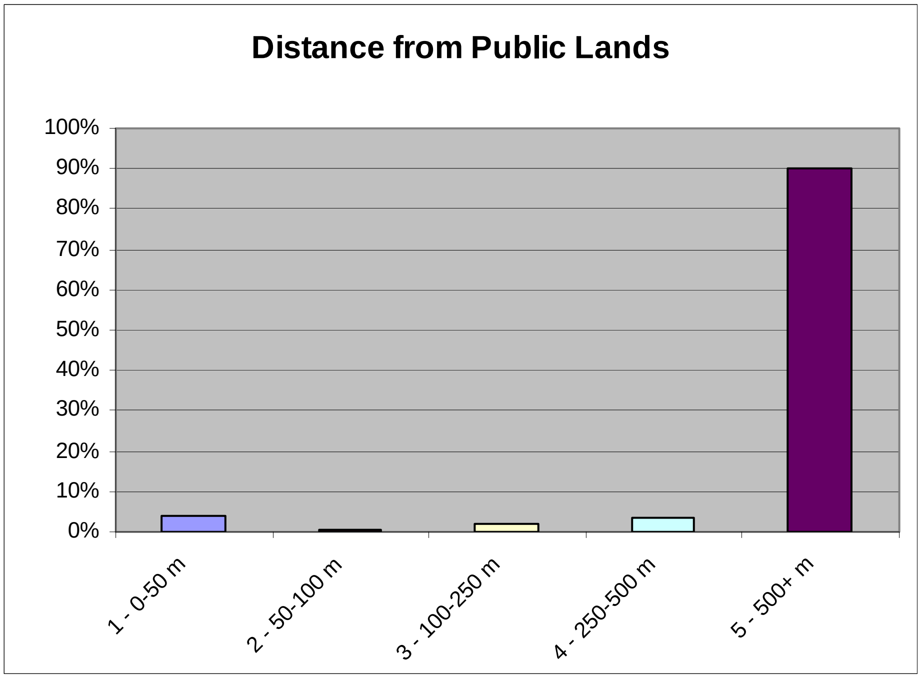


Figure 7. Distribution of distance from public lands within study area.

Distance form Urban Areas and Impervious Surfaces

All urban and impervious classes from the 2005 MoRAP Land Use/Land Cover were selected and a distance grid was created. The distances were then grouped into 5 classes (see Figure 8 and Appendix 14):
1 – 500+ meters
2 –500 – 250 meters
3 – 250 – 100 meters
4 – 100 – 50 meters
5 – 0 – 50 meters
The further from urban areas and impervious surfaces the better the ranking, based on the rationale that areas within or adjacent to urban areas suffer more from deleterious urban impacts and edge effects, and are more likely to be converted to urban land over time.

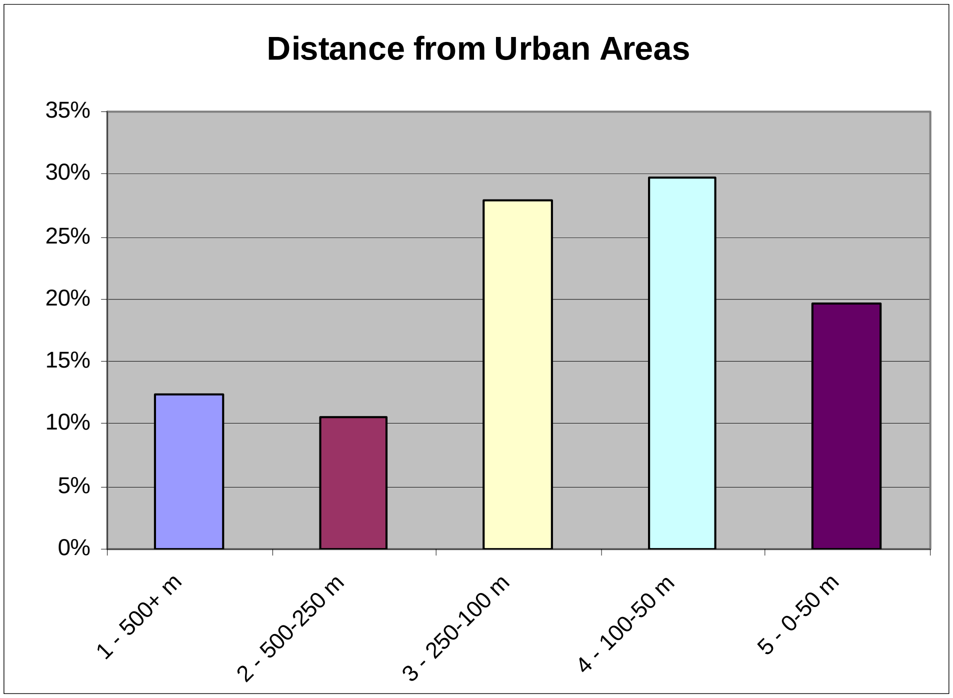


Figure 8. Distribution of distance from urban areas.

Landscape Context

In order to gain some contextual information, all three distance grids were added together to identify those areas that are most ideal for restoration based on proximity to urban areas, natural vegetation, and public lands. This dataset represents a composite of the distance grids in which pixels with the lower values are "most ideal" for restoration based on landscape context (see Figure 9 and Appendix 15). A value of three indicates the most ideal area for restoration, as it is furthest from urban and closest to natural vegetation and public lands. As the value increases, the less ideal the location for restoration becomes, until the maximum value of 15 is reached. A value of 15 indicates that the area is within or directly adjacent to urban areas and impervious surfaces and the furthest distance from natural vegetation and public areas. However, this index is strongly influenced by the distance to public lands, since so few exist within the floodplain.

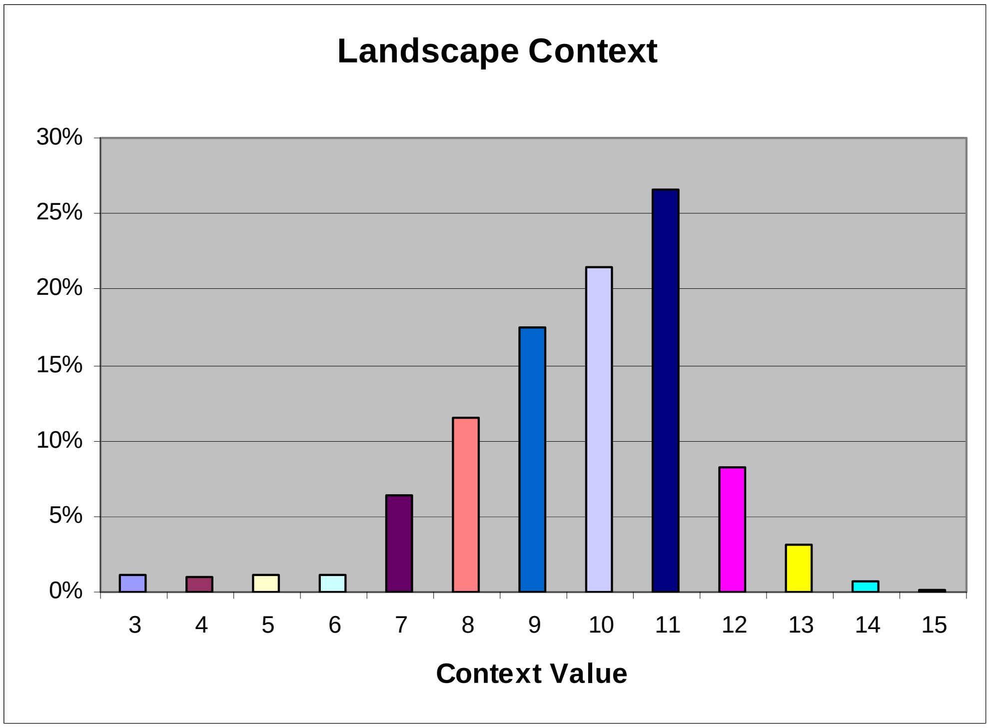


Figure 9. Distribution of context values created to identify the best restoration areas based on proximity to urban areas, natural vegetation, and public lands by adding the distance grids. A value of 3 is considered the best location (closest to natural vegetation and public lands and furthest from urban areas) and 15 is the worst (furthest from natural vegetation public lands and closest to urban areas).

2005 USDA FSA National Agriculture Imagery Program (NAIP) Color Imagery

Included for viewing purposes are ortho-rectified color NAIP images for all counties within the study area. These images can be used to help determine what real world features are on the ground at sites within the study area. NAIP acquires digital ortho imagery during the agricultural growing seasons in the continental U.S. NAIP quarter quads are formatted to the UTM coordinate system using NAD83 and have a spatial resolution of 2 meters. The NAIP imagery for Missouri counties was acquired from the Missouri Spatial Data Information Service (MSDIS) webpage at msdisweb.missouri.edu, while imagery for Kansas counties was acquired from the Kansas Geospatial Community Commons (KGCC) webpage located at www.kansasgis.org.

Potential Restoration Areas

Potential herbaceous wetland and bottomland forest restorations areas were identified by intersecting the relative elevation (river) and soil hydrologic group datasets. Holbrook et al. (2006) suggested that ideal locations for wetland restoration within the

Missouri River floodplain occur at locations that have relatively low topographic elevation and have slow rates of infiltration. Thus, ideal locations for herbaceous wetland restoration are those that have low relative elevation as well as slow infiltration. Those areas that have relatively high elevation and high infiltration rates were considered ideal bottomland forest restoration areas.

The data set was created by adding the relative elevation grid to the soil hydrologic group grid (Figure 11). Each grid was coded 1 through 4:

Relative Elevation	**Soil Hydrologic Group**
1 – Low Elevation	1 – Very Slow Infiltration
2 – Medium Low Elevation	2 – Slow Infiltration
3 – Medium High Elevation	3 – Moderate Infiltration
4 – High Elevation	4 – High Infiltration

Therefore, a resultant value of 2 identifies locations with low elevation (1) and very slow infiltration, which indicates that this location is most suitable for herbaceous wetland restoration. As values increase, the areas become less suited for wetland restoration and more suited for bottomland forest restoration, until the maximum value of 8 is reached. A value of 8 identifies locations with high elevation and high infiltration. There is more area with a potential for wetland restoration than bottomland forest restoration (Figure 10).

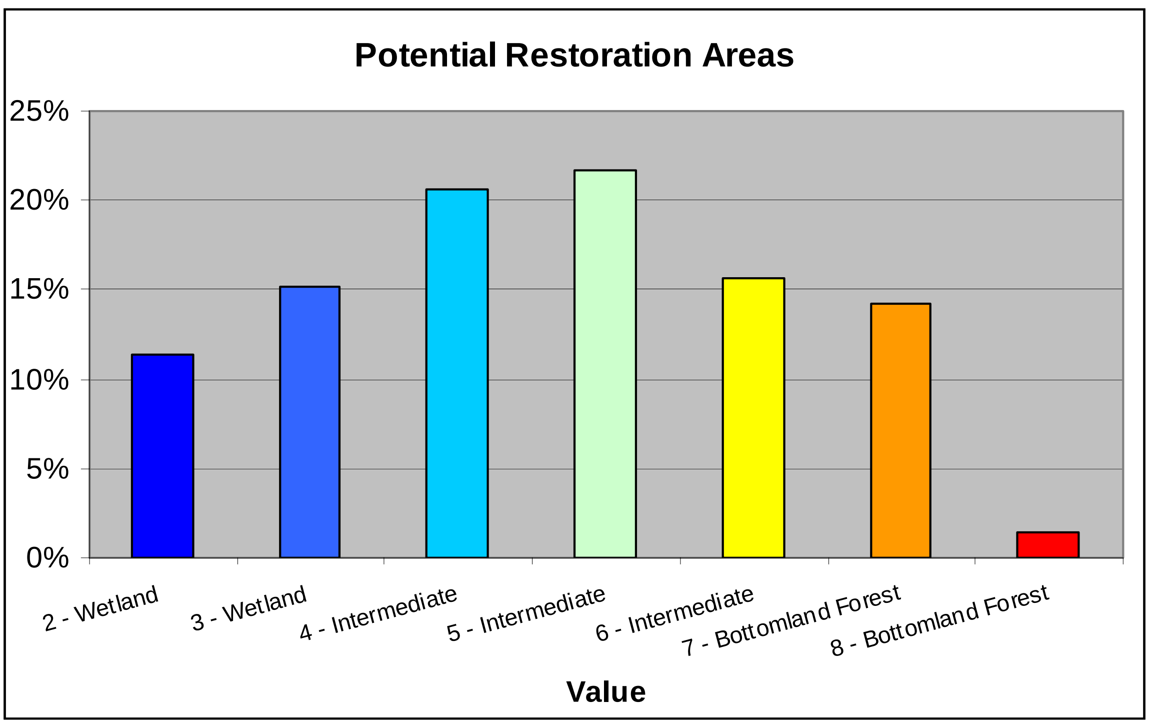


Figure 10. Distribution of potential herbaceous wetland and bottomland forest restoration areas within the study area. Potential wetland restoration is characterized by areas that have low relative elevation and slow soil infiltration rates. Bottomland forest restoration areas are characterized by high relative elevation and high infiltration rates.

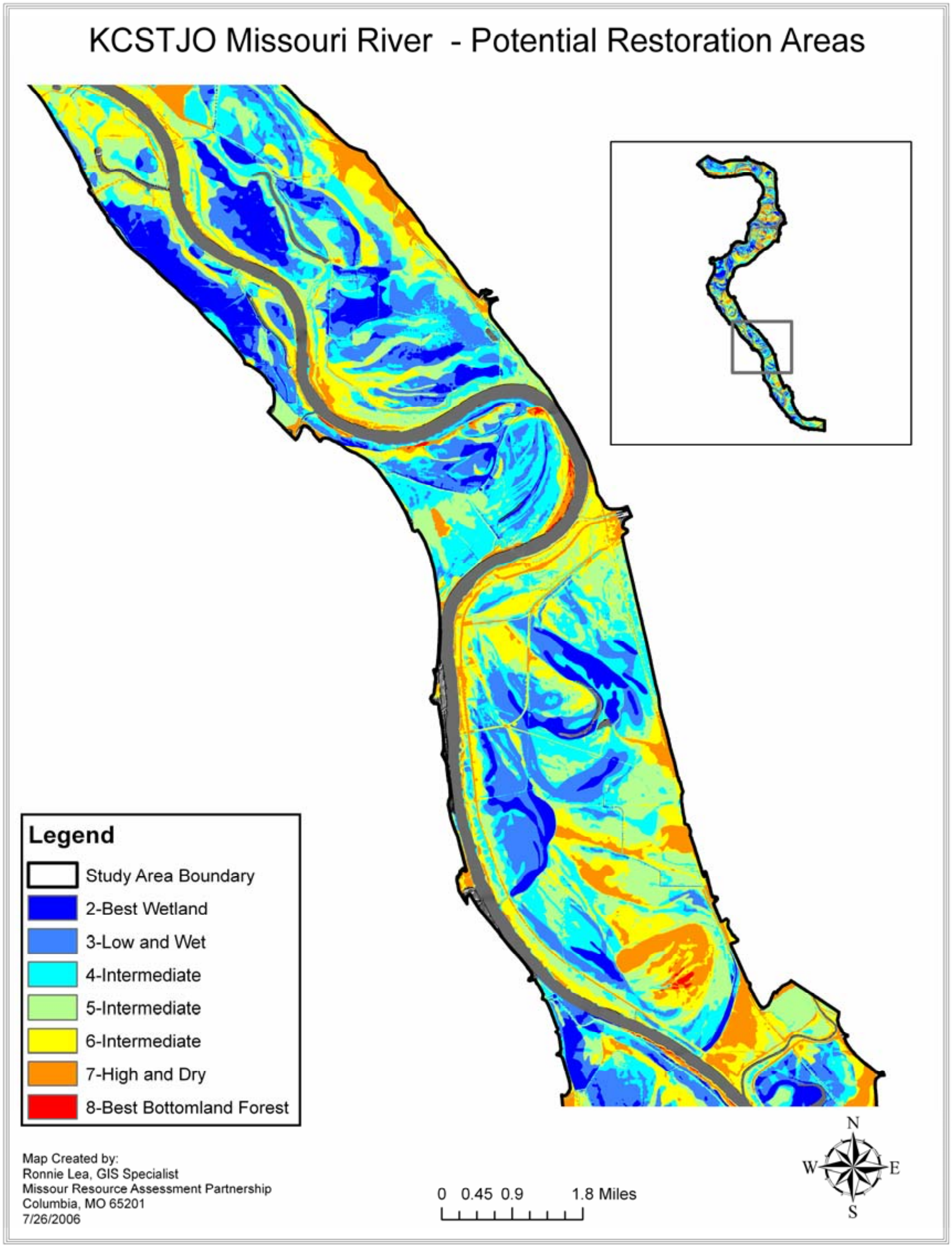
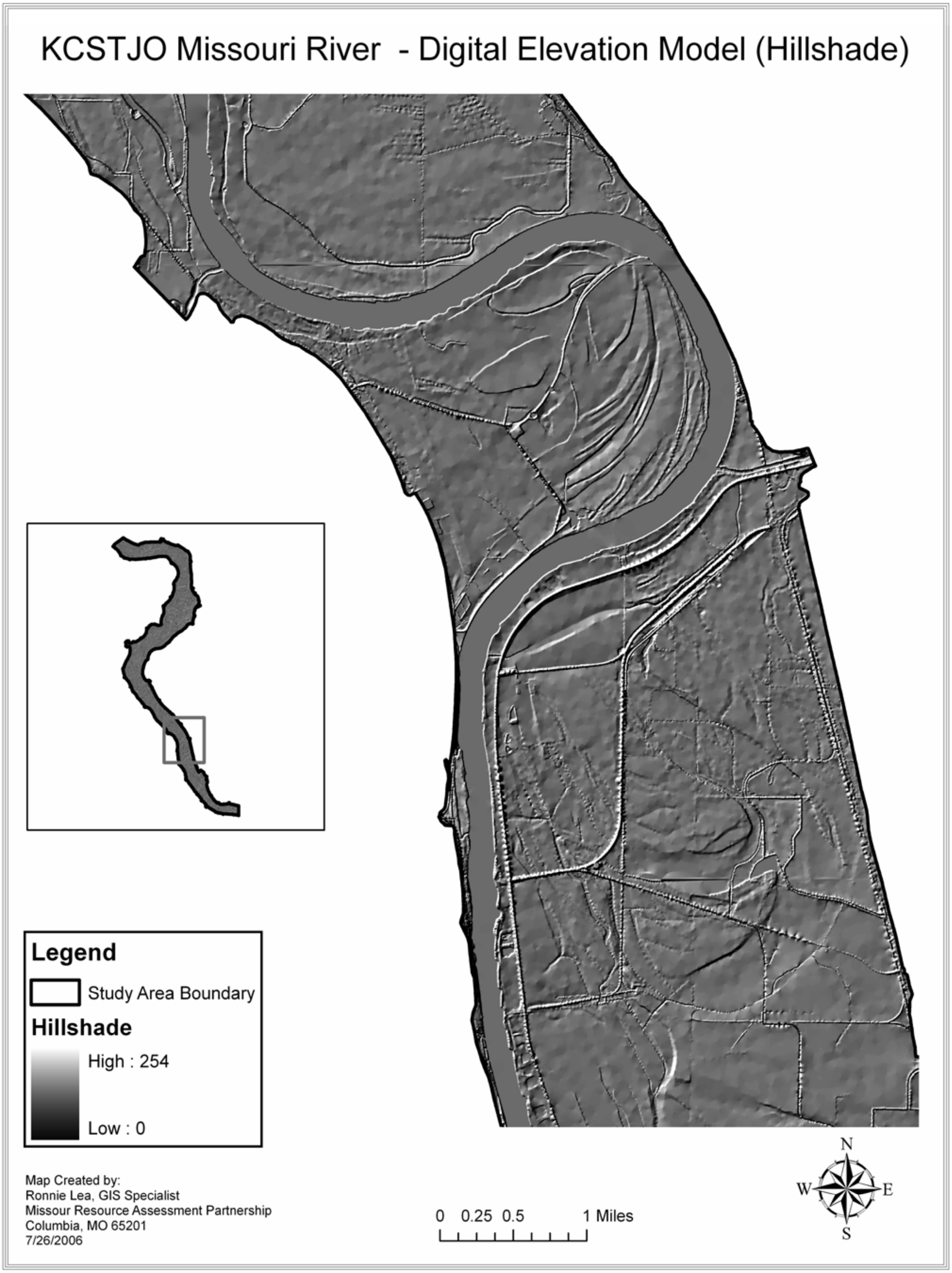


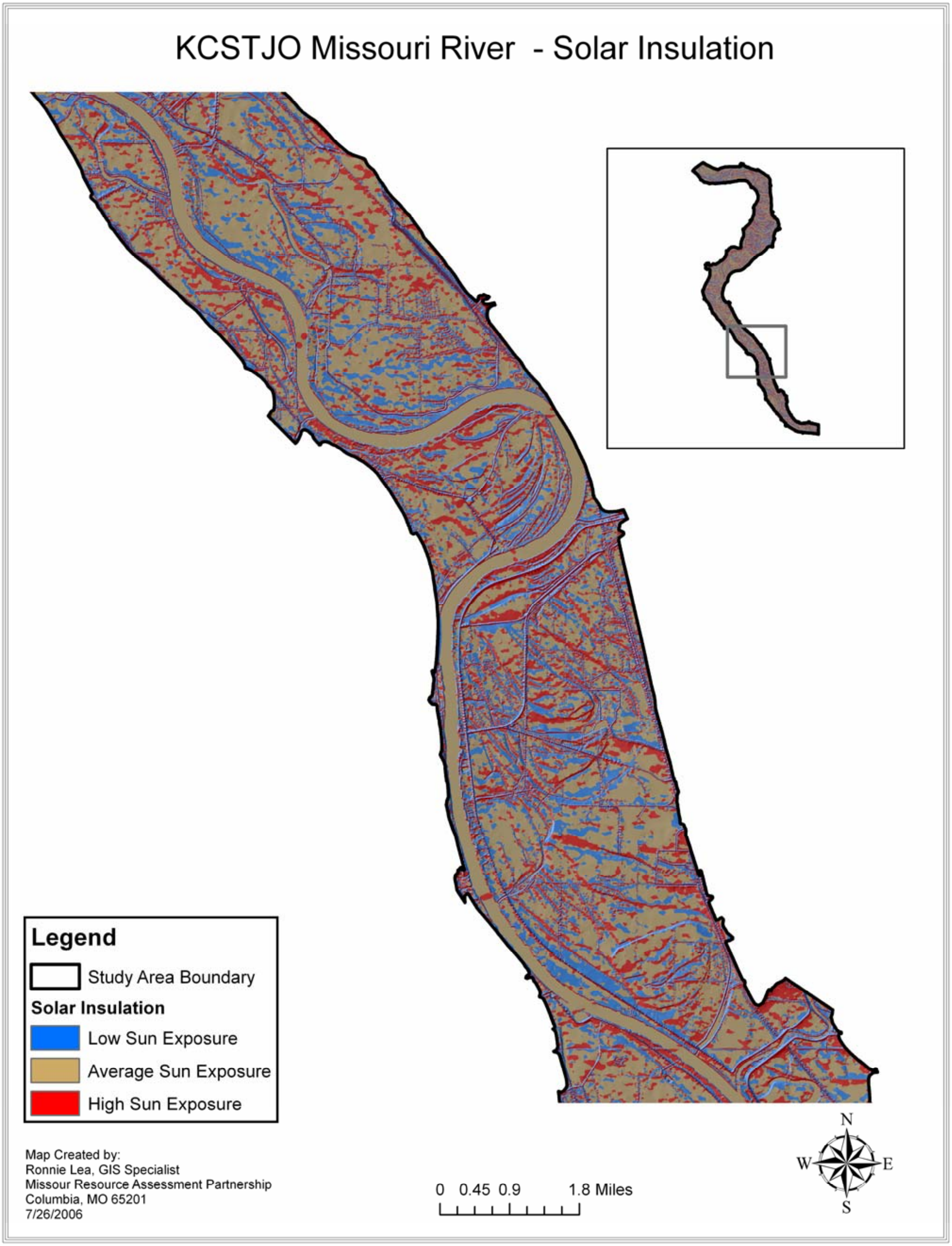
Figure 11. Potential restoration areas created by intersecting relative elevation and soil infiltration rates.

Appendix

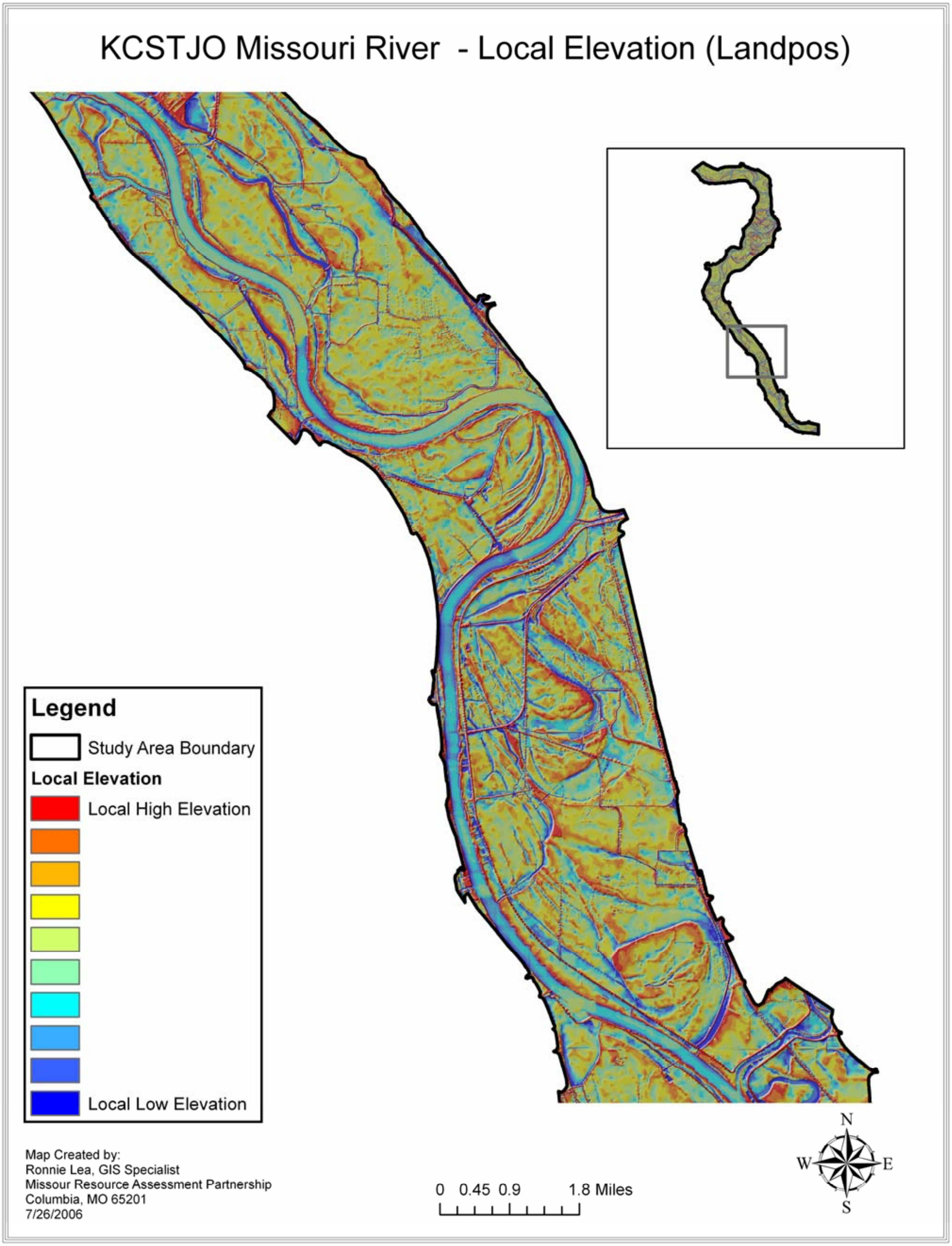
Appendix 1: KCSTJO Missouri River Digital Elevation Model
Appendix 2: KCSTJO Missouri River Solar Insolation
Appendix 3: KCSTJO Missouri River Local Elevation (Landpos)
Appendix 4: KCSTJO Missouri River Relative Elevation (River Level)
Appendix 5: KCSTJO Missouri River Relative Elevation (10 year Flood Stage)
Appendix 6: KCSTJO Missouri River USDA NRCS SSURGO Soil Hydrologic Group
Appendix 7: KCSTJO Missouri River USDA NRCS SSURGO Soil Drainage Class
Appendix 8: KCSTJO Missouri River Public Lands
Appendix 9: KCSTJO Missouri River USDA NRCS Common Land Units
Appendix 10: KCSTJO Missouri River Abiotic Habitat Site Type
Appendix 11: KCSTJO Missouri River 2005 MoRAP LULC
Appendix 12: KCSTJO Missouri River Distance from Natural Vegetation
Appendix 13: KCSTJO Missouri River Distance from Public Lands
Appendix 14: KCSTJO Missouri River Distance from Urban Areas/Impervious Surfaces
Appendix 15: KCSTJO Missouri River Proximity to Urban, Natural Vegetation, and Public Lands
Appendix 16: KCSTJO Potential Restoration Areas


KCSTJO Missouri River - Digital Elevation Model (Hillshade)
Legend
Study Area Boundary
Hillshade
High : 254
Low : 0
Map Created by:
Ronnie Lea, GIS Specialist
Missour Resource Assessment Partnership
Columbia, MO 65201
7/26/2006
0 0.25 0.5 1 Miles
N
W
E
S

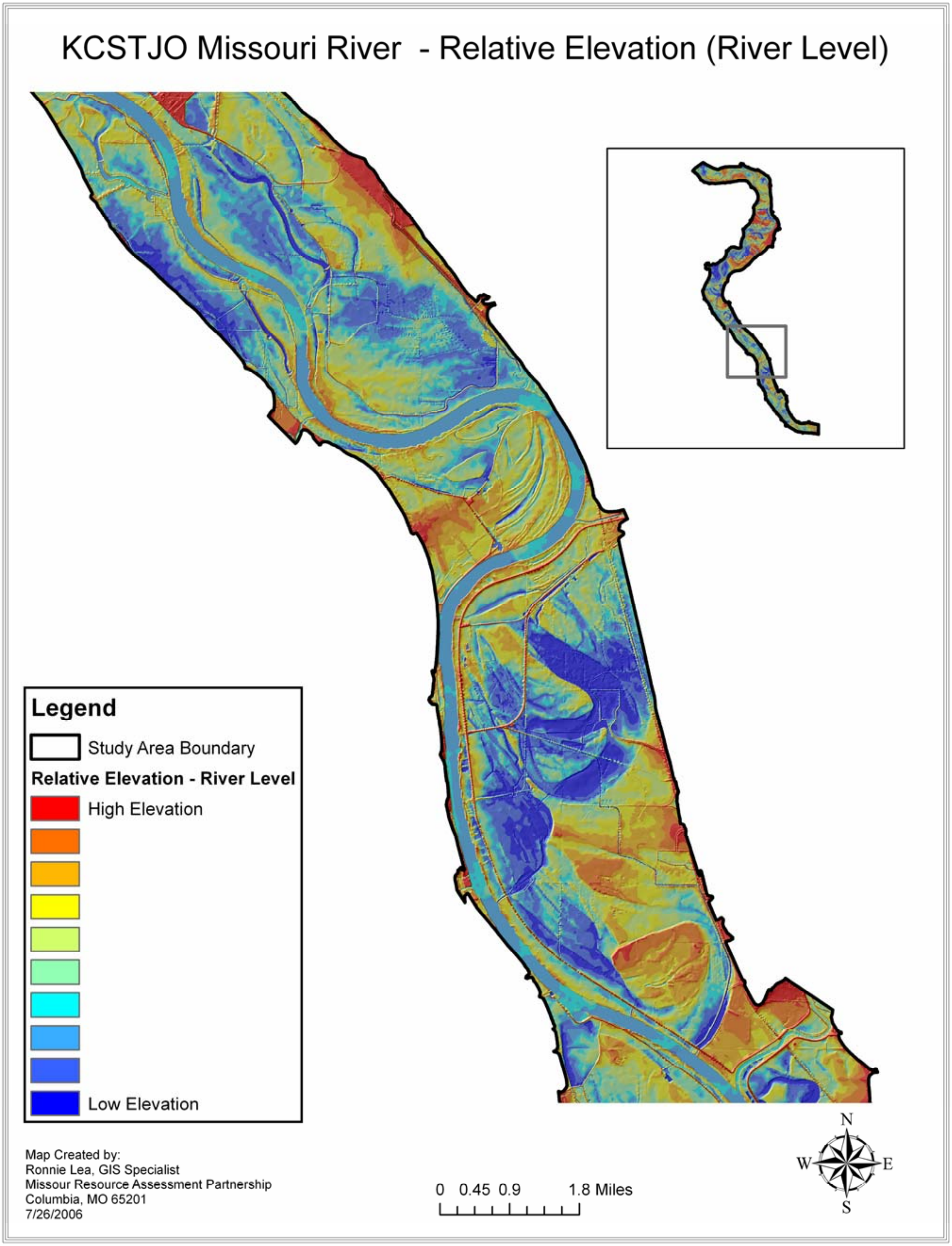
Appendix 1


KCSTJO Missouri River - Solar Insulation
Legend
Study Area Boundary
Solar Insulation
Low Sun Exposure
Average Sun Exposure
High Sun Exposure
Map Created by:
Ronnie Lea, GIS Specialist
Missour Resource Assessment Partnership
Columbia, MO 65201
7/26/2006
0 0.45 0.9 1.8 Miles
N
W
E
S

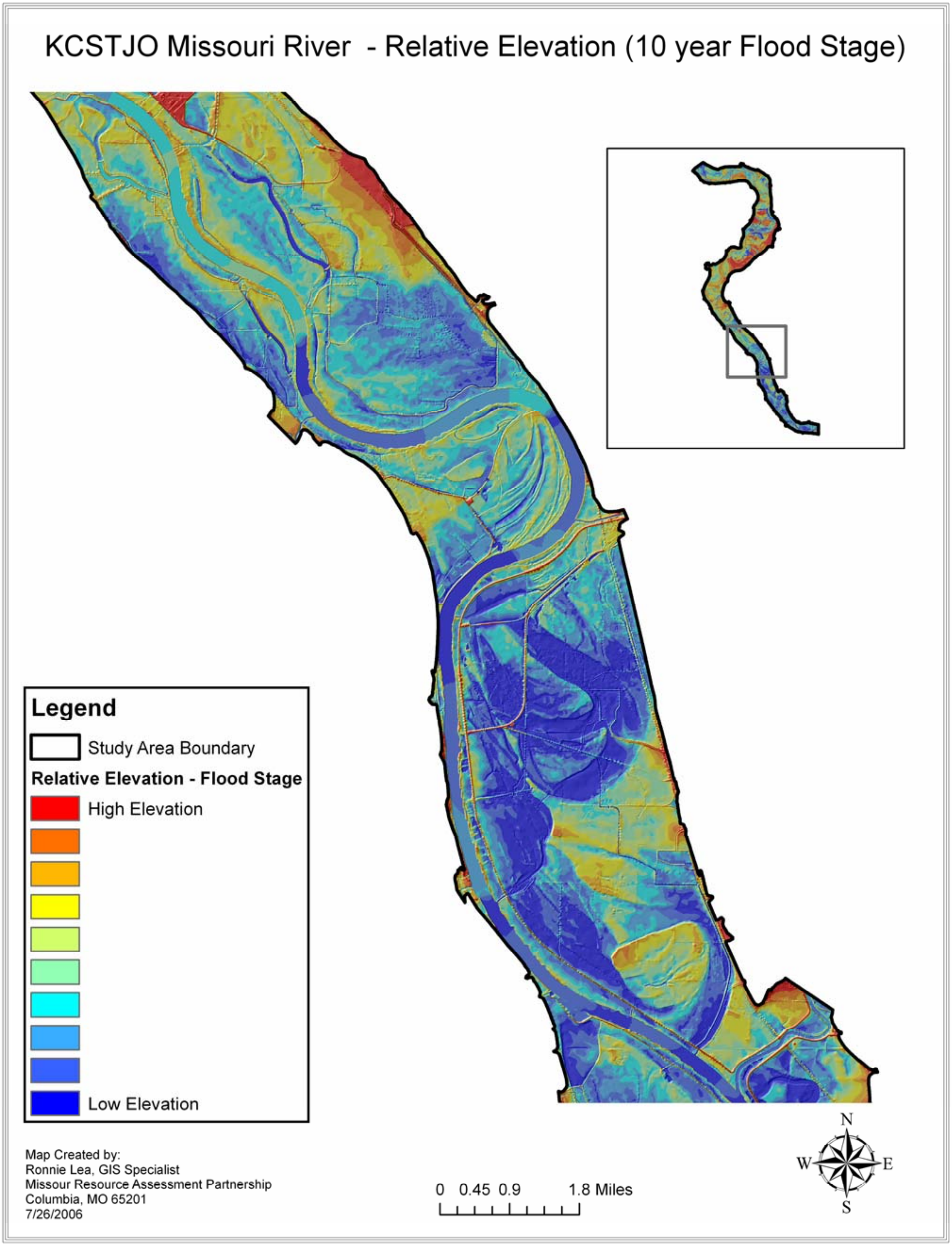
Appendix 2


KCSTJO Missouri River - Local Elevation (Landpos)
Legend
Study Area Boundary
Local Elevation
Local High Elevation
Local Low Elevation
Map Created by:
Ronnie Lea, GIS Specialist
Missour Resource Assessment Partnership
Columbia, MO 65201
7/26/2006
0 0.45 0.9 1.8 Miles
N
W
E
S

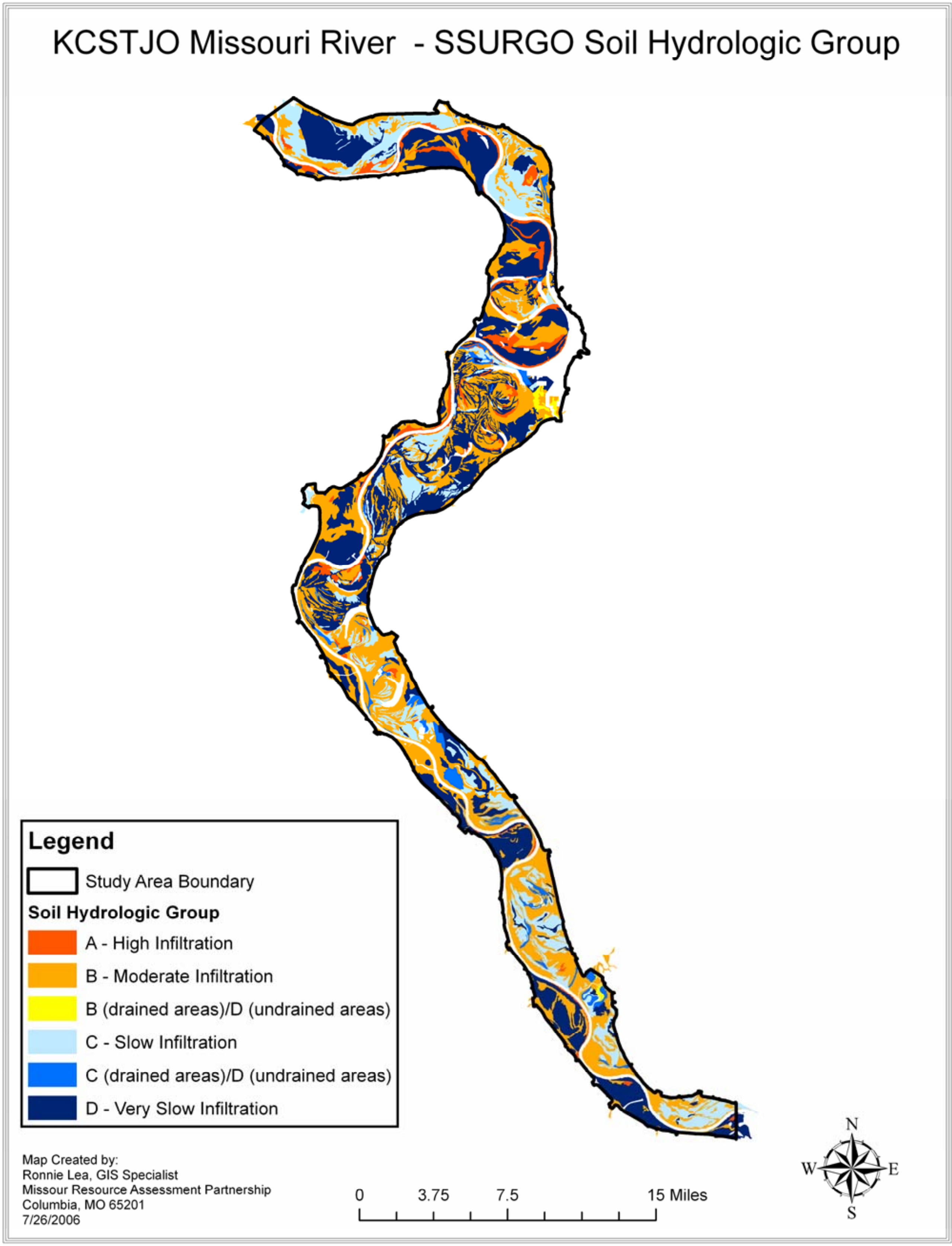
Appendix 3


KCSTJO Missouri River - Relative Elevation (River Level)
Legend
Study Area Boundary
Relative Elevation - River Level
High Elevation
Low Elevation
Map Created by:
Ronnie Lea, GIS Specialist
Missour Resource Assessment Partnership
Columbia, MO 65201
7/26/2006
0 0.45 0.9 1.8 Miles
N
W
E
S

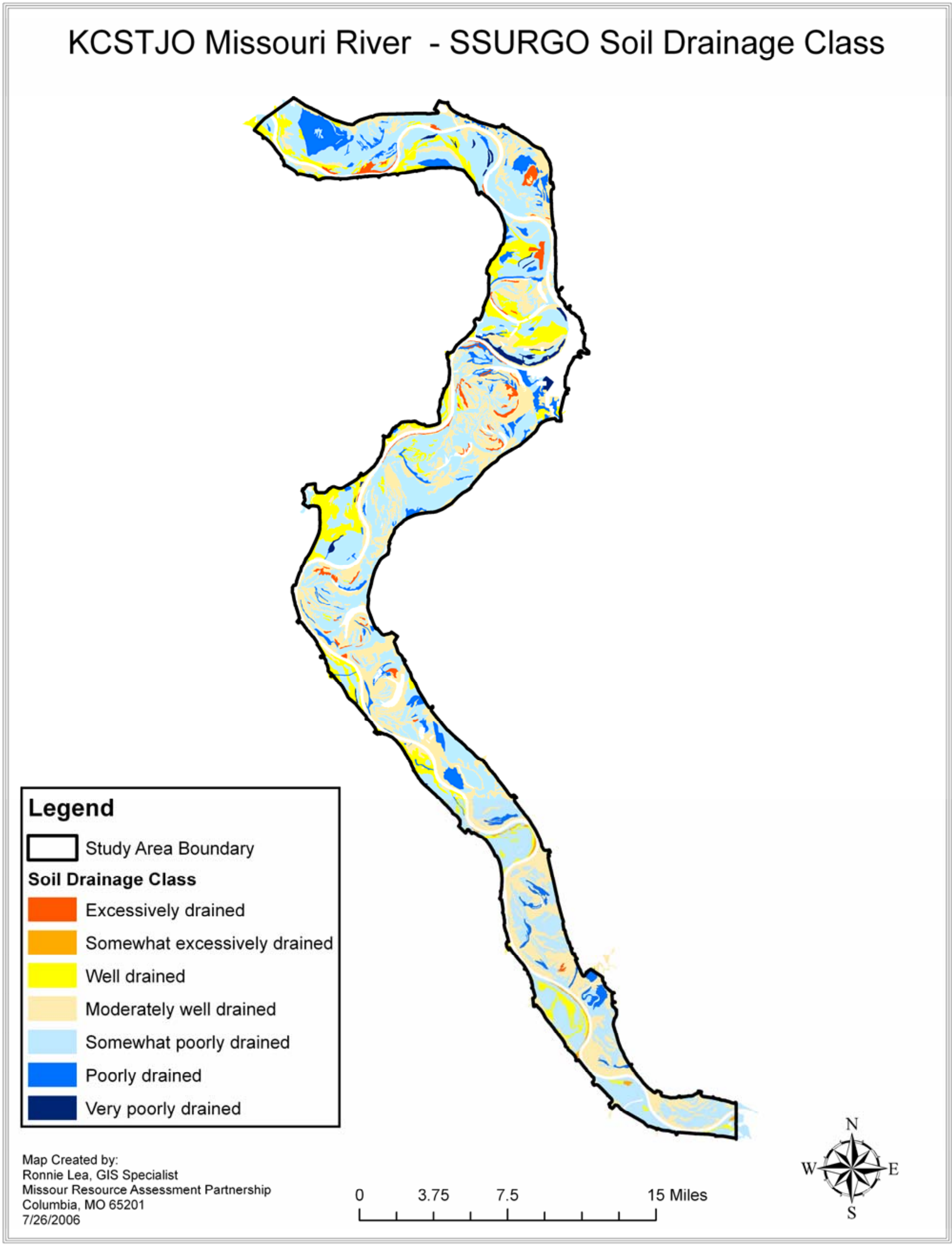
Appendix 4


KCSTJO Missouri River - Relative Elevation (10 year Flood Stage)
Legend
Study Area Boundary
Relative Elevation - Flood Stage
High Elevation
Low Elevation
Map Created by:
Ronnie Lea, GIS Specialist
Missour Resource Assessment Partnership
Columbia, MO 65201
7/26/2006
0 0.45 0.9 1.8 Miles
N
W
E
S

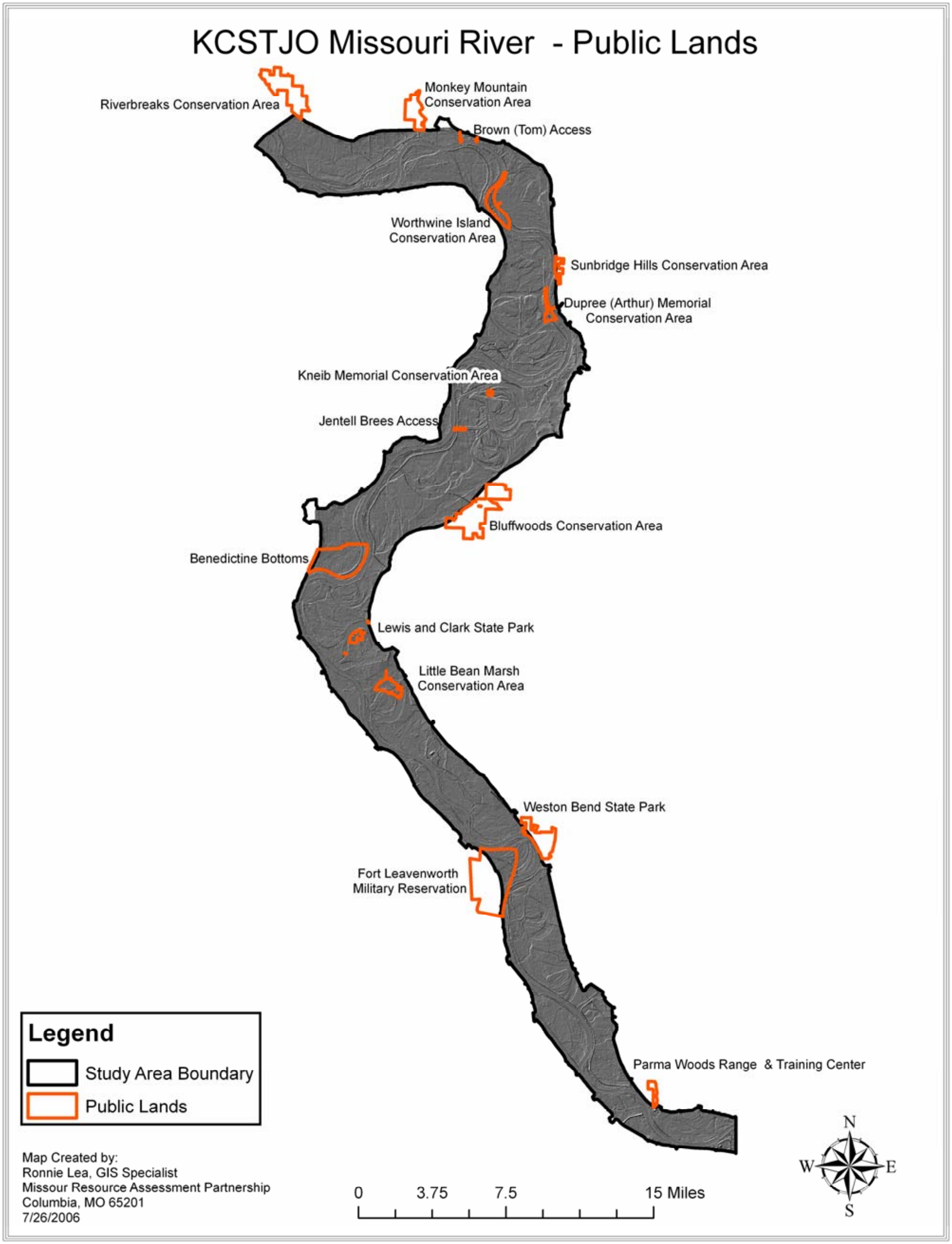
Appendix 5


KCSTJO Missouri River - SSURGO Soil Hydrologic Group
Legend
Study Area Boundary
Soil Hydrologic Group
A - High Infiltration
B - Moderate Infiltration
B (drained areas)/D (undrained areas)
C - Slow Infiltration
C (drained areas)/D (undrained areas)
D - Very Slow Infiltration
Map Created by:
Ronnie Lea, GIS Specialist
Missour Resource Assessment Partnership
Columbia, MO 65201
7/26/2006
0
3.75
7.5
15 Miles
N
W
E
S

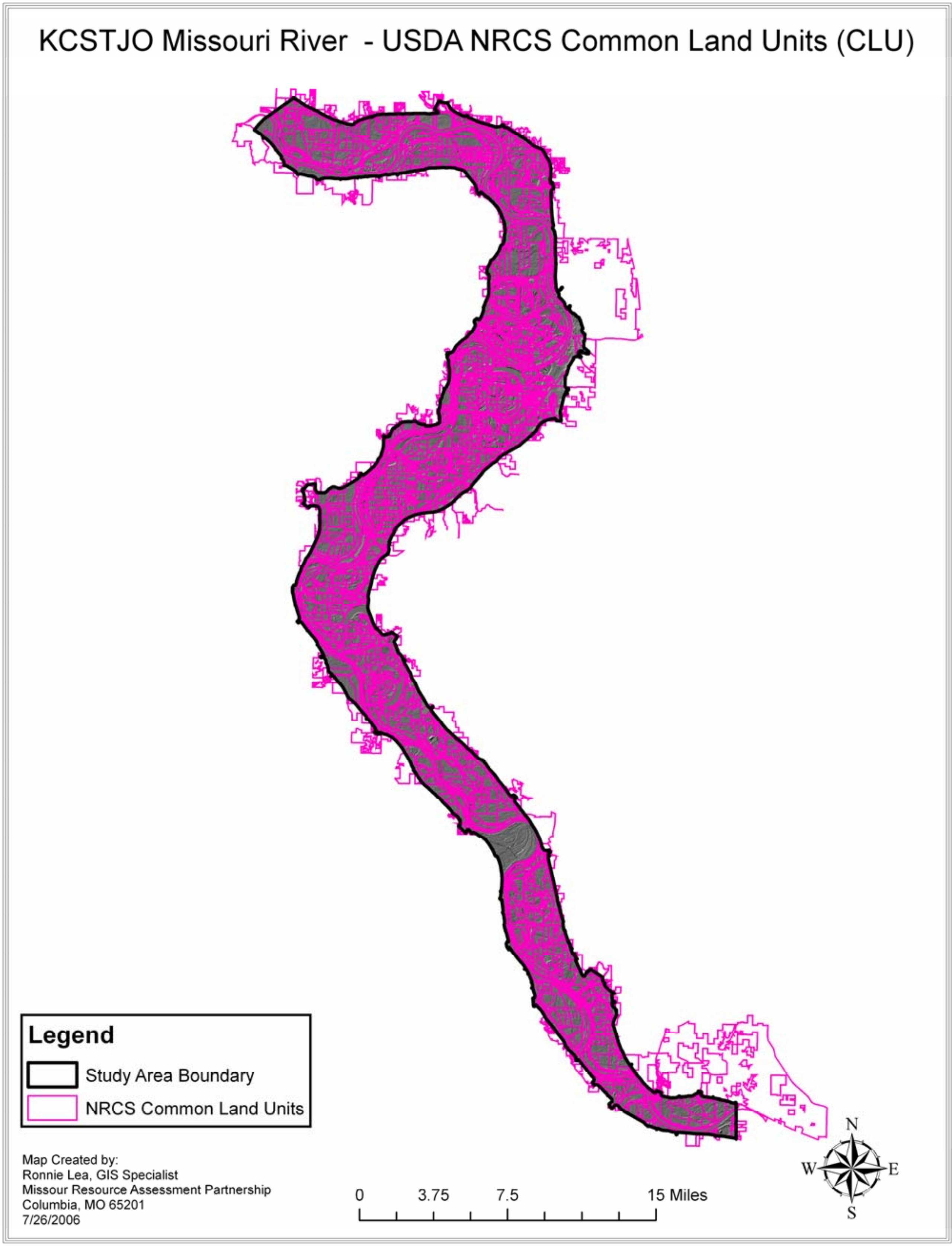
Appendix 6


KCSTJO Missouri River - SSURGO Soil Drainage Class
Legend
Study Area Boundary
Soil Drainage Class
Excessively drained
Somewhat excessively drained
Well drained
Moderately well drained
Somewhat poorly drained
Poorly drained
Very poorly drained
Map Created by:
Ronnie Lea, GIS Specialist
Missour Resource Assessment Partnership
Columbia, MO 65201
7/26/2006
0
3.75
7.5
15 Miles
N
W
E
S

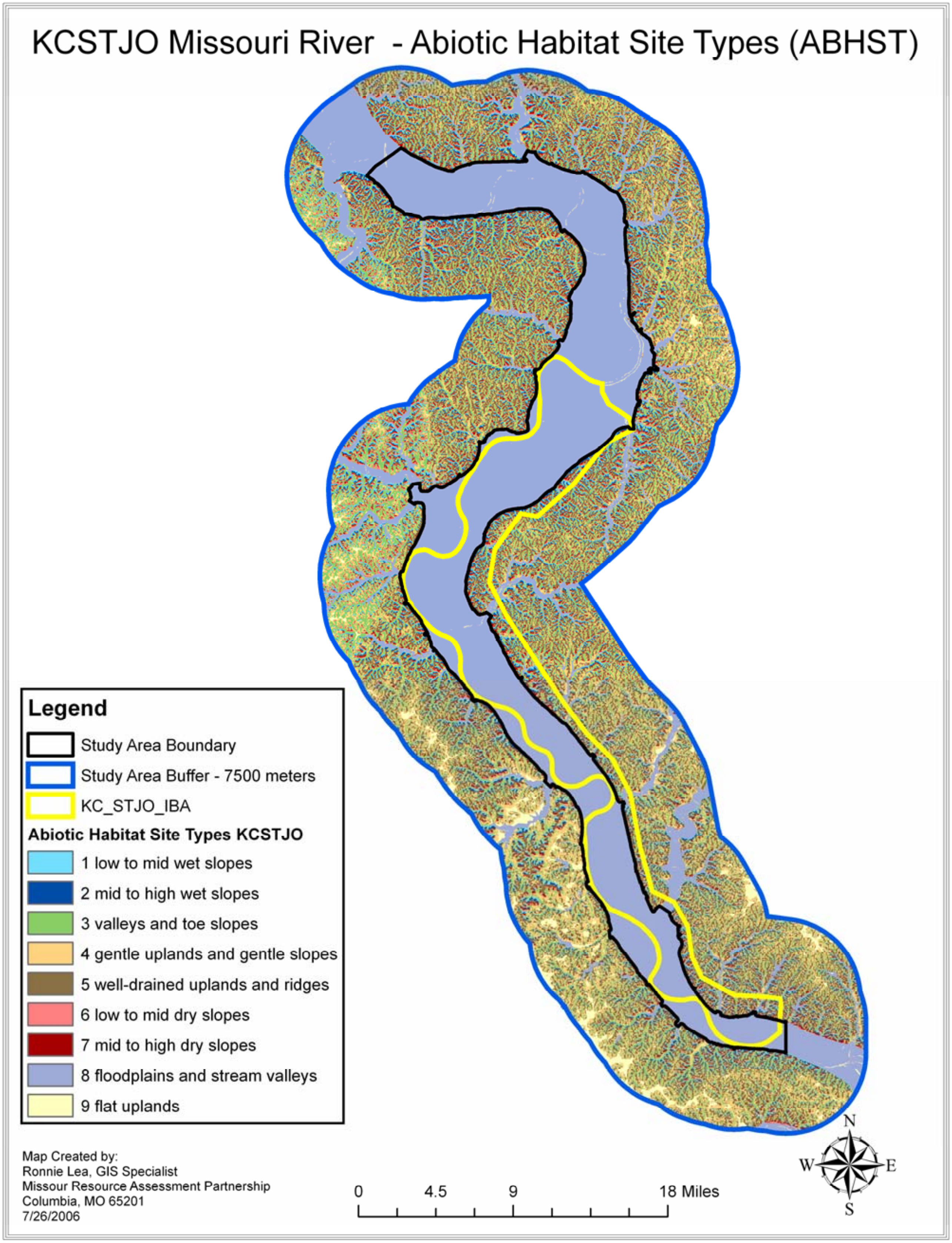
Appendix 7


KCSTJO Missouri River - Public Lands
Riverbreaks Conservation Area
Monkey Mountain
Conservation Area
Brown (Tom) Access
Worthwine Island
Conservation Area
Sunbridge Hills Conservation Area
Dupree (Arthur) Memorial
Conservation Area
Kneib Memorial Conservation Area
Jentell Brees Access
Bluffwoods Conservation Area
Benedictine Bottoms
Lewis and Clark State Park
Little Bean Marsh
Conservation Area
Weston Bend State Park
Fort Leavenworth
Military Reservation
Parma Woods Range & Training Center
Legend
Study Area Boundary
Public Lands
Map Created by:
Ronnie Lea, GIS Specialist
Missour Resource Assessment Partnership
Columbia, MO 65201
7/26/2006
0
3.75
7.5
15 Miles
N
W
E
S

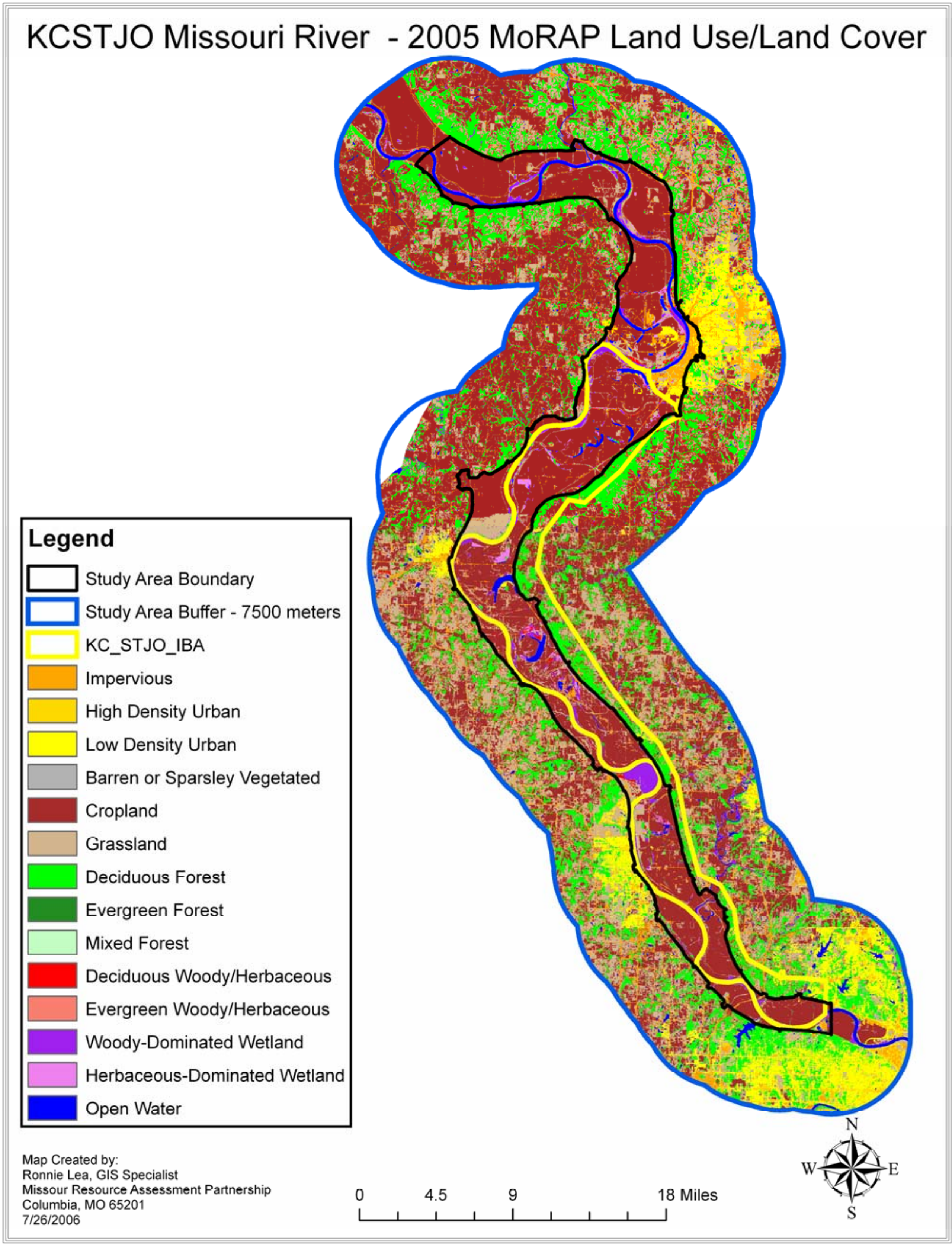
Appendix 8


KCSTJO Missouri River - USDA NRCS Common Land Units (CLU)
Legend
Study Area Boundary
NRCS Common Land Units
Map Created by:
Ronnie Lea, GIS Specialist
Missour Resource Assessment Partnership
Columbia, MO 65201
7/26/2006
0
3.75
7.5
15 Miles
N
W
E
S

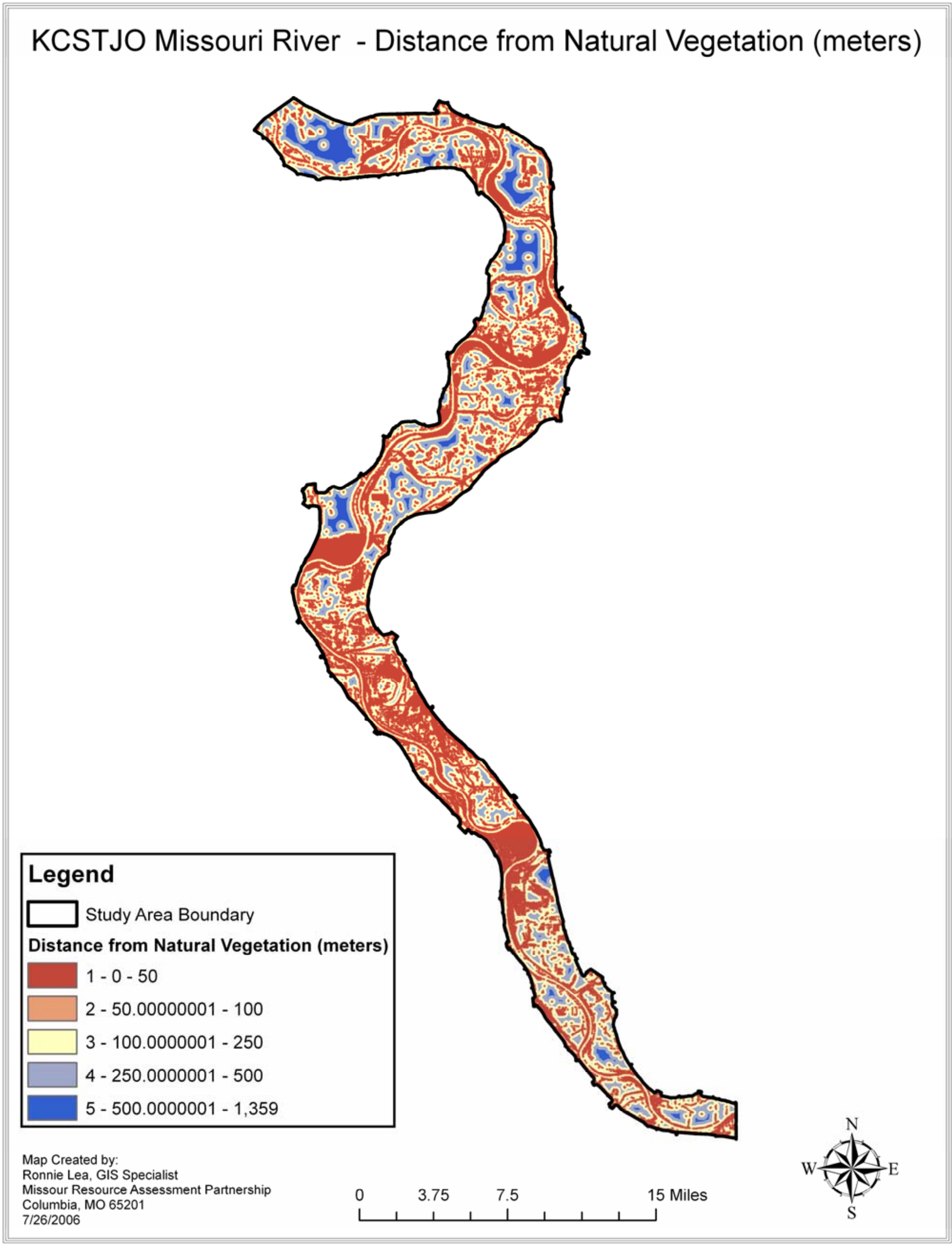
Appendix 9


KCSTJO Missouri River - Abiotic Habitat Site Types (ABHST)
Legend
Study Area Boundary
Study Area Buffer - 7500 meters
KC_STJO_IBA
Abiotic Habitat Site Types KCSTJO
1 low to mid wet slopes
2 mid to high wet slopes
3 valleys and toe slopes
4 gentle uplands and gentle slopes
5 well-drained uplands and ridges
6 low to mid dry slopes
7 mid to high dry slopes
8 floodplains and stream valleys
9 flat uplands
Map Created by:
Ronnie Lea, GIS Specialist
Missour Resource Assessment Partnership
Columbia, MO 65201
7/26/2006
0
4.5
9
18 Miles
N
W
E
S

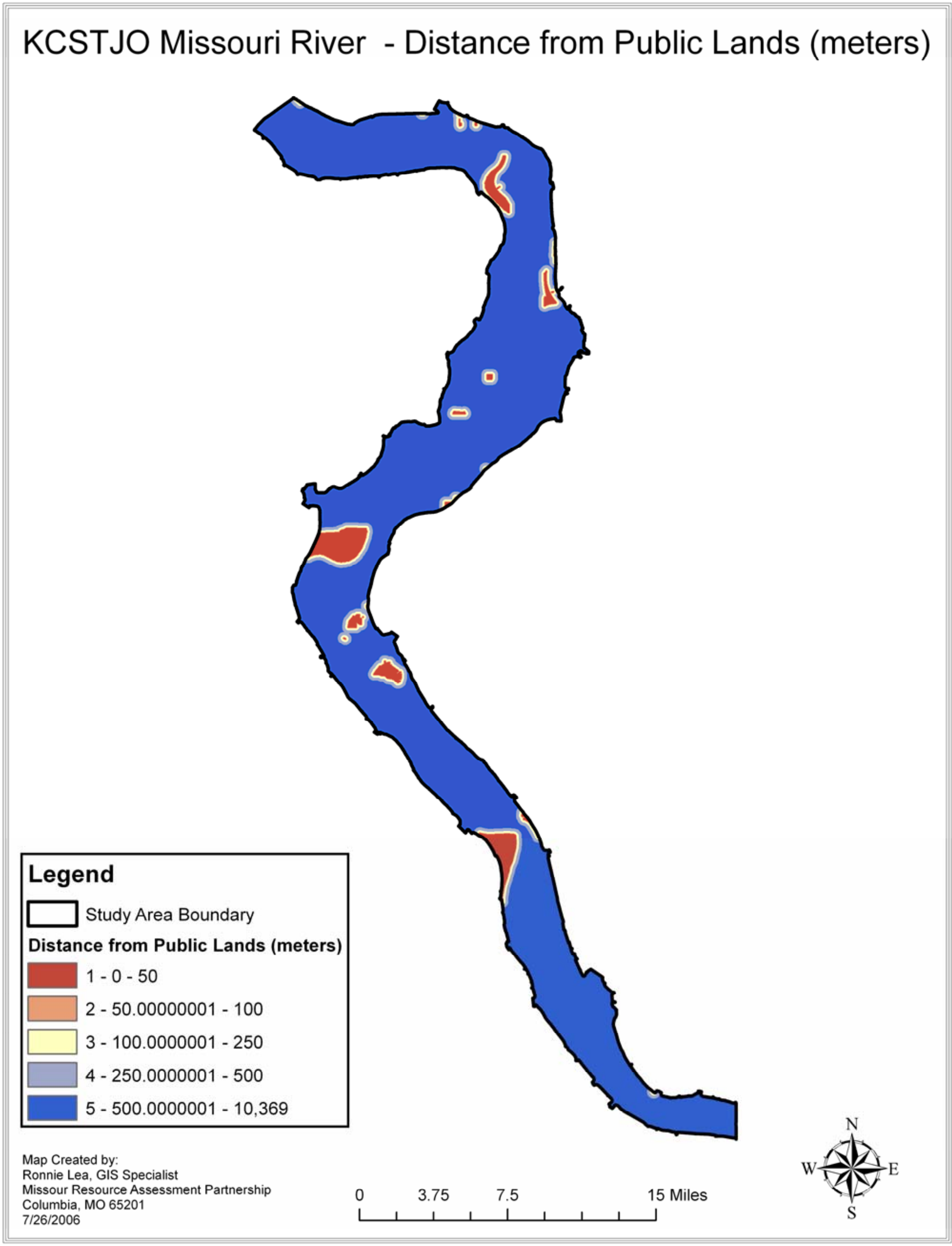
Appendix 10


KCSTJO Missouri River - 2005 MoRAP Land Use/Land Cover
Legend
Study Area Boundary
Study Area Buffer - 7500 meters
KC_STJO_IBA
Impervious
High Density Urban
Low Density Urban
Barren or Sparsley Vegetated
Cropland
Grassland
Deciduous Forest
Evergreen Forest
Mixed Forest
Deciduous Woody/Herbaceous
Evergreen Woody/Herbaceous
Woody-Dominated Wetland
Herbaceous-Dominated Wetland
Open Water
Map Created by:
Ronnie Lea, GIS Specialist
Missour Resource Assessment Partnership
Columbia, MO 65201
7/26/2006
0
4.5
9
18 Miles
N
W
E
S

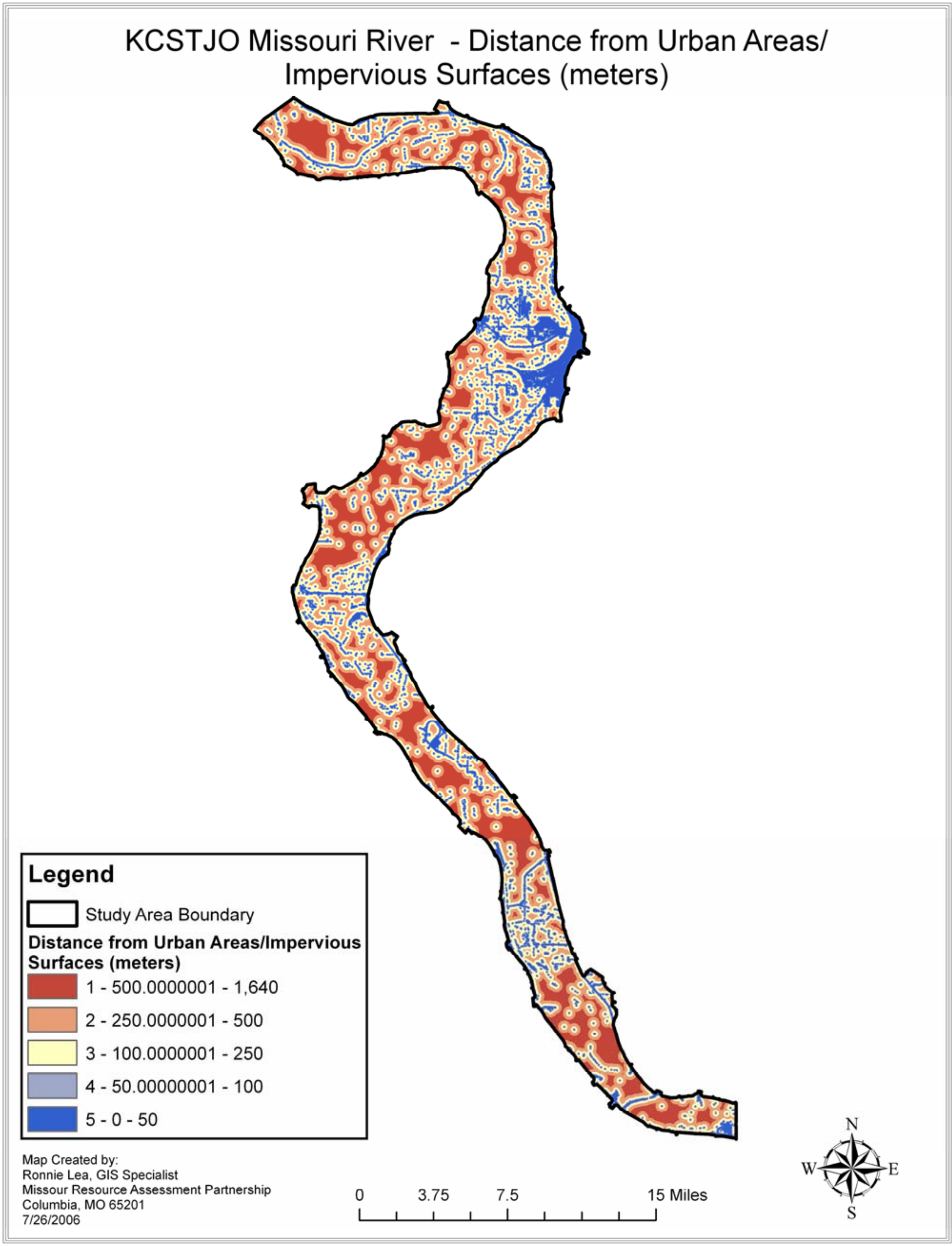
Appendix 11


KCSTJO Missouri River - Distance from Natural Vegetation (meters)
Legend
Study Area Boundary
Distance from Natural Vegetation (meters)
1 - 0 - 50
2 - 50.00000001 - 100
3 - 100.0000001 - 250
4 - 250.0000001 - 500
5 - 500.0000001 - 1,359
Map Created by:
Ronnie Lea, GIS Specialist
Missour Resource Assessment Partnership
Columbia, MO 65201
7/26/2006
0
3.75
7.5
15 Miles
N
W
E
S

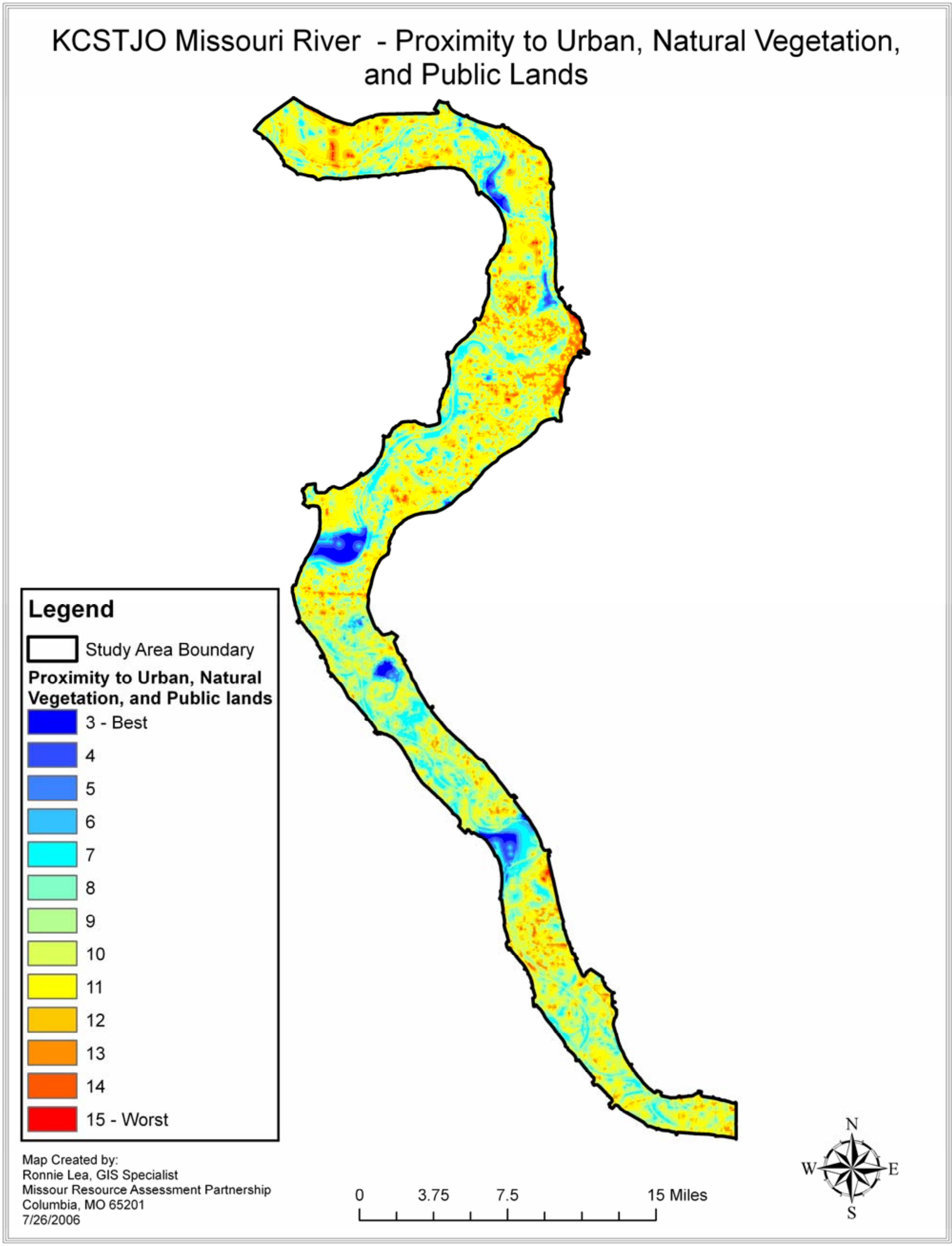
Appendix 12


KCSTJO Missouri River - Distance from Public Lands (meters)
Legend
Study Area Boundary
Distance from Public Lands (meters)
1 - 0 - 50
2 - 50.00000001 - 100
3 - 100.0000001 - 250
4 - 250.0000001 - 500
5 - 500.0000001 - 10,369
Map Created by:
Ronnie Lea, GIS Specialist
Missour Resource Assessment Partnership
Columbia, MO 65201
7/26/2006
0
3.75
7.5
15 Miles
N
W
E
S

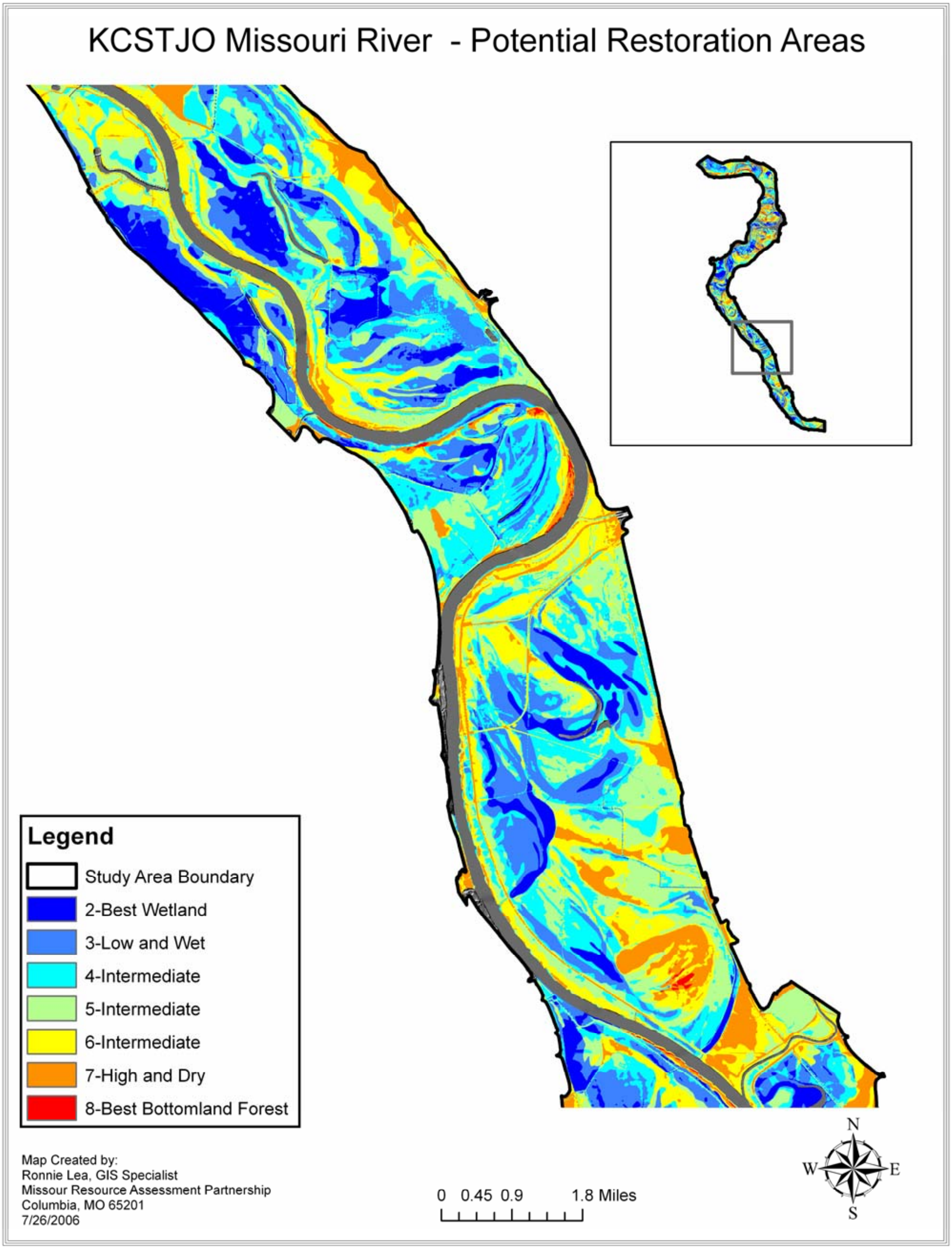
Appendix 13


KCSTJO Missouri River - Distance from Urban Areas/ Impervious Surfaces (meters)
Legend
Study Area Boundary
Distance from Urban Areas/Impervious Surfaces (meters)
1 - 500.0000001 - 1,640
2 - 250.0000001 - 500
3 - 100.0000001 - 250
4 - 50.00000001 - 100
5 - 0 - 50
Map Created by:
Ronnie Lea, GIS Specialist
Missour Resource Assessment Partnership
Columbia, MO 65201
7/26/2006
0
3.75
7.5
15 Miles
N
W
E
S

Appendix 14


KCSTJO Missouri River - Proximity to Urban, Natural Vegetation, and Public Lands
Legend
Study Area Boundary
Proximity to Urban, Natural Vegetation, and Public lands
3 - Best
4
5
6
7
8
9
10
11
12
13
14
15 - Worst
Map Created by:
Ronnie Lea, GIS Specialist
Missour Resource Assessment Partnership
Columbia, MO 65201
7/26/2006
0
3.75
7.5
15 Miles
N
W
E
S

Appendix 15


KCSTJO Missouri River - Potential Restoration Areas
Legend
Study Area Boundary
2-Best Wetland
3-Low and Wet
4-Intermediate
5-Intermediate
6-Intermediate
7-High and Dry
8-Best Bottomland Forest
Map Created by:
Ronnie Lea, GIS Specialist
Missour Resource Assessment Partnership
Columbia, MO 65201
7/26/2006
0 0.45 0.9 1.8 Miles
N
W
E
S

Appendix 16

Literature Cited

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