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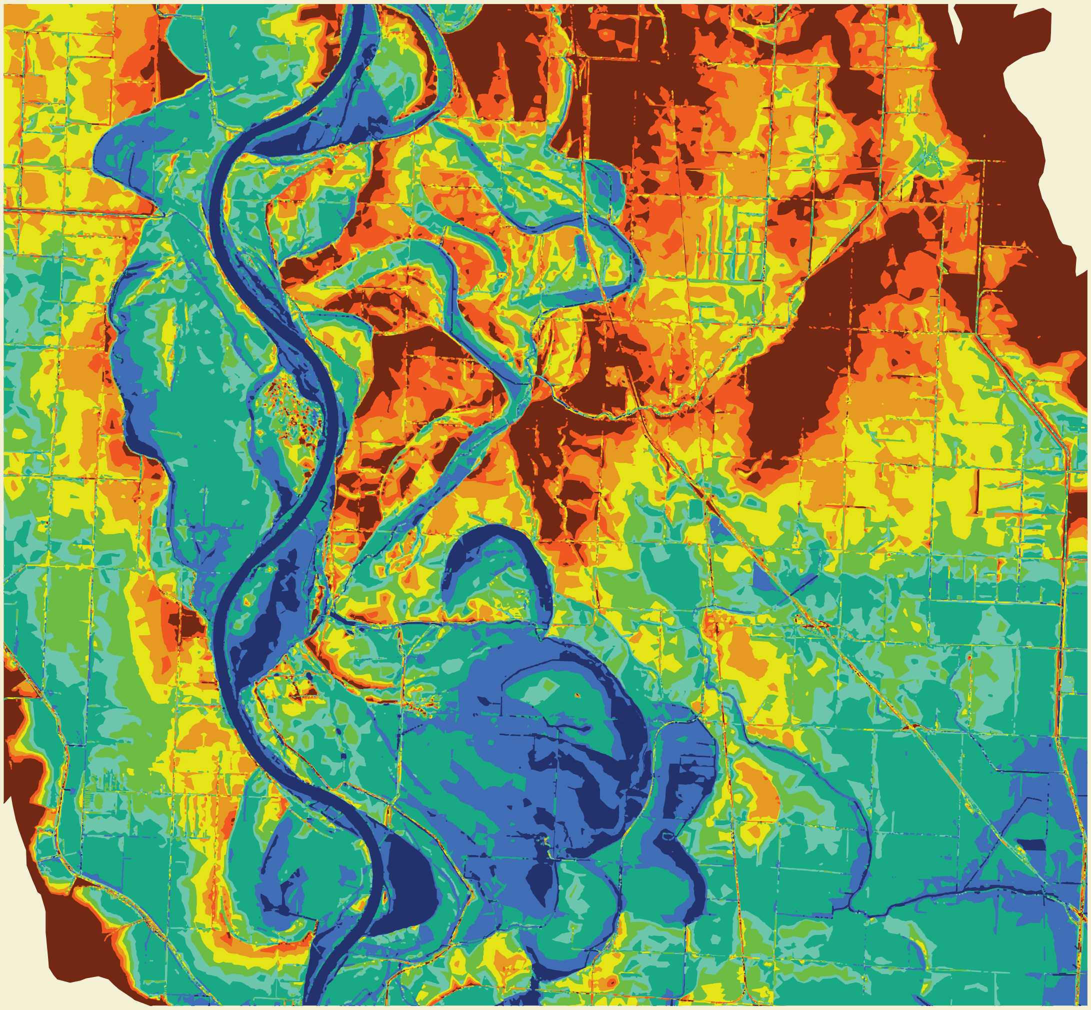
Land Capability Potential Index (LCPI) and Geodatabase for the Lower Missouri River Valley



Data Series 736

U.S. Department of the Interior
U.S. Geological Survey

Front cover. Modified version of figure 6 showing the modeled flow-recurrence interval of a part of the Lower Missouri River valley bottom near Omaha, Nebraska.

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KEN SALAZAR, Secretary

U.S. Geological Survey
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Conversion Factors and Datum

Inch/Pound to SI

Multiply	By	To obtain
	Length	
mile (mi)	1.609	kilometer (km)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

SI to Inch/Pound

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
	Area	
hectare (ha)	2.471	acre
square kilometer (km^2)	247.1	acre
hectare (ha)	0.003861	square mile (mi^2)
square kilometer (km^2)	0.3861	square mile (mi^2)

To communicate effectively with stakeholders, managers, and other scientists working on the Lower Missouri River, this report uses a mix of U.S. customary units and International System of Units (SI) units of measure. Distances along the Missouri River are given in river miles upstream from the confluence with the Mississippi River at St. Louis, Missouri, as measured by the U.S. Army Corps of Engineers in 1960. Discharges are provided in the customary units of cubic feet per second.

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Land Capability Potential Index (LCPI) and Geodatabase for the Lower Missouri River Valley

By Kimberly A. Chojnacki, Matthew A. Struckhoff, and Robert B. Jacobson

Abstract

The Land Capacity Potential Index (LCPI) is a coarse-scale index intended to delineate broad land-capability classes in the Lower Missouri River valley bottom from the Gavins Point Dam near Yankton, South Dakota to the mouth of the Missouri River near St. Louis, Missouri (river miles 811–0). The LCPI provides a systematic index of wetness potential and soil moisture-retention potential of the valley-bottom lands by combining the interactions among water-surface elevations, land-surface elevations, and the inherent moisture-retention capability of soils.

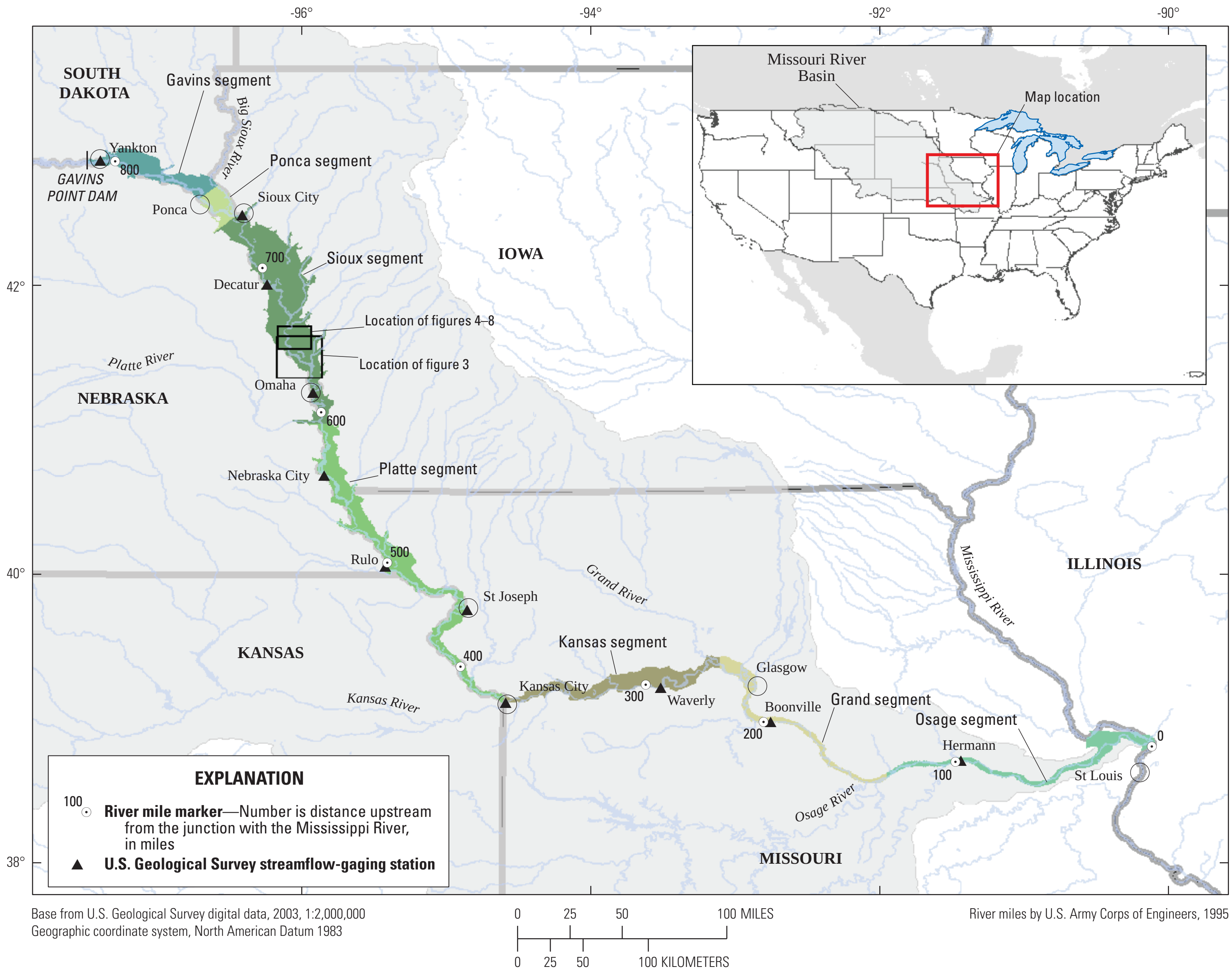
A nine-class wetness index was generated by intersecting a digital elevation model for the valley bottom with sloping water-surface elevation planes derived from eight modeled discharges. The flow-recurrence index was then intersected with eight soil-drainage classes assigned to soils units in the digital Soil Survey Geographic (SSURGO) Database (Soil Survey Staff, 2010) to create a 72-class index of potential flow-recurrence and moisture-retention capability of Missouri River valley-bottom lands. The LCPI integrates the fundamental abiotic factors that determine long-term suitability of land for various uses, particularly those relating to vegetative communities and their associated values. Therefore, the LCPI provides a mechanism allowing planners, land managers, landowners, and other stakeholders to assess land-use capability based on the physical properties of the land, in order to guide future land-management decisions. This report documents data compilation for the LCPI in a revised and expanded, 72-class version for the Lower Missouri River valley bottom, and inclusion of additional soil attributes to allow users flexibility in exploring land capabilities.

Introduction

The potential for valley-bottom lands to support various long-term land uses (for example, agricultural, industrial, municipal, or conservation uses) depends on the interactions among topography, hydrology, and soils. These factors determine the suitability of land not just for agricultural and urban development, but also for supporting vegetation communities (Fredickson and Batema, 1992; Fredrickson and Taylor, 1982; Hughes, 1997; Merigliano, 2005; Seabloom, van der Valk, and Moloney, 1998) and the services that they provide. Decisions about competing land-use options in valley-bottom lands will benefit from an understanding of the geographic distribution of these fundamental properties and how they affect the biophysical capacity of the land. The Lower Missouri River valley bottom has detailed and extensive datasets that contribute to development of a framework for understanding valley-bottom land potential.

The Lower Missouri River is defined as the segment of the Missouri River downstream from Gavins Point Dam near Yankton, South Dakota to the junction with the Mississippi River, near St. Louis, Missouri (fig. 1). The valley bottom varies from 2.4 kilometers (km) to more than 26 km in width, is 1,305 km long, and comprises more than 9,800 square kilometers (km^2) in area. The Lower Missouri River valley bottom contains parts of South Dakota, Nebraska, Iowa, Kansas, and Missouri. Longitudinal variability in biophysical capacity of the river valley arises from variable hydrology and sediment regimes, variable geological controls on floodplain sediments and valley widths, and variable engineering of the channel and flood-control infrastructure.

From the late 1980's to the present the Lower Missouri River valley bottom has been subject to large floods and changing land-management policies. Floods in 1993, 1995, 1997, 2004, 2007, and 2011 have been responsible for substantial damages to cropland, residential developments, levees, and transportation infrastructure; such damages have been costly. The "Great Flood" of 1993 resulted in $12–$16 billion of damage in the Missouri and Mississippi River floodplains (Interagency Floodplain Management Review Committee, 1994). State and Federal agencies have placed as much as 800 km^2 of valley-bottom lands in conservation status by fee-title acquisition or purchase of easements during the same time period (Jacobson and others, 2011). Land-management decisions have lacked a systematic classification of the abiotic characteristics of Lower Missouri River valley-bottom lands to guide assessment of net socioeconomic and conservation values.



Base from U.S. Geological Survey digital data, 2003, 1:2,000,000
Geographic coordinate system, North American Datum 1983

River miles by U.S. Army Corps of Engineers, 1995

Figure 1. The Lower Missouri River study area from Gavins Point Dam to St. Louis, Missouri.

The Land Capacity Potential Index (LCPI) presented in this report was developed to provide an index of potential flow-recurrence and soil moisture-retention capability of the valley-bottom lands within the Lower Missouri River (Jacobson and others, 2007). Although these factors are critical to determining the suitability of land for agricultural and industrial development, this report emphasizes the potential ability of the LCPI to provide decision support for the management of biotic resources, particularly wetlands and other vegetation communities, and the services they provide. The original version of the LCPI included 16 classes and was developed for rivermiles 423–670 (Jacobson and others, 2007); the current (2012) version presented here expands the geographic area covered by the LCPI to include the whole Lower Missouri River from mile 0 to mile 811 and provides increased thematic resolution in potential flow-recurrence interval and soil-drainage class. In addition, the LCPI geodatabase has been expanded relative to previous versions to provide additional flexibility to devise and explore custom indices of valley-bottom land capabilities. The index was developed by U.S. Geological Survey (USGS) in partnership with the U.S. Fish and Wildlife Service (USFWS), Rainwater Basin Joint Venture, Nebraska Partnership for All Bird Conservation, U.S. Army Corps of Engineers (USACE) Missouri River Integrated Science Program, Nebraska Game and Parks Commission, and The Nature Conservancy's Missouri River Program.

Purpose and Scope

The purpose of this report is to document methods used to create the LCPI for the Lower Missouri River valley bottom from the Gavins Point Dam near Yankton, South Dakota to the mouth of the Missouri River near St. Louis, Missouri (fig. 1). The LCPI is intended to provide a systematic index of flow-recurrence potential and soil moisture-retention capability of the Lower Missouri River valley-bottom based on topography, water-surface elevations, and soil characteristics. In addition, the LCPI geodatabase includes additional soil characteristics for flexibility in exploring alternative assessments. The LCPI provides information that can be used for assessing land-use capabilities at the scale of tens to hundreds of kilometers. The LCPI was created from existing land-surface elevation, hydrologic, hydraulic, and soils datasets, as such there are inherent limitations in applying the LCPI to specific sites. The utility of the information at scales of 10's to 100's of hectares has not been explored. The intent of the LCPI is to provide an index that planners, land managers, landowners, and other stakeholders can use to assess the inherent abiotic capabilities of lands within the valley bottom at a broad scale. Although other uses may be identified, the primary application of the LCPI addressed in this study involves the management of vegetative communities on the valley floor.

Physical Setting and Study Segments

The Missouri River drains approximately one-sixth of the continental United States, encompassing 1.37 million km^2 in 10 states (Colorado, Iowa, Kansas, Minnesota, Missouri, Montana, Nebraska, North Dakota, South Dakota, and Wyoming) and 25,000 km^2 in Canada (Galat and others, 2005). Historical descriptions suggest that the Missouri River was a dynamic complex of channels, chutes, sloughs, side channels, backwater areas, migrating islands, and sandbars until channel modifications began in the 1800's (Funk and Robinson, 1974; Hesse and others, 1988). Presently, approximately one-third of the Missouri River has been impounded behind a series of six mainstem dams. These dams were constructed primarily during the 1950's and 1960's to address identified societal needs including flood control, navigation, hydropower, and water supply, resulting in substantial modification of the natural hydrograph of the river. The degree of flow alteration tends to diminish in the downstream direction (Galat and Lipkin, 2000; Jacobson and Galat, 2008). Additionally, these dams substantially have reduced the sediment load of the Missouri River because most of the sediments once carried by the river are being deposited within the reservoir system (National Research Council, 2002; Jacobson and others, 2009). The channel has incised 3–5 meters (m) within the 100 km reach immediately downstream from Gavins Point Dam (fig. 2) as a result of diminished sediment load. Channel elevations generally recover to near-historical values near Omaha, Nebraska. The section of river between Omaha, Nebraska and Nebraska City, Nebraska has relatively stable bed elevation, but discharges in excess of flood stage have become more frequent because of levee confinement and aggradation of the narrow floodplain between the levees (U.S. Army Corps of Engineers, 2007; Jacobson and others, 2009). Farther downstream near Kansas City, Missouri, the channel bed is degrading substantially (fig. 2; U.S. Army Corps of Engineers, 2004a).

The Missouri River has been engineered to maintain a self-scouring navigation channel from Sioux City, Iowa to St. Louis, Missouri. Narrowing of the channel, bank stabilization, and construction of levees have resulted in substantial losses of valley-bottom habitats. The U.S. Army Corps of Engineers (2004b) has estimated that these measures have resulted in the loss of as much as 400 km^2 of aquatic habitat, 274 km^2 of terrestrial habitat (sandbars and low-lying lands), and as much as 1,400 km^2 of connected wetland habitats . Additionally, levees and revetments have isolated the main channel of the Missouri River from its valley-bottom floodplain while ditching and channelization of tributaries have increased the efficiency of draining water from these lands. These actions made it possible to convert most of the natural habitats to row crop agriculture (Ferrell, 1995). Natural vegetation communities within the valley bottom remain as narrow riparian zones between the channel and levees and as insolated patches within a largely agricultural landscape.

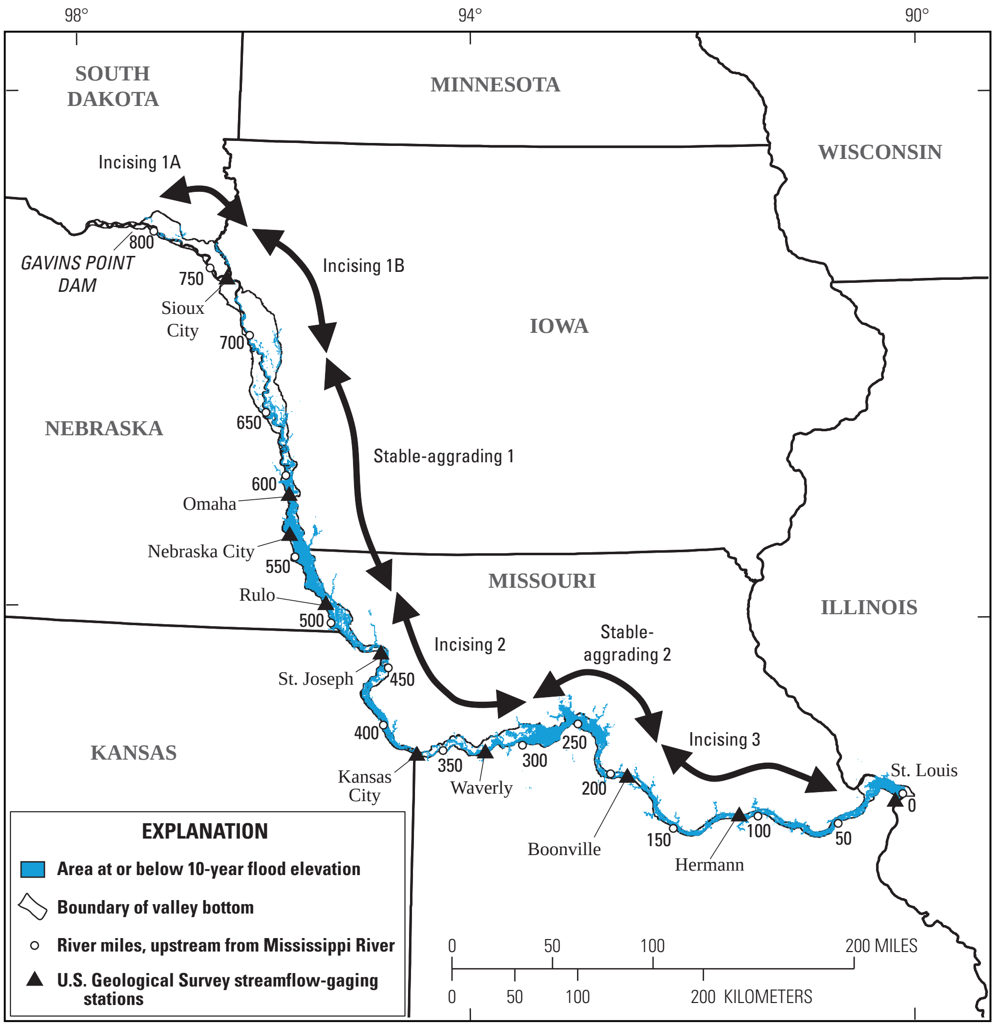


Figure 2. Representation of area at or below 2-year flooding reference elevation, illustrating how the pattern of incision and aggradation affects potential for restoring floodplain connectivity on the Lower Missouri River. (Jacobson and others, 2009).

The valley bottom consists of active channel, meander belt, alluvial terraces, and bordering colluvial landforms that are downslope of bluffs (fig. 3; Jacobson and others, 2007). The active channel refers to the part of the valley bottom characterized by the river bed, sandbars, and banks, and contains most of the mainstem discharge of the river. The meander belt is defined as the part of the valley bottom occupied by the river channel during the Late Holocene Era (Jacobson and others, 2007). The meander belt is characterized by ridge and swale topography created by the natural meandering of the Missouri River. This topography results in a juxtaposition of areas with differing potential for inundation by surface water. Additionally, this topography is indicative of differing underlying surficial geology and therefore is indicative of differing soil moisture-retention capabilities (Jacobson and others, 2007). The ridge and swale topography may have been altered to various extents by farming or construction activities. Alluvial terraces are surfaces underlain by alluvial deposits adjacent to the meander belt. Alluvial terraces and bordering colluvial landforms tend to flood much less frequently than the meander belt (Jacobson and others, 2007).

The study area is divided into seven segments from the Gavins Point Dam to the Mississippi River confluence (fig. 1, table 1). The segments include Gavins segment, from the Gavins Point Dam to Ponca, Nebraska; Ponca segment, from Ponca, Nebraska to the Big Sioux River; Sioux segment, from the Big Sioux River to the Platte River; Platte segment, from the Platte River to the Kansas River; Kansas segment, from the Kansas River to the Grand River; Grand segment, from the Grand River to the Osage River; and Osage segment, from the Osage River to the Mississippi River (Jacobson and others, 2010). These segments were delineated by locations of tributaries considered to be significant to the hydrology, geomorphology, or sediment supply of the Lower Missouri River (Jacobson and others, 2010).

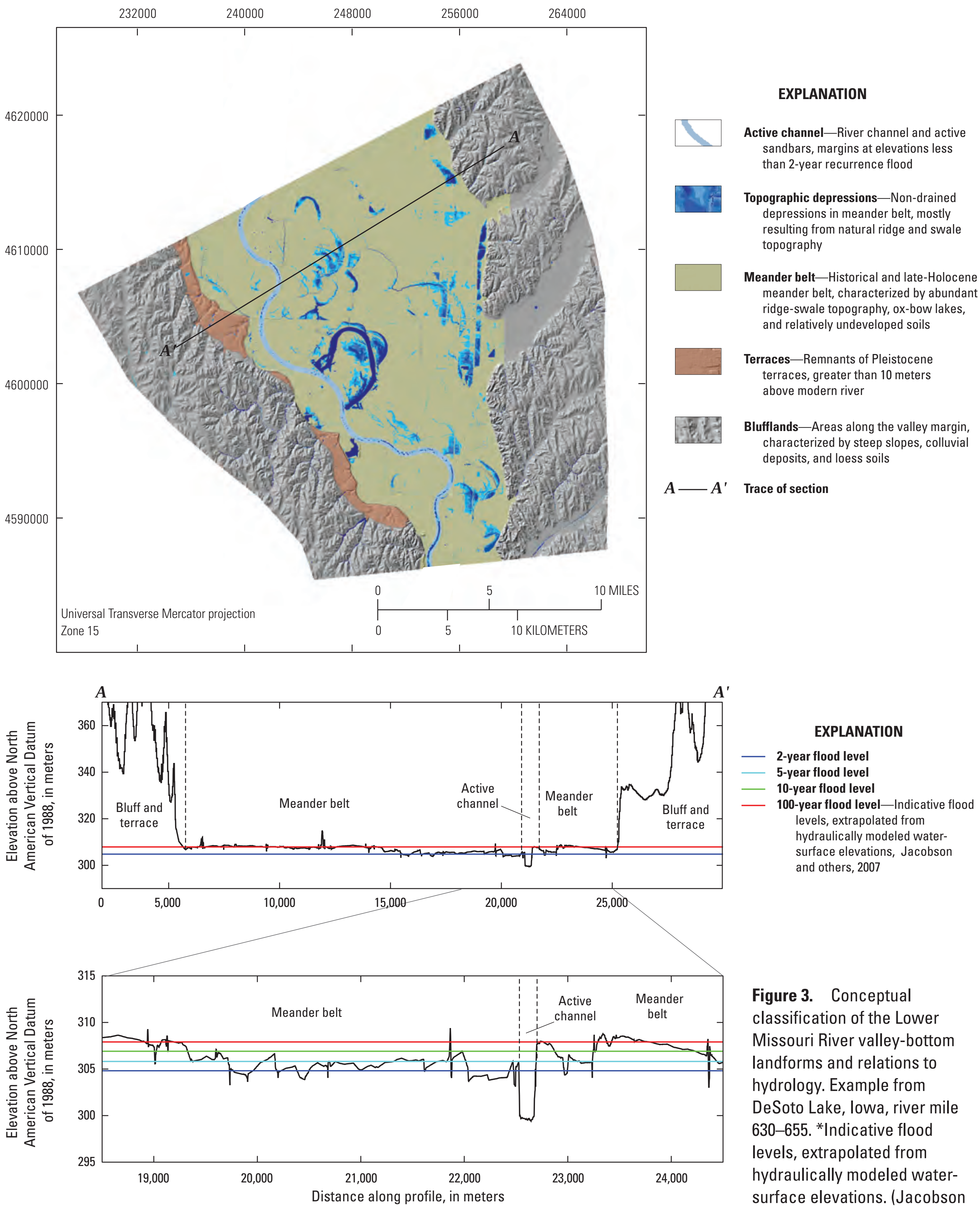


Figure 3. Conceptual classification of the Lower Missouri River valley-bottom landforms and relations to hydrology. Example from DeSoto Lake, Iowa, river mile 630–655. *Indicative flood levels, extrapolated from hydraulically modeled water-surface elevations. (Jacobson and others, 2007).

Table 1. Geomorphic segments of the Lower Missouri River.

[From U.S. Geological Survey development of a channel classification to evaluate potential for cottonwood restoration, lower segments of the Middle Missouri River, South Dakota and Nebraska (Jacobson and others, 2010)]

Segment name	Segment	River mile start	River mile end	Length, in miles
Gavins	Gavins Point Dam to Ponca, Nebraska	811.1	753	58.1
Ponca	Ponca, Nebraska to Big Sioux River	753	734	19
Sioux	Big Sioux River to Platte River	734	594.5	139.5
Platte	Platte River to Kansas River	594.5	367.5	227
Kansas	Kansas River to Grand River	367.5	250	117.5
Grand	Grand River to Osage River	250	130.4	119.6
Osage	Osage River to Mississippi River	130.4	0	130.4

Approach and Methods

The LCPI geodatabase integrates modeled water-surface elevations, land-surface elevation, and soil-drainage classes to provide a basis for understanding potential flow-recurrence interval and water-retention capabilities of lands within the valley bottom. The following sections outline the steps taken to develop the LCPI, including the hydrology, hydraulics, land-surface elevations, and soil datasets. All data used to create the LCPI geodatabase were compiled from existing sources. The current (2012) version of the LCPI geodatabase, associated metadata, and map document accompany this report.

Modeling Water-Surface Elevations

Hydrologic data were obtained from the USACE Upper Mississippi River System Flow Frequency Study (UMRSFFS; U.S. Army Corps of Engineers, 2004c), which calculated flow frequencies at 12 USGS streamflow-gaging stations (table 2). These calculations provided estimated discharges for the 2-, 5-, 10-, 20-, 50-, 100-, 200-, and 500-year flood-recurrence intervals (equivalent to annual probabilities of 50, 20, 10, 5, 2, 1, 0.5, and 0.2 percent) under reservoir regulation (Jacobson and others, 2007). The LCPI uses the modeled water-surface elevation estimates, which are considered to be an index of potential flow-recurrence rather than a prediction of flood probability.

Estimations of water-surface elevations were obtained from one-dimensional unsteady hydraulic models used in the UMRSFFS (U.S. Army Corps of Engineers, 2004c). These models were calibrated to reproduce water-surface elevations for the eight estimated flows, therefore providing reliable estimates of water-surface elevations at approximately 1-mile intervals along the river (Jacobson and others, 2007). The effects of levees are accounted for in the UMRSFFS models such that flows within the levees are constricted, resulting in locally increased water-surface elevations. Modeled flows that overtop local levee elevations are dispersed over the local landscape, resulting in locally decreased water-surface elevations (Jacobson and others, 2007).

Table 2. Hydrologic data for calculations of Land Capability Potential Index.

[%, percent]

Streamflow-gaging station	Location	Flows at indicated recurrence intervals (percent chance), in cubic feet per second[1]							
		2 years (50%)	5 years (20%)	10 years (10%)	20 years (5%)	50 years (2%)	100 years (1%)	200 years (0.5%)	500 years (0.2%)
6934500	Hermann, Missouri	248,000	363,000	439,000	511,000	604,000	673,000	742,000	833,000
6909000	Boonville, Missouri	203,000	289,000	352,000	415,000	503,000	573,000	648,000	753,000
6895500	Waverly, Missouri	150,000	212,000	258,000	305,000	371,000	424,000	480,000	561,000
6893000	Kansas City, Missouri	142,000	210,000	245,000	289,000	351,000	401,000	454,000	530,000
6818000	St. Joseph, Missouri	109,000	147,000	174,000	199,000	233,000	261,000	287,000	324,000
6813500	Rulo, Nebraska (Kansas City, Corps)[2]	96,100	132,000	158,000	184,000	220,000	250,000	281,000	320,000
6813500	Rulo, Nebraska (Omaha, Corps)[2]	94,700	132,300	160,900	188,600	217,300	252,200	296,900	370,700
6807000	Nebraska City, Nebraska	88,000	118,700	149,800	189,900	206,400	236,700	275,900	345,400
6610000	Omaha, Nebraska	64,200	85,300	123,600	132,700	147,900	174,700	204,500	247,900
6601200	Decatur, Nebraska	52,400	70,500	87,200	101,600	120,500	141,800	164,800	197,700
6486000	Sioux City, Iowa	49,500	66,800	78,300	93,900	113,800	133,800	155,000	185,400
6467500	Yankton, South Dakota	45,300	63,000	65,000	69,100	74,700	84,900	98,000	123,500

[1]From U.S. Army Corps of Engineers Upper Mississippi River System Flow Frequency Study (U.S. Army Corps of Engineers, 2004c).

[2]Frequency analyses for the Rulo gage were completed by two offices of the U.S. Army Corps of Engineers, with slightly different results (U.S. Army Corps of Engineers, 2004c).

Water-surface elevations corresponding to flow-recurrence intervals were assigned to points at every river mile along the Lower Missouri River as measured by the USACE in 1960. Elevations also were assigned to points on lines delineating the left and right valley walls based on their proximity as nearest neighbors to the river-mile points. The locations of the valley-wall points were shifted somewhat along the valley wall to define transects perpendicular to the valley to create realistically sloping water-surface elevations (Jacobson and others, 2007). Using relevant water-surface elevations as the height source, we converted the points to a triangulated irregular network (TIN), a data model that partitions geographic space into adjoining, nonoverlapping triangles (Bratt and Booth, 2000). The TIN was then converted to a grid with 5-m cells.

Modeling Land-Surface Elevation

A land-surface digital elevation model was created from mass point (height measurements at points randomly or systematically collected in open areas) and breakline (lines of high-density data representing a discontinuity of slope along linear features such as levees, banks, and roads) datasets compiled for the UMRSFFS (U.S. Army Corps of Engineers, 2004c; fig. 4). These data originally were compiled using photogrammetric methods and had a root-mean square vertical error of 0.2 m (U.S. Army Corps of Engineers, 2004c). The mass point and breakline datasets were used to create a TIN, which allowed the model to capture abrupt changes in elevation, such as along levees or roads. The resulting TIN subsequently was converted to a digital elevation model with 5-m grid cells (fig. 5).

The land-surface dataset was augmented with a bathymetric dataset for the Missouri River collected by the USACE for the UMRSFFS during 1994 to 1998 (U.S. Army Corps of Engineers, 2004c). Bathymetric data were collected by echo-sounding cross sectional transects spaced approximately 150 m apart, with accuracies estimated at 0.15 m (Jacobson and others, 2007). The software Multi-dimensional Surface Water Modeling System (McDonald and others, 2005) was used to interpolate the bathymetric data because the software allows for a streamwise interpolation, producing a realistic topographic representation of the channel, thalweg, and bars (Jacobson and others, 2007). These data were then gridded to 5-m cells that subsequently were incorporated into the larger land-surface digital elevation model using a mosaic function. Navigation structures are not well represented in the final dataset because they were not sampled at the same resolution as the bathymetric data. Because of the wide spacing of transects and dynamic nature of the Missouri River, these data should be considered indicative of general channel conditions rather than relevant to contemporary, site-specific conditions (Jacobson and others, 2007).

Modeling Flow-Recurrence Intervals

Water- and land-surface elevation models were then used to create a flow-recurrence index. This was accomplished by subtracting the land-surface elevation grid from each of the eight water-surface elevation grids on a cell by cell basis. The resulting grids, representing the area of inundation at each of the eight flow-recurrence intervals, were then converted to polygon datasets. Areas not inundated by water elevations corresponding to any of the eight flow-recurrence intervals were assigned to a polygon dataset representing the greater than 500-year flow-recurrence class. These areas include former meander belt and alluvial terrace surfaces at high elevations compared to the present-day channel and some non-alluvial landforms on the margins of the valley wall. The polygon datasets were then combined to create a unified index with nine flow-recurrence interval classes (0–2, 2–5, 5–10, 10–20, 20–50, 50–100, 100–200, 200–500, and greater than 500 years; fig. 6).

It should be noted that the purpose of flow-recurrence index is to provide references for potential wetness, not to predict flood-hazard areas. The water-surface elevations, indicated by interpolating flows between streamflow-gaging stations, do not account for variations in hydraulic roughness, channel morphology, or channel slope, which could strongly affect local stage (Jacobson and others, 2007). Also, these calculations do not take into account whether or not water has an overland flow path to all areas in the valley bottom at or below the modeled water-surface elevation; therefore, the modeled water-surface elevations may not reach all the indicated polygons because there may be natural or engineered topographic barriers, such as roads or levees, preventing actual water flow. Thus, mapped polygons may overestimate (“over-map”) potential areas that would be flooded by overbank flows, even without levees, at flows that are overbank but lower than levee tops. These “over-mapped” areas are important because they indicate parts of the valley bottom that could be affected by impeded interior drainage or ground-water drainage if water levels in the channel were held against the levees for long durations. For the purposes of the LCPI, “over-mapped” areas are treated as having the same flow-recurrence interval as comparable elevations on the channel side of the levee. The 100- and 500-year elevations would overtop all levees except those present in urban areas. Since the UMRSFFS models explicitly included these levees, the mapped flooded areas within the LCPI are consistent with UMRSFFS model predictions (Jacobson and others, 2007).

Soil-Drainage Class

Soils data were obtained from the United States Department of Agriculture, Natural Resource Conservation Service (NRCS), Soil Survey Geographic (SSURGO) database (Soil Survey Staff, 2010). Tabular and spatial data for the 55 counties in five states intersecting the Missouri River valley were compiled to form a single spatial data set (fig. 7) and a single tabular dataset. Spatial data were then clipped to the extent of the land-surface elevation dataset. Because the soils data were mapped during a number of years, by different persons,

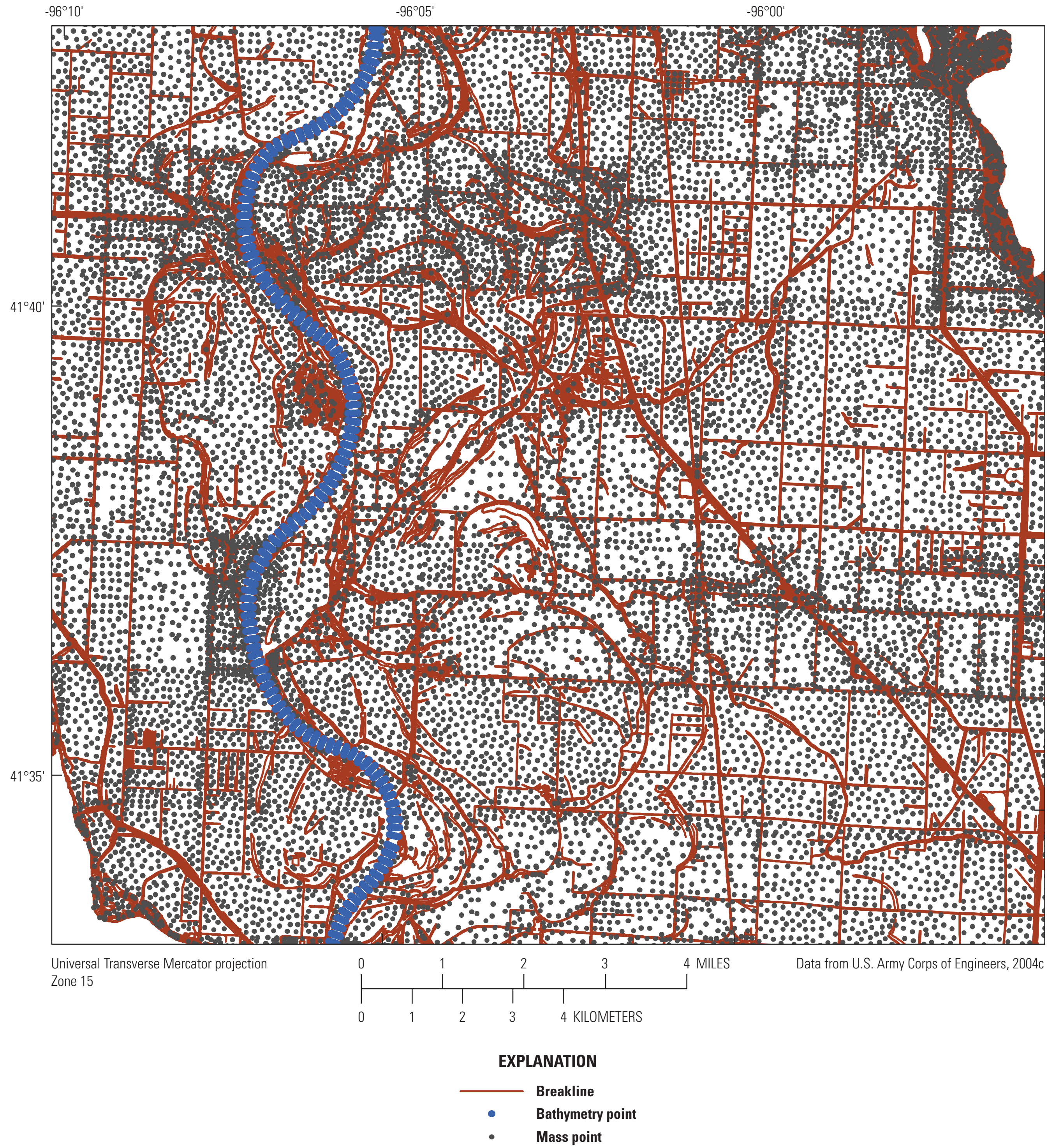


Figure 4. Mass point, bathymetric, and breakline datasets of a part of the Lower Missouri River valley bottom near Omaha, Nebraska.

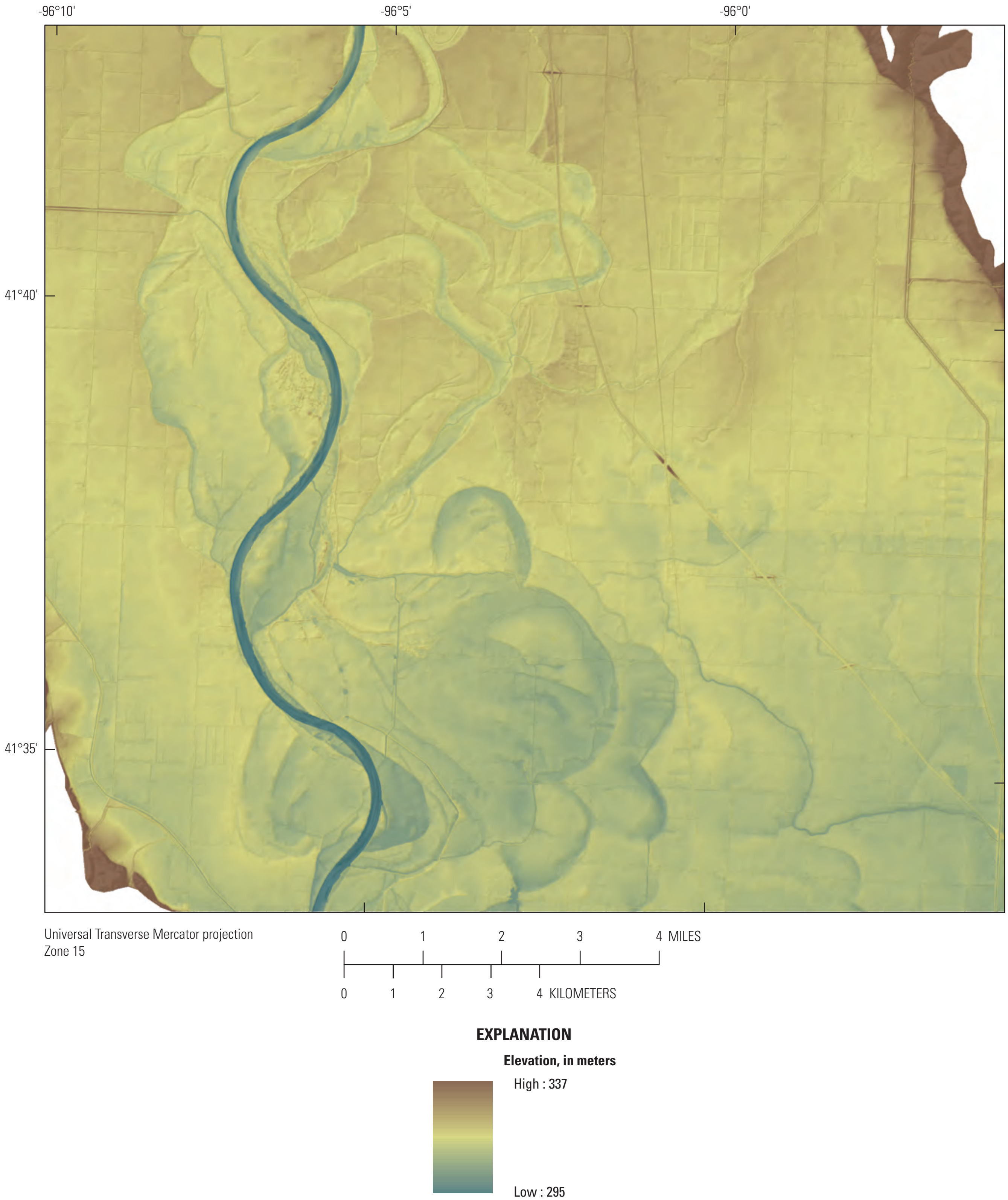


Figure 5. The topographic detail available in the elevation dataset of a part of the Lower Missouri River valley bottom near Omaha, Nebraska.

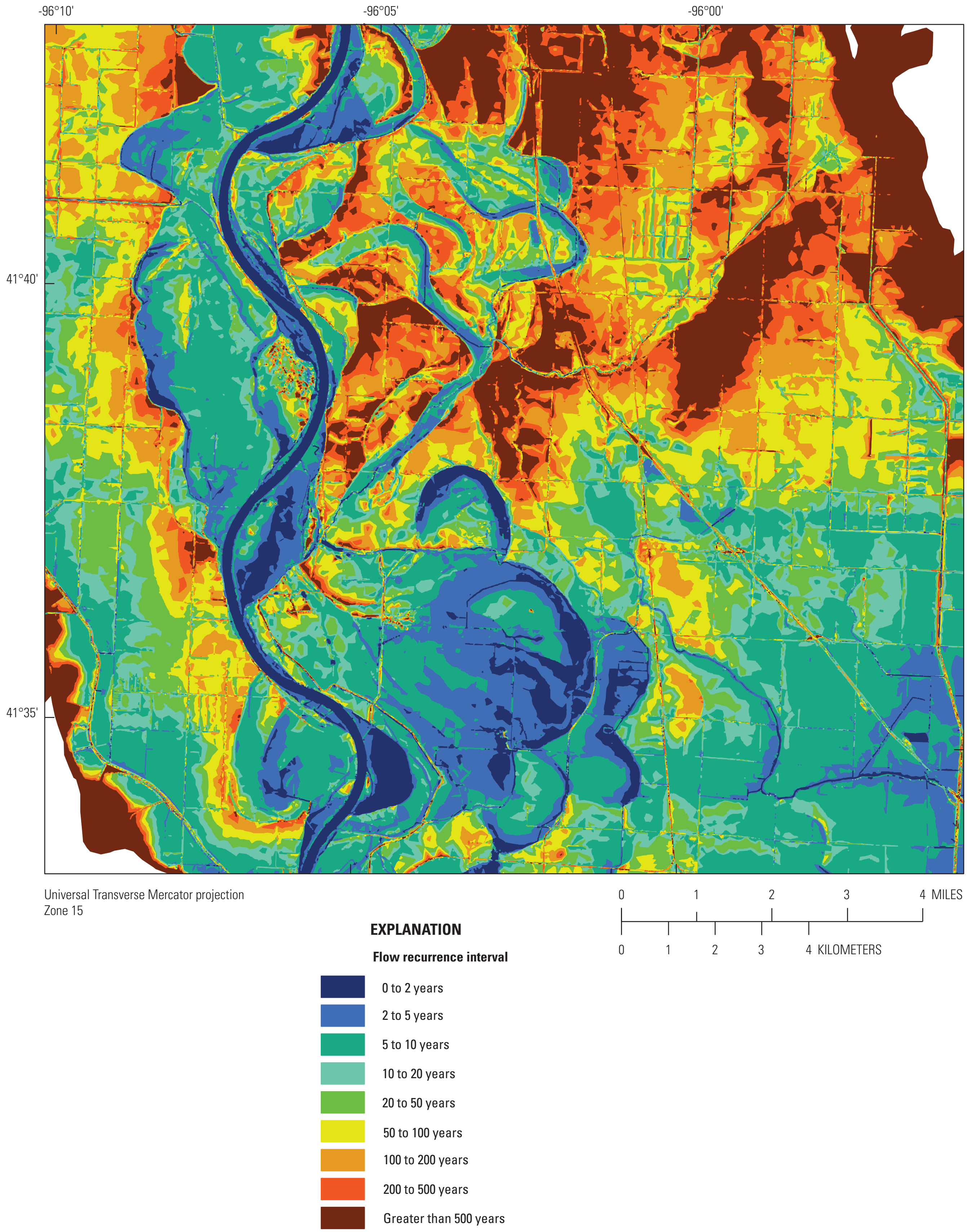


Figure 6. Modeled flow-recurrence interval of a part of the Lower Missouri River valley bottom near Omaha, Nebraska, estimated by intersecting a series of eight water-surface profiles with land-surface elevations.

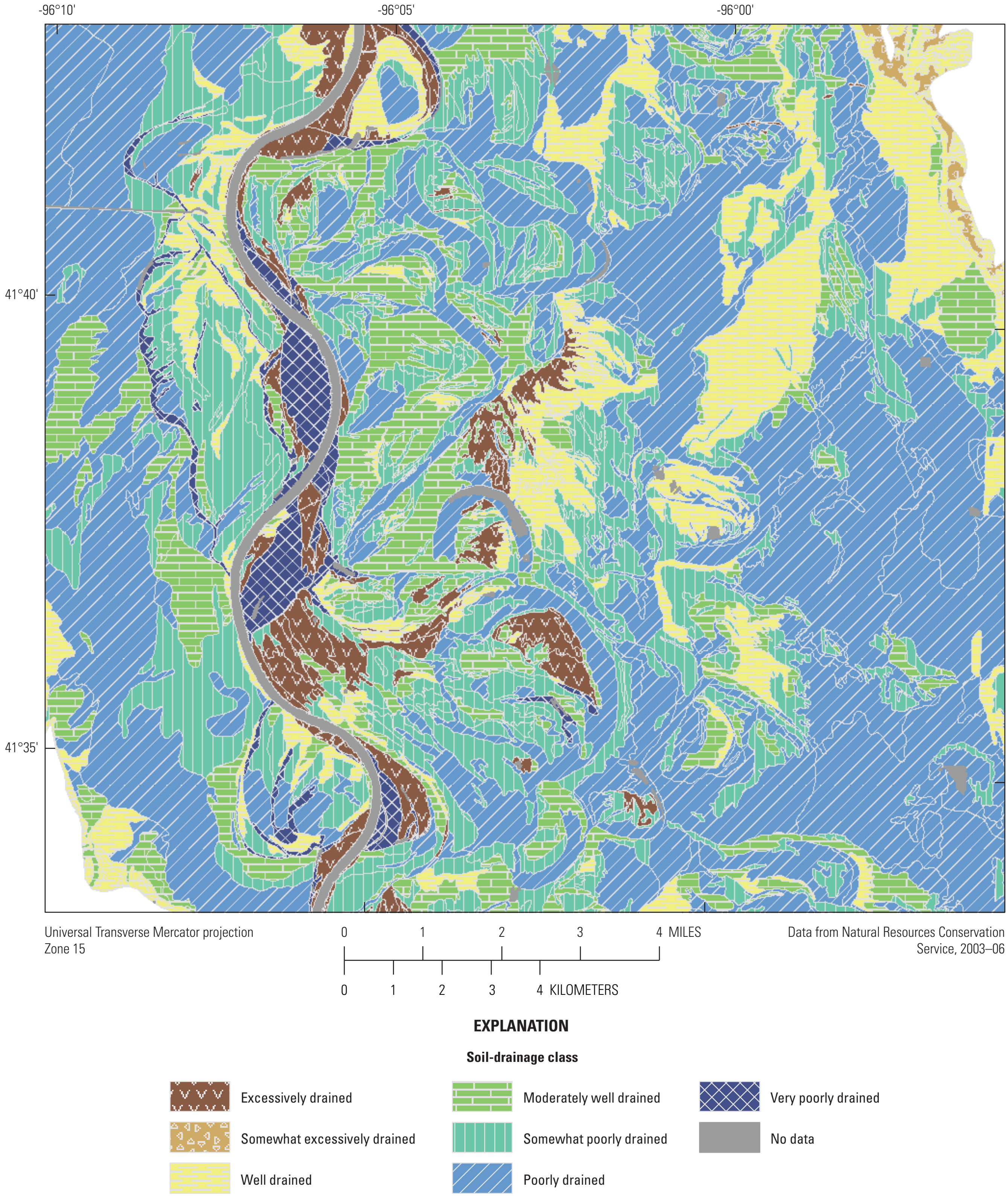


Figure 7. Soil Survey Geographic database soil-drainage classes (Soil Survey Staff, 2010) of a part of the Lower Missouri River valley bottom near Omaha, Nebraska.

and with differing specifications, the map units do not always match at county boundaries (Jacobson and others, 2007). Additionally, the spatial resolution of the data may vary from county to county.

Soil-drainage classes are used as a measure of the tendency of soil units to retain or drain water following saturated conditions (Jacobson and others, 2007). Assignation of soil-drainage class is based primarily on the presence and location of redoximorphic features, soil texture, and soil depth to bedrock (Schoeneberger and others, 2002). The eight soil-drainage classes used to define land-cability classes are described in table 3 (Soil Survey Staff, 1993).

In addition to soil-drainage class, this version of the LCPI geodatabase includes 11 attributes from the SSURGO dataset to allow for additional exploration of land-capability indicators. These include soil map unit identifiers (musym, mukey, and muname), and other attributes relating to the availability of water: minimum annual depth to water (wtdepannmi), dominant hydrologic group (hydgrpdcd), soil-drainage class for the wettest (drclasswet) component, the available water storage to 25, 50, 100, and 150 centimeters (aws025wta, aws050wta, aws0100wta, and aws0150wta, respectively), and mean annual precipitation (map_r). The attributes relating to the availability of water also provide continuous variables that support a broader suite of statistical analyses than are available when using classified data. More complete descriptions of each attribute are available from the SSURGO Database (Soil Survey Staff, 2010).

Table 3. Descriptions of soil drainage classes.

[From Soil Survey Manual (Soils Survey Staff, 1993)]

Soil drainage class	Description
Very poorly drained	Water is at or near the soil surface during much of the growing season. Internal free water is very shallow and persistent or permanent. Unless the soil is artificially drained, most mesophytic crops cannot be grown. Commonly, the soil occupies a depression or is level. If rainfall is persistent or high, the soil can be sloping.
Poorly drained	The soil is wet at shallow depths periodically during the growing season or remains wet for long periods. Internal free water is shallow or very shallow and common or persistent. Unless the soil is artificially drained, most mesophytic crops cannot be grown. The soil, however, is not continuously wet directly below plow depth. The water table is commonly the result of low or very low saturated hydraulic conductivity class or persistent rainfall, or a combination of both factors.
Somewhat poorly drained	The soil is wet at a shallow depth for significant periods during the growing season. Internal free water is commonly shallow to moderately deep and transitory to permanent. Unless the soil is artificially drained, the growth of most mesophytic plants is markedly restricted. The soil commonly has a low or very low saturated hydraulic conductivity class, or a high water table, or receives water from lateral flow, or persistent rainfall, or some combination of these factors.
Moderately well drained	Water is removed from the soil somewhat slowly during some periods of the year. Internal free water commonly is moderately deep and may be transitory or permanent. The soil is wet for only a short time within the rooting depth during the growing season, but long enough that most mesophytic crops are affected. The soil commonly has a moderately low, or lower, saturated hydraulic conductivity class within 1 meter of the surface, or periodically receives high rainfall, or both.
Well drained	Water is removed from the soil readily, but not rapidly. Internal free water commonly is deep or very deep; annual duration is not specified. Water is available to plants in humid regions during much of the growing season. Wetness does not inhibit growth of roots for significant periods during most growing seasons.
Somewhat excessively drained	Water is removed from the soil rapidly. Internal free water commonly is very rare or very deep. The soils are commonly coarse-textured, and have high saturated hydraulic conductivity, or are very shallow.
Excessively drained	Water is removed from the soil very rapidly. Internal free water commonly is very rare or very deep. The soils are commonly coarse-textured, and have very high saturated hydraulic conductivity class or are very shallow.
No data	These soils have no drainage class information recorded, and usually these areas are underwater or in urban areas.

The LCPI Model: Intersecting Flow-Recurrence and Soil-Drainage Classes

The nine-class flow-recurrence index was intersected with the eight-class soils dataset to create the final 72-class LCPI geodatabase (fig. 8). Finally, all polygons less than 900 m^2 (approximately 0.1 hectare) were eliminated by combining them with neighboring polygons with the longest shared border. The polygons eliminated by this process were considered smaller than the index was designed to capture and below the scale of typical management actions. The flow-recurrence index, SSURGO soils data, and the LCPI were then imported into an ESRI file geodatabase. In addition to a pre-selected index based on flow interval and drainage class, the resulting geodatabase can be queried for a wide range of other soil attributes available from the SSURGO data set.

The file geodatabase (LCPIv3_2.gdb), an ArcGIS (version 10) map document file (LCPIv3_2.mxd), and a metadata file accompany this report. The map document file is constructed with layers that illustrate flow-recurrence index, soil-drainage class, and all LCPI classes; however, the map document file and database were compiled to allow users to customize their own map document file to query, display, or simplify derivative maps.

Abundance of Wetness Classes

The final LCPI models the wetness potential of more than 2.4 million acres (approximately one million hectares) on 811 river miles (1,305 km) of the Lower Missouri River valley. The LCPI includes 72 classes based on 9 modeled flow-recurrence interval classes and 8 mapped soil-drainage classes.

For the study area, classes representing the extremes of the flow-recurrence interval spectrum are more abundant than classes with moderate length flood-return intervals. Approximately 27.7 percent of the lands within the study area are within the 0- to 2-year flow-recurrence class and an additional 17.1 percent of lands are within the 2- to 5-year flow-recurrence class (table 4). The greater than 500-year flow-recurrence class accounted for 30.0 percent of all valley-bottom lands. Combined, the six classes representing flow-return intervals from 5 to 500 years accounted for only 25.2 percent of the total area.

In addition, the abundance of wetness classes varies by segment (fig. 9*A*). Valley-bottom area upstream from river mile 680 is dominated by higher elevation lands with longer modeled flow-return intervals. Areas from river miles 520 to 580 (Omaha, Nebraska to Rulo, Nebraska), 380 to 410 (St. Joseph, Missouri to Kansas City, Missouri), and 300 to 230 (Waverly, Missouri to Glasgow, Missouri) are dominated by lower elevation lands with shorter modeled flow-return intervals. By segment, the Gavins, Ponca, and Sioux segments are modeled as distinctly drier, with only 7.3, 3.9, and 5.0 percent of lands in the 0- to 2-year flow-recurrence class, respectively (fig. 10; table 4), but with 86.8, 70.7, and 45.2 percent of lands in the greater than 500-year flow-recurrence class, respectively. Longer flow-return intervals also dominate downstream from Kansas City, where recent channel incision has lowered the stream channel relative to the valley bottom (fig. 9). The Platte, Grand, and Osage segments are distinctly wetter with 50.1, 49.7, and 48.9 percent, respectively, of lands in the 0- to 2-year flow-recurrence class. These same segments had only 8.4, 5.8, and 6.9 percent, respectively, of the area in the greater than 500-year flow-recurrence class. Variations in wetness are consistent with trends reported in the spatial distribution of channel degradation and aggradation from analysis of trends in streamflow-gaging station records (U.S. Army Corps of Engineers, 2004b).

At a local scale, the 72 classes of the LCPI represent a complex mosaic of patches with varying land-capability potential. These classes delineate areas of comparable potential wetness and moisture-retention characteristics, the fundamental abiotic drivers of land capability within the river valley. The LCPI does not account for manmade structures such as roadways, ditches or levees that can alter surface and groundwater flow patterns on the landscape.

Table 4. Area within flow-recurrence classes by river segment.

[>, greater than]

Modeled flow elevation	River segment, in square kilometers and (percent)							
	Gavins	Ponca	Sioux	Platte	Kansas	Grand	Osage	Total
0 to 2 years	66.8 (7.3)	13.7 (3.9)	164.7 (5.0)	1,110.9 (50.1)	508.6 (37.9)	373.2 (49.7)	497.6 (48.9)	2,735.5 (27.7)
2 to 5 years	7.9 (0.9)	5.8 (1.6)	249.1 (7.6)	609.4 (27.5)	240.3 (17.9)	227.7 (30.3)	341.5 (33.5)	1,681.7 (17.1)
5 to 10 years	1.3 (0.1)	3.0 (0.9)	325.1 (9.9)	132.1 (6.0)	141.8 (10.6)	63.3 (8.4)	54.6 (5.4)	721.3 (7.3)
10 to 20 years	2.6 (0.3)	5.5 (1.6)	135.9 (4.2)	74.0 (3.3)	124.3 (9.3)	20.9 (2.8)	24.5 (2.4)	387.7 (3.9)
20 to 50 years	4.3 (0.5)	9.1 (2.6)	224.4 (6.9)	41.6 (1.9)	92.5 (6.9)	12.9 (1.7)	15.0 (1.5)	399.8 (4.1)
50 to 100 years	8.8 (1.0)	13.8 (3.9)	252.8 (7.7)	27.5 (1.2)	35.7 (2.7)	4.4 (0.6)	7.0 (0.7)	349.9 (3.5)
100 to 200 years	9.1 (1.0)	16.9 (4.8)	213.8 (6.5)	17.9 (0.8)	26.7 (2.0)	2.5 (0.3)	4.8 (0.5)	291.7 (3.0)
200 to 500 years	19.7 (2.2)	35.4 (10.1)	224.5 (6.9)	17.0 (0.8)	30.6 (2.3)	2.8 (0.4)	2.9 (0.3)	333.0 (3.4)
>500 years	793.1 (86.8)	248.9 (70.7)	1,479.0 (45.2)	186.1 (8.4)	140.6 (10.5)	43.9 (5.8)	70.4 (6.9)	2,962.0 (30.0)

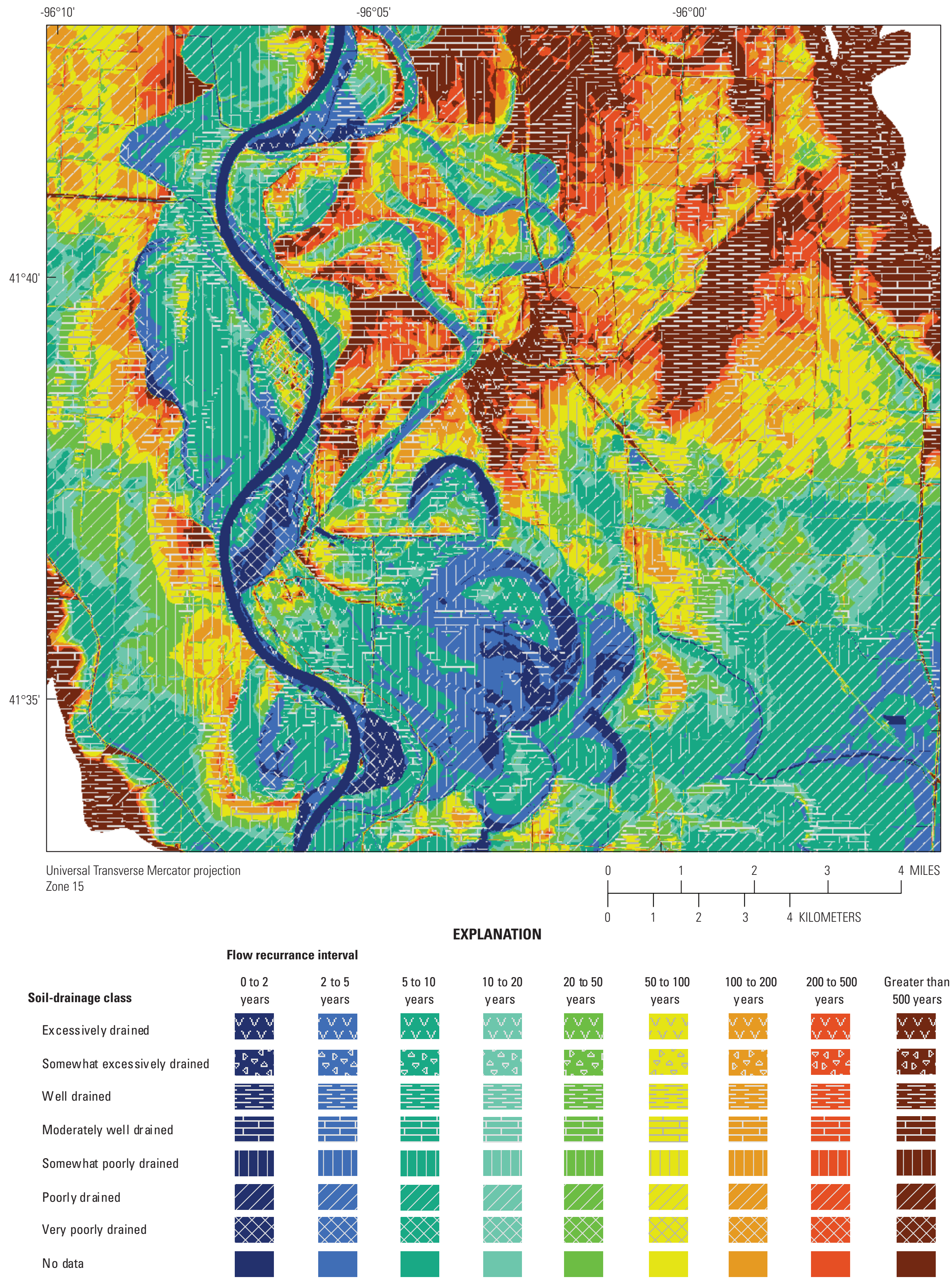


Figure 8. Land Capability Potential Index classes calculated by intersecting water-surface elevations, land-surface elevations, and Soil Survey Geographic database soil-drainage classes (Soil Survey Staff, 2010) of a part of the Lower Missouri River valley bottom near Omaha, Nebraska.

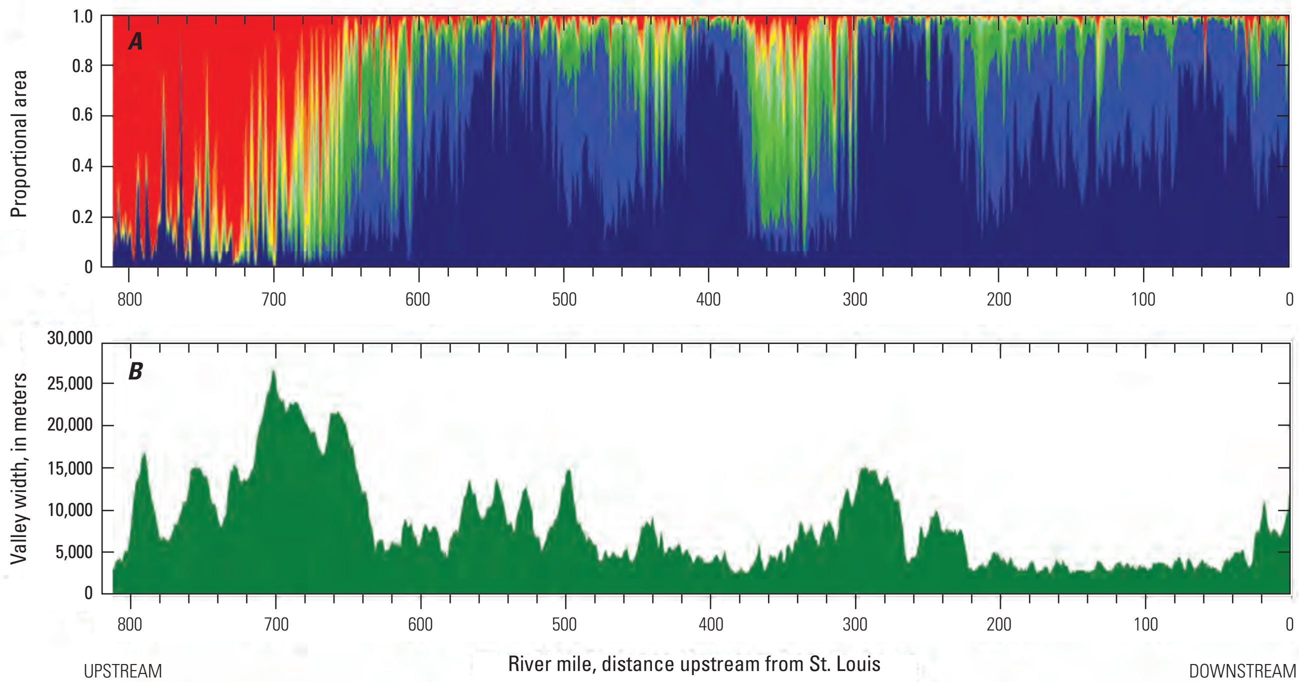


Figure 9. Longitudinal graphs of *A*, proportional area of valley bottom occupied by land with surfaces in the indicated wetness classes, and *B*, area of valley bottom.

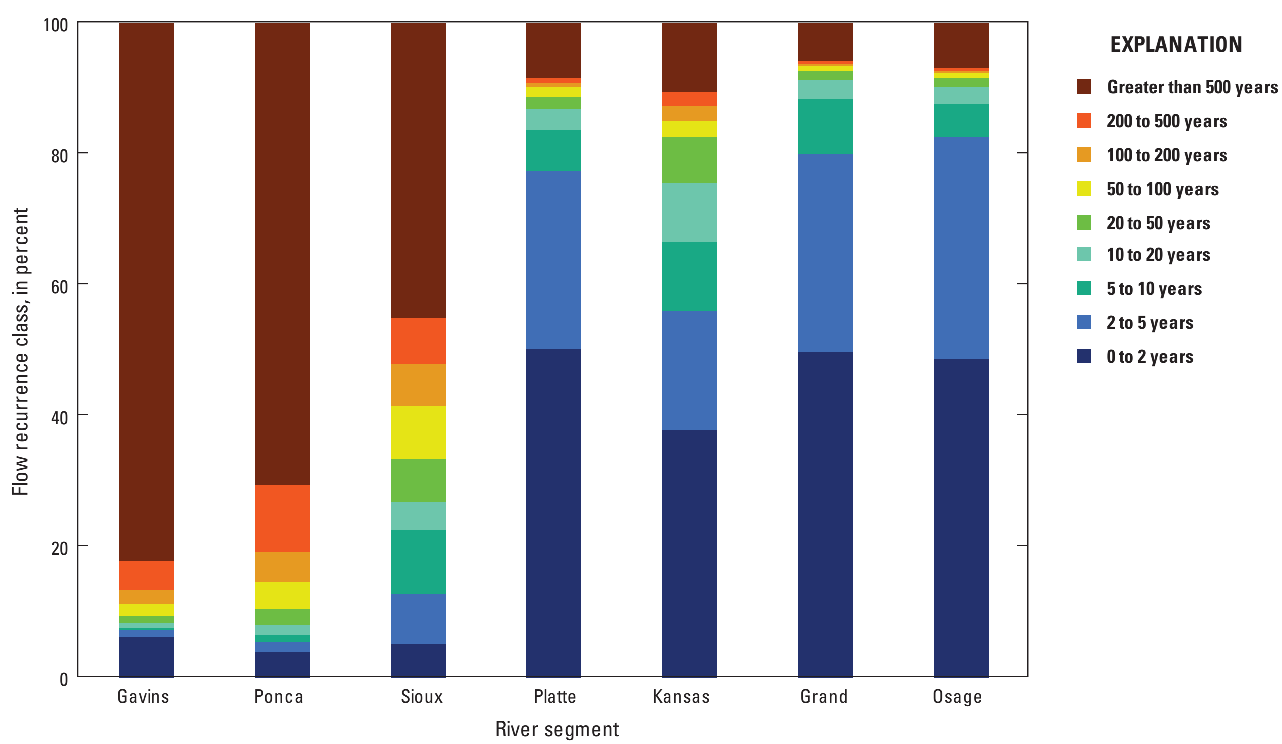


Figure 10. Percent flow recurrence interval per river segment.

Potential Planning and Management Applications

The LCPI provides a decision-support tool for land-management decisions in the Lower Missouri River valley bottom, provided users are aware of the inherent limitations of the underlying data and index model. First among these limitations is the assumption of connectivity to the river, which forms the basis for classifications of potential flow frequency. Again, the purpose of flow-recurrence index is to provide an index of potential wetness, not to predict flood-hazard areas; modeled flow frequencies obviously will not apply on floodplains protected by levees or otherwise separated from the river by structures that impede flow, such as railroad and road grades. In such instances, groundwater and surface flow from the uplands will be the most likely sources of water inflow. For surface water, the LCPI can be used to identify locations where surface water will naturally collect (based on elevation) and be retained (based on soil-drainage class). For groundwater, the LCPI will identify low-lying areas likely to receive the earliest influx of groundwater, provided the soil does not impede flow. Additional research is needed to thoroughly describe the hydrologic behavior of LCPI classes on both levee-protected and connected flood plains.

Other limitations of the LCPI arise from the SSURGO soils data that provide the basis for the soil-drainage component of each LCPI class. The study area encompasses nearly 10,000 km^2 in parts of 5 states and 55 counties in 4 different Major Land Resource Areas (MLRA) within the SSURGO program. Each MLRA establishes guidelines for mapping based on soils types known or likely to occur within the mapping area; however, mapping skill and interpretation of those guidelines vary among counties. These issues are most evident where soil classifications abruptly shift at county and state boundaries. Also, the spatial and thematic accuracy are difficult to quantify across the study area.

Finally, limitation arises from the fact that past land use and other ecological factors may alter the ability of LCPI to predict landscape response. In the case of ecological restoration of floodplain lands, past land use will affect the condition of the soil, the existing vegetation, and the available seed bank. These effects will be further mediated by ecological processes such as disturbance, competitive exclusion, and succession. Within this context, the LCPI model can only indicate locations more or less likely to support a given habitat or species.

With a firm understanding of the above limitations, it is possible to use the LCPI for a variety of purposes. At coarse scales, the LCPI enables assessment of the wetness potential of different lands, information that can be used for assessing regional restoration or flood-damage potential. Based on our current understanding of vegetation and wetness relations, such assessments can indicate the ability of valley-bottom segments to support desired communities and habitats (Jacobson and others, 2011). For example, segments that include few examples of LCPI classes with short flow-recurrence intervals likely to support hydrologically connected wetlands would require expensive restoration approaches. By contrast, wetland restoration would be more effective in areas where the LCPI indicates a greater abundance of classes with short modeled flow-recurrence intervals.

At the moderate scale of dozens of kilometers, the LCPI can start to indicate how various land uses might be arranged and interact as a mosaic of patches. This understanding could be applied to determining optimal locations or patch structure of conventional crops, biofuel crops, agroforestry crops, or restored habitats.

The LCPI may have significant potential to aid efficiency in natural resources management at the local scale (such as a wildlife refuge management unit, covering hundreds of hectares), where limited resources must be directed to locations where there is a high likelihood of success. In this scenario, the LCPI model may facilitate the identification of areas likely to support particular plant species and communities across a range of hydrologic regimes and soil conditions; hydrology and soils are known determinants of plant species distribution (Fredickson and Batema, 1992; Fredrickson and Taylor, 1982; Hughes, 1997; Merigliano, 2005; Seabloom, van der Valk, and Moloney, 1998). An earlier version of the LCPI was recently utilized in wetland restoration planning between St. Joseph, Missouri and Yankton, South Dakota (Jacobson and others, 2011), and current research is explicitly examining relations between vegetation and LCPI classes to improve our understanding of how these classes might support desired communities and species.

Conclusions

The Land Capability Potential Index (LCPI) was developed using modeled water-surface elevations, land-surface elevations, and soil-drainage class datasets for the Lower Missouri River valley from Yankton, South Dakota to St. Louis, Missouri (river miles 811–0). The LCPI estimates wetness potential by intersecting water-surface elevation models with a high-resolution land-surface elevation model to create a nine-class index of potential flow recurrence. The moisture-retention capability of the soils is estimated by overlaying the eight soil-drainage classes that are determined from permeability of surface soils and subsurface geologic strata. This version of the LCPI geodatabase includes additional soil attributes to facilitate exploration of land potential.

The LCPI is a coarse-scale index intended to delineate general land-capability classes by integrating the fundamental abiotic factors that help determine suitability of land for various uses. As such, the LCPI may provide a useful mechanism to guide future land-management decisions. For example, the LCPI could provide a useful tool for prioritizing land acquisition or enrollment of lands into conservation reserve programs.

References Cited

Bratt, S., and Booth, B., 2000, Using ArcGIS 3D Analyst: ESRI, Inc., 374 p.

Ferrell, J., 1995, Soundings—100 years of the Missouri River navigation project: U.S. Army Corps of Engineers, Kansas City District, 171 p.

Fredickson, L.H., and Batema, D.L., 1992, Greentree reservoir management handbook—Wetland Management Series No. 1: Puxico, Missouri, University of Missouri-Columbia, Gaylord Memorial Laboratory, 88 p.

Fredrickson, L.H., and Taylor, I.S.. 1982, Management of seasonally flooded impoundments for wildlife: Washington, D.C., U.S. Fish and Wildlife Service, Resource Publication 148, 22 p. plus appendixes.

Funk, J.L., and Robinson, J.W., 1974, Changes in the channel of the Lower Missouri River and effects on fish and wildlife: Jefferson City, Mo., Missouri Department of Conservation, 52 p.

Galat, D.L., Berry, C.R., Jr., Peters, E.J., and White, R.G., 2005, Missouri River Basin, *in* Benke, A.C., and Cushing, C.E., eds., Rivers of North America: Oxford, Elsevier, p. 427–480.

Galat, D.L., and Lipkin, R., 2000, Restoring ecological integrity of great rivers—Historical hydrographs aid in defining reference conditions for the Missouri River: Hydrobiologia, v. 422/423, p. 29–48.

Hesse, L.W., Wolfe, C.W., and Cole, N.K., 1988, Some aspects of energy flow in the Missouri River ecosystem and a rationale for recovery, *in* Benson, N.G., ed., The Missouri River—The resources their uses and values: North Central Division of the American Fishereis Society, Special Publication 8, p. 13–20.

Hughes, F.M.R., 1997, Floodplain biogeomorphology: Progress in Physical Geography, v. 21, no. 4, p. 501–529.

Interagency Floodplain Management Review Committee, 1994, Sharing the challenge: floodplain management into the 21st century: U.S. Government Printing Office, 191 p.

Jacobson, R., Janke, T., and Skold, J., 2011, Hydrologic and geomorphic considerations in restoration of river-floodplain connectivity in a highly altered river system, Lower Missouri River, USA: Wetlands Ecology and Management, v. 19, no. 4, p. 295–316.

Jacobson, R.B., Blevins, D.W., and Bitner, C.J., 2009, Sediment regime constraints on river restoration—An example from the Lower Missouri River: Geological Society of America Special Paper, v. 451, p. 1–22.

Jacobson, R.B., Chojnacki, K.A., and Reuter, J.M., 2007, Land capability potential index (LCPI) for the Lower Missouri River valley: U.S. Geological Survey Scientific Investigations Report 2007–5256, 19 p.

Jacobson, R.B., Elliott, C.M., and Huhmann, B.L., 2010, Development of a channel classification to evaluate potential for cottonwood restoration, lower segments of the Middle Missouri River, South Dakota and Nebraska: U.S. Geological Survey Scientific Investigations Report 2010–5208, 38 p.

Jacobson, R.B., and Galat, D.L., 2008, Design of a naturalized flow regime—An example from the Lower Missouri River, USA: Ecohydrology, v. 1, p. 81–104.

McDonald, R.R., Nelson, J.M., and Bennett, J.P., 2005, Multidimensional surface-water modeling system user's guide: U.S. Geological Survey Techniques and Methods, book 6, chap. B2, 136 p.

Merigliano, M. F., 2005, Cottonwood understory zonation and its relation to floodplain stratigraphy: Wetlands. v. 25, no. 2, p 356–374.

National Research Council, 2002, The Missouri River ecosystem, exploring the prospects for recovery: Washington, D.C., National Academy Press, 176 p.

Schoeneberger, P.J., Wysocki, D.A., Benham, E.C., and Broderson, W.D., eds., 2002, Field book for describing and sampling soils, Version 2.0: Lincoln, Nebr., Natural Resources Conservation Service, National Soil Survey Center, 228 p.

Seabloom, E.W., van der Valk, A.G., and Moloney, K.A., 1998, The role of water depth and soil temperature in the determining initial composition of prairie wetland coenoclines: Plant Ecology, v. 138, p. 203–216.

Soil Survey Staff, 1993, Soil survey manual: Washington, D.C., United States Department of Agriculture, Soil Conservation Service, Agricultural Handbook No. 18, accessed on January 2, 2012, at *http://soils.usda.gov/technical/manual/*.

Soil Survey Staff, 2010, Spatial and tabular data of soil surveys for counties in Iowa, Nebraska, South Dakota, Kansas, and Missouri Soil Survey Geographic (SSURGO) database: U.S. Department of Agriculture, Natural Resources Conservation Service, accessed on January 2, 2012, at *http://SoilDataMart.nrcs.usda.gov/*.

U.S. Army Corps of Engineers, 2004a, Missouri River stage trends: U.S. Army Corps of Engineers, Northwestern Division, Reservoir Control Center Technical Report A04, 43 p.

U.S. Army Corps of Engineers, 2004b, Summary Missouri River final environmental impact statement—Master water control manual review and update: U.S. Army Corps of Engineers, Northwest Division, 28 p.

U.S. Army Corps of Engineers, 2004c, Upper Mississippi River system flow frequency study: Rock Island, Ill., U.S. Army Corps of Engineers, 33 p.

U.S. Army Corps of Engineers, 2007, Missouri River Stage Trends: U.S. Army Corps of Engineers, Northwestern Division, Reservoir Control Center Technical Report Ja-07, 43 p.

U.S. Geological Survey, 2012, National Water Information System (NWISWeb); U.S. Geological Survey database, accessed January 1, 2012, at *http://waterdata.usgs.gov/nwis/*.

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