Spring 2011

COTTONWOOD RIPARIAN SITE SELECTION ON THE CHEYENNE RIVER SIOUX RESERVATION

Julie A. Thorstenson
Presentation College

Diane Rickerl
South Dakota State University, diane.rickerl@sdstate.edu

Janet H. Gritzner
South Dakota State University

Great Plains Research 21 (Spring 2011):39–48

COTTONWOOD RIPARIAN SITE SELECTION ON THE CHEYENNE RIVER SIOUX RESERVATION

Julie A. Thorstenson

Lakota Campus Director
P.O. Box 1070
Presentation College
Eagle Butte, SD 57625

Diane H. Rickerl

Graduate School
SAD 130, Box 2201
South Dakota State University
Brookings, SD 57007
diane.rickerl@sdstate.edu

and

Janet H. Gritzner

Department of Geography
Box 504, Scobey Hall
South Dakota State University
Brookings, SD 57007

ABSTRACT—The construction of the Oahe Dam on the Missouri River eliminated thousands of acres of riparian and floodplain lands on the Cheyenne River Sioux Reservation in South Dakota. Restoration is needed to replace wildlife habitat. This study focused on site selection for native cottonwood (*Populus deltoides* Bartr. Ex Marsh. ssp. *Monilifers* (Ait.) Eckenwalde) restoration to help mitigate this loss. Geographic information systems technologies were used to develop a suitability model for cottonwood restoration. Tribal lands were extracted from a digital dataset of landownership. Those touched by or included in a 46 m border of the Moreau River were candidate sites. Of the 182 candidates, 50 sites were randomly selected for model development. Slope, aspect, stream length and number, soil properties, and land cover criteria were given a numeric score and these were summed; the lowest total score possible was -7 and the highest score possible was 33. The sample sites were evaluated and ranked as high (21 to 33, 7 sites), medium (7 to 20, 35 sites), or low (-7 to 6, 8 sites) for growth and maintenance of riparian cottonwood forests. Five sites were selected for cottonwood restoration using the model developed. Bare root trees were planted mechanically and by hand. Drought conditions limited survival and 50% of the area was replanted. Further data collection may increase the use of geographic information system (GIS) technology and facilitate site selection for cottonwood restoration in the northern Great Plains.

Key Words: GIS, *Populus*, riparian restoration

INTRODUCTION

In 1944 the Flood Control Act was passed authorizing the U.S. Army Corps of Engineers to construct water development projects, including five Missouri River main-stem dams (Oahe, Big Bend, Gavins Point, Fort Randall, and Garrison). These reservoirs were constructed to facilitate flood control, hydroelectric power generation, irrigation, and navigation, and to improve municipal and industrial water supply, recreation, and fish and wildlife habitat (Johnson 1998; Cheyenne River Sioux Tribe 1999). The Cheyenne River Sioux Tribe lost 42,290 ha (104,420 ac) of land to the construction of the

Manuscript received for review, July 2009; accepted for publication, December 2009.

Oahe Dam, including lands not flooded but determined to be potential erodible areas; approximately 28,815 ha (71,148 ac) of wildlife habitats were inundated. In August of 1999 legislation passed to reclaim lands taken by the Corps of Engineers during the construction of two dams on the Missouri River. Public Law 106-53 provided for the transfer of lands back to the three entities and for the establishment of terrestrial wildlife habitat restoration trust funds upon the completion of restoration plans. The Cheyenne River Sioux Tribe submitted their terrestrial wildlife habitat restoration plan in October 1999.

The tribal plan describes three main goals, one of which is to mitigate for the loss of wildlife habitat. On the Cheyenne River Sioux Reservation, the flooding of the Missouri River resulted in the loss of 9,778 ha (24,143 ac) of riparian habitats (Cheyenne River Sioux Tribe 1999) with 5,708 ha (14,095 ac) being cottonwood/ash and cottonwood/willow habitats. Due to the large loss of riparian areas, the Cheyenne River Sioux Tribe gave riparian restoration the highest priority of all habitat mitigation activities.

The journals of Lewis and Clark (1804–1806; Coues 1893) indicate that along the Missouri River in Montana, cottonwood were scattered, being dense in some areas and absent in others. Native American Indians used cottonwood for fuel and for horse forage (Winship 1904). The cottonwood also serves an important role in Lakota ceremonies (http://angelfire.com/co/MedicineWolf/Lakota/sundance.html). Cottonwoods dominated the unregulated Missouri River floodplain with almost half of the original forest along the upper Missouri River being early-successional cottonwood-willow forest less than 40 years old (Johnson 1998). Severson and Boldt (1978) described the cottonwood-dominated floodplain with the dominant species from Canada to Texas being the plains cottonwood with subordinates of willows (*Salix* L.) and silver sagebrush (*Artemisia cana* Pursh). The dominant species lost in the inundated riparian areas on the Cheyenne River Sioux Reservation were cottonwood, green ash (*Fraxinus pennsylvanica* Marsh.), and willow trees (U.S. Army Corps of Engineers 1982).

Natural establishment of cottonwood seedlings occurs on bare moist sites. Bradley and Smith (1986) found cottonwood stands on portions of point bars that remained moist, but also safe from extended flooding and ice flows in the river. Mature cottonwood seeds must reach a moist seedbed and germinate in a very short period. The timing of seed release and flooding is critical (Borman and Larson 2002). Vegetative reproduction can occur from sprouts, root suckers, broken branches, and shed branchlets (Borman and Larson 2002) depending on species and environmental conditions. Natural establishment is hindered by changes in flooding patterns. An understanding of local fluvial processes is necessary for effective management (Scott et al. 1997).

Among the objectives of the tribal plan's riparian restoration goals are restoration and management of 3,240 ha (8,000 ac) of native cottonwood riparian habitat and the establishment of ranking criteria for evaluation of site need and monitoring of project accomplishments. Geographic information systems are proving to be a useful management tool in many fields of natural resource management. The ability of GIS tools to store and integrate many abiotic and biotic criteria makes it increasingly popular as a means to assist habitat targeting in restoration projects (Bailey et al. 2003). Store and Kangas (2001) used a GIS as a platform for managing, combining, and displaying criterion data and for producing new data by using spatial analysis functions in a habitat suitability model. The Cheyenne River Sioux Tribe uses GIS for wildlife management, habitat restoration monitoring, law enforcement, and range management, using existing data and creating new data with global positioning systems (GPS).

Currently the Game, Fish, and Parks Department of the Cheyenne River Sioux Tribe has been identifying riparian restoration sites on a producer interest basis. In order to increase long-term success of the riparian restoration projects, a more systematic method is needed. The objective of this project was to establish a site-ranking method for native cottonwood riparian habitat restoration utilizing GIS technology.

METHODS

The reservation is often broken into four quadrants for wildlife management due to the large land base; the study was conducted only in the northeastern quadrant, Dewey County, of the reservation (Fig. 1).

The reservation is a mosaic of landownership and jurisdictions. Within the reservation there are tribal, federal and state land jurisdictions. The Cheyenne River Sioux Tribe is responsible for wildlife management on all tribal lands, approximately 567,000 ha (1.4 million acres). Therefore, the first step for this project was to select lands under tribal jurisdiction, 3,640 tracts.

The study focused on the Moreau River which runs through the entire northeast quadrant of the reservation and is the primary stream in this region. Typically the Moreau River consists of sand bars and gently sloping

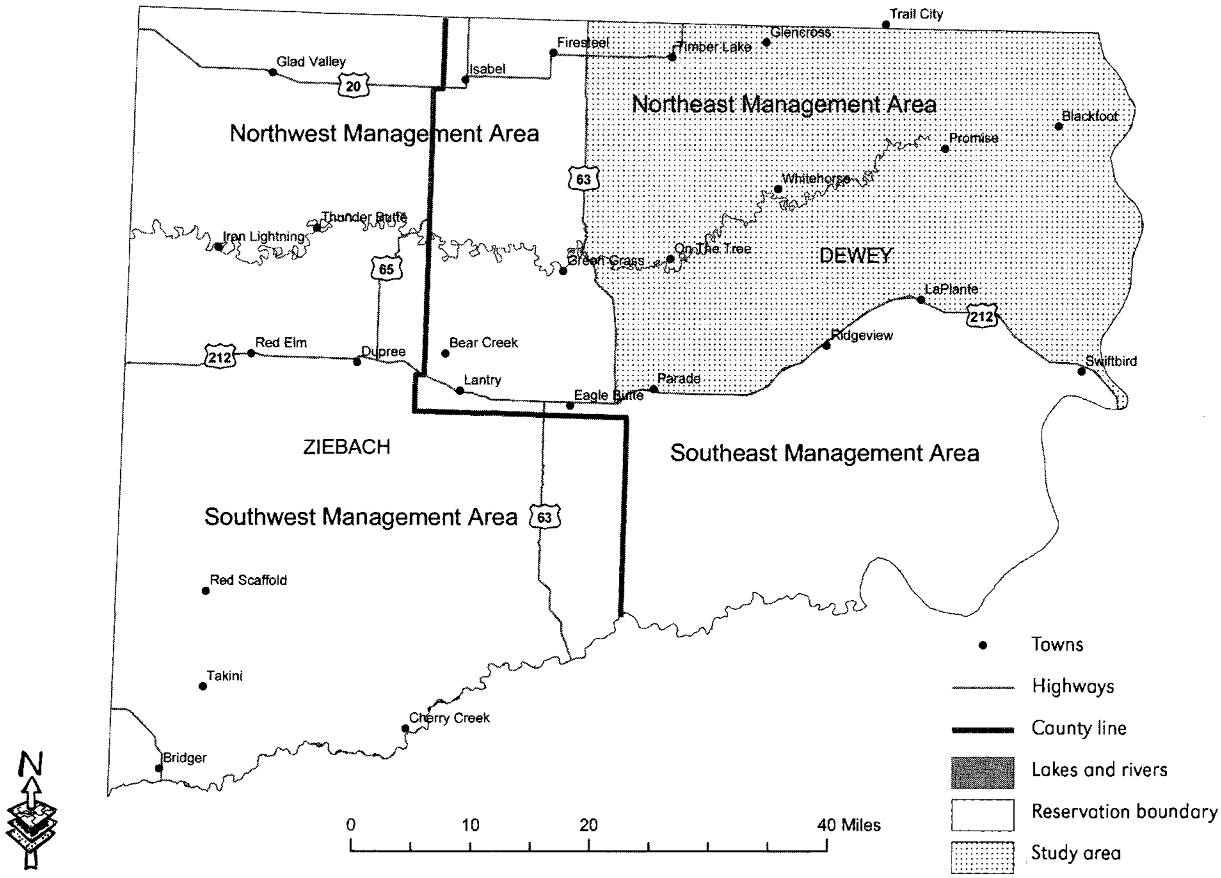

Figure 1. The study area in the northeast quadrant of the Cheyenne River Sioux Reservation, South Dakota. Map created by Julie Thorstenson, 2005.

floodplains with steep, sparsely vegetated cut banks occurring throughout the river system. Land tracts that were partially or wholly within 46 m (150 ft) of the Moreau River were selected from the new layer containing the 3,640 tracts. These 182 tracts were numbered to keep their identity confidential and these numbers were exported into a Microsoft Excel spreadsheet for random selection of 50 tracts to build the model (Fig. 2). Various selection criteria were applied to these 50 tracts. The tract size ranged from 8.1 ha (20 ac) to 258.8 ha (639.2 ac).

Restoration project success depends partly on how closely the site characteristics match the needs of the ecosystem being restored (Baird 1989). In order to rank potential riparian restoration sites, we assigned positive values to Moreau River presence, stream number and length, slope, aspect, soil properties, and land cover. Negative values were assigned for excessive mean slope and excessive grasslands.

GIS software was used to clip the Moreau River layer for each of the sample tracts, and the total length of the Moreau River in each sample site was calculated. Presence of the Moreau River within the sample site was given a value of 5 to emphasize the importance of water to cottonwood restoration. Riparian restoration sites on the Cheyenne River Sioux Reservation are fenced and have been kept to a maximum of 1.6 km (1 mile) to avoid denying water access and grazing. Five categories were assigned for length of the Moreau River; these categories and their respective values are shown in Table 1. Lengths less than 201 m (660 ft) were considered too small to be cost effective and were assigned a value of zero.

Small stream channels and their riparian zones provide unique habitats (Meyers and Wallace 2001), but there is no clear definition or agreement of what constitutes a small stream (Moore and Richardson 2003). Various intermittent and ephemeral streams drain into the Moreau River. A Dewey County stream layer was sized, using ArcGIS, to the study area (Fig. 2). This new stream layer was clipped to each of the sample sites. These streams are very important as potential restoration sites because

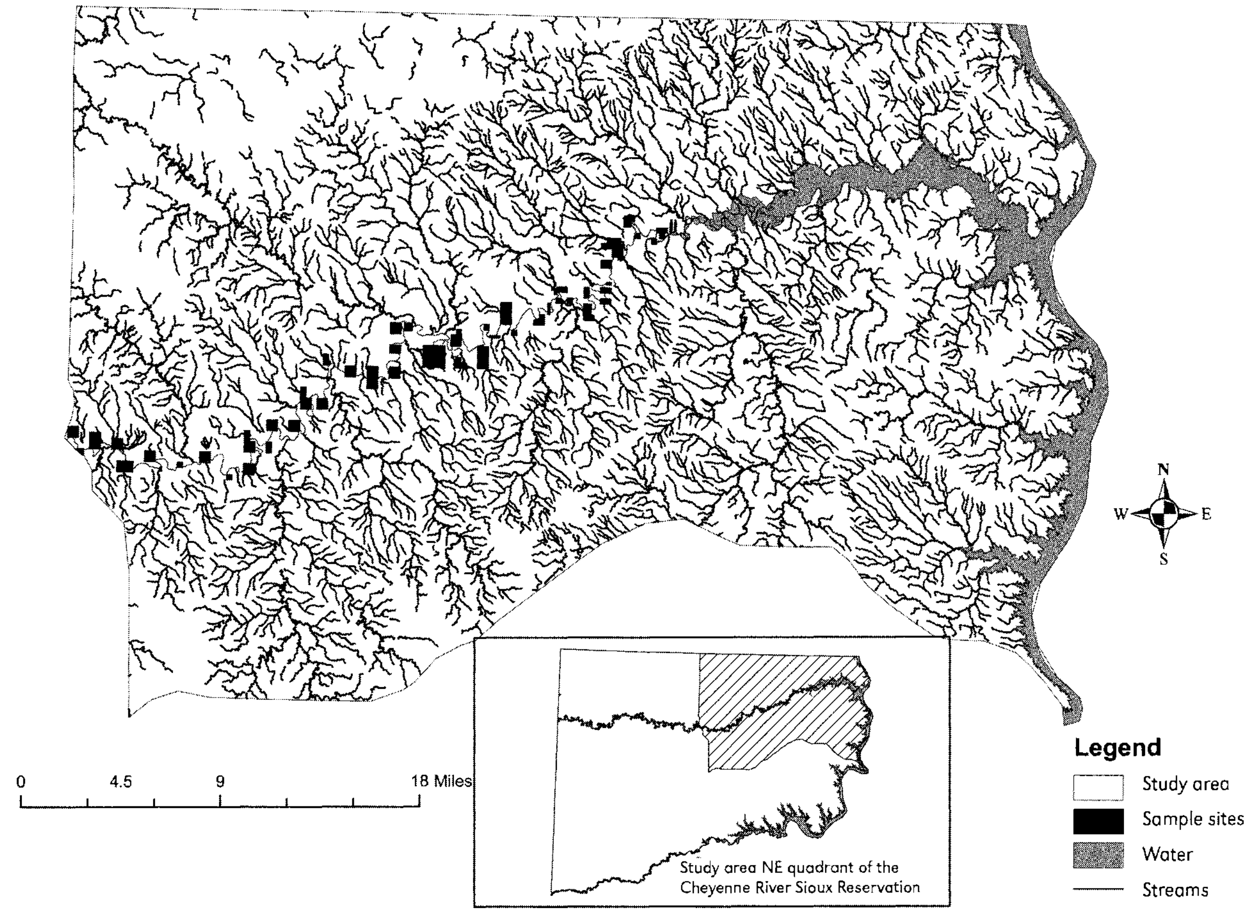

Figure 2. Streams and sample sites within the study area. Map created by Julie Thorstenson, 2005.

they provide seasonal flooding needed for cottonwood establishment. Their importance is defined in the stream factors category. The total number of streams was broken into six categories (Table 1) and values were assigned for each. Total length of all streams within each sample site was also calculated. The total stream length was considered, with categories ranging from 0 to 1520+ m (5,001+ ft) (Table 1).

Slope of the land often dictates the vegetation and land use. Hodorff et al. (1988) found that topography influenced woodlands stand structure and that steep slopes of closed stands discouraged livestock use. To analyze slope factors, a slope raster was derived from a digital elevation model (DEM) of Dewey County using ArcGIS Spatial Analyst. Slope was analyzed for each of the 50 sample sites using the zonal statistics option in Spatial Analyst. Ormsby and Alvi (1999) define zones as sets of cells with the same value. This resulted in a slope statistics table detailing such factors as minimum, mean, and maximum for each of the sample sites. Mean slope, expressed as a percentage, was used for evaluation purposes. Mean slope was divided into four categories and values assigned for each of the four (Table 1). The lower the percentage of mean slope, the greater the value assigned. Putnam et al. (1960) reported that eastern cottonwood occurs natively on well-drained flats and that where it occurs on slopes, it is confined to the lower ones. Any slope over 15% was considered excessive for cottonwood growth and maintenance and a value of 5 was deducted from the total score. A negative value was assigned to steep slopes because they are poorly suited to establishment and survival and are difficult to plant and maintain.

Aspect was obtained from the Dewey County digital elevation model. It depicts the direction in which the land is sloping as measured in degrees (0° to 360°). Most of the approximately 810 ha (2,000 ac) of native trees and shrubs in Dewey County are on bottomland, in natural draws, and on steep, north-facing slopes (Kalvels and Boden 1979). A new grid dataset depicting aspect for the study area was created using the Surface Analyst component of Spatial Analyst. Aspect was analyzed for each of the 50 sample sites using the zonal statistics component of

TABLE 1
SITE EVALUATION FORM AND NUMBER OF SAMPLE SITES (FROM 50) RECEIVING EACH SCORE

Criteria	Characterization	Value/Score	No. of sample sites
Moreau River present	Yes	5	44
	No	0	6
Moreau River length (m)	>1,605	4	4
	803–1,605	3	11
	402–802	2	15
	201–401	1	7
	<201	0	7
Total stream length (m)	>1,520	4	3
	761–1,520	3	4
	305–760	2	13
	31–304	1	6
	<31	0	24
Number of streams	5	5	2
	4	4	1
	3	3	3
	2	2	7
	1	1	14
	0	0	23
Mean slope (%)	0–5	3	2
	5.1–10	2	10
	10.1–15	1	11
	>15 (excessive)	–5	27
Mean aspect (°)	179–269	3	23
	89–178	2	27
	270–360	1	0
	0–88	0	0
Presence of excellent or good soil (≥0.4 ha)	Excellent	2	44
	Good	1	6
	Neither	0	5
Total hectares of good and/or excellent soil	>41	4	13
	21–41	3	11
	5–20	2	17
	0.4–4	1	4
	0	0	5
Deciduous forest present (≥0.4 ha)	Yes	1	25
	No	0	25
Wetland vegetation present (≥0.4 ha)	Yes	1	30
	No	0	20
Excessive grassland (%)	>75	–2	26

Spatial Analyst. This resulted in an aspect statistics table detailing such factors as minimum, mean, and maximum for each of the sample sites. Mean aspect, expressed in degrees, was used for evaluation purposes. Aspect was divided into four categories and values assigned for each, with northeast facing slopes (179° to 269°) receiving the highest score (Table 1). Southwest-facing slopes were not considered suitable for cottonwood growth and received a score of zero.

Soil type is accepted as an important abiotic factor in determining a site's suitability for a particular habitat (Tansley 1939, cited in Bailey et al. 2003). Friedman et al. (1995) found that a site with coarse soil texture and low organic matter should be chosen to increase cottonwood seedling survival. A Dewey County soil map layer was clipped to the study area using ArcGIS. The sample sites were overlaid on the study area soil layer and the soil layer was clipped using the intersect function in ArcGIS. In this case the input layers were the sample sites and the soil layer, which resulted in soils for each sample site. The soil composite of each of the 50 sample sites was then summarized. An acre percentage field was created and calculations made to yield a percentage of each soil type for the sample site. Next, all of the soils present in the 50 sample sites were recorded and examined. A ranking system was created to rank each soil series for suitability to grow and maintain native cottonwoods. The following factors were used to determine the suitability ranking of the soil: available water holding capacity, windbreak suitability (soil characteristics and plant species), fertility, runoff, permeability, erosion potential, and organic material (Dewey County soil survey). Values were summed and the soils were broken into one of four suitability indexes: poor, fair, good, and excellent. To receive a score for the soil rating, the sample site had to contain a minimum of 0.4 ha (1 acre) of excellent and/or good soil. Presence of excellent soil yielded a value of 2 and presence of good soil, a value of 1 (Table 1). Total acreage of good and excellent soil was also considered. Five categories were established for total acreage and values assigned to each (Table 1).

The 1992 National Land Cover Data (NLCD) was obtained through the U.S. Geological Survey (USGS) Seamless Data Distribution System for the eastern half of the reservation. This 30-m raster dataset was then clipped using ArcInfo to an area that included all 50 sample sites. ArcGIS Spatial Analyst was used to analyze acreage and percentage of land-cover classes represented for each of the 50 sample sites. NLCD is a 21-class land-cover classification scheme applied consistently over the United States (U.S. Geological Survey 2003). Land-cover classes include water, developed (areas with a high percentage of constructed materials), barren, forested upland, shrubland, non-natural woody, herbaceous upland natural/seminatural vegetation, herbaceous planted/cultivated and wetlands. The U.S. Geological Survey (2003) defines deciduous forests as areas dominated by trees where 75% or more of the tree species present shed foliage simultaneously in response to seasonal change. Wetlands are described by the U.S. Geological Survey (2003) as areas where the soil or substrate is periodically saturated with or covered with water. Wetland vegetation and deciduous forests are often common in riparian areas. Therefore, presence of each was examined and scored (Table 1). At least 0.4 ha (1 acre) needed to be present to receive a value. A value of -2 was applied if an area was greater than 75% grassland (Table 1). Grasslands are defined as "areas dominated by upland grasses and forbs" (U.S. Geological Survey 2003). It was assumed that greater than 75% grassland indicated an upland area, not favorable for growing and maintaining cottonwood trees.

Once the ranking criteria were examined and weighted, an evaluation form was created (Table 1). Each of the 50 sample sites was evaluated based on this form, and scores were totaled and recorded. The lowest possible value any site could receive was a -7 and the highest possible score was 33. Threshold levels were determined for a suitability index. Low sites were sites with a score of -7 to 6, medium, 7 to 20; and high, 21 to 33. For the model, low sites were assumed to be unsuitable for cottonwood restoration. Medium sites were sites that might be able to grow and maintain cottonwoods, but might require various degrees of additional site work. High scores indicated the best sites for cottonwood restoration. Future work will be conducted to "ground truth" the model and test these assumptions.

RESULTS

The 50 tracts included in the study totaled 2,829 ha (6,986 ac) with a minimum size of 8 ha (20 ac), maximum of 259 ha (640 ac) and an mean of 57 ha (140 ac).

In 44 of the 50 sample sites, the Moreau River was present. Of these, 7 sites contained lengths less than 201 m (660 ft), 7 contained between 201 m and 401 m (660 and 1,319 ft), 15 contained 402 m to 802 m (1,320 to 2,639 ft), 11 contained between 803 m and 1,605 m (2,640 and 5,279 ft) and 4 sites contained more than 1,605 m (5,279 ft) (Table 1). Most of the riparian restoration projects presently on the reservation are at least 1,605 m (5,280 ft) in length. However, length does not influence the overall quality of a site for restoration. The minimum reach to receive a positive value was 201 m (660 ft). Several factors contributed to the selection of this minimum. It is not cost efficient for the tribe to execute extremely small restoration sites due to the distance traveled and the labor and supplies required. However, the allowance of a shorter length gives landowners with less access to the Moreau River a chance to improve riparian habitat. Most of the land in the study area is rangeland used for livestock production. The Moreau River provides a water source and much-needed winter protection to these producers. The shorter reach allows a producer to restore cottonwood habitat without restricting complete access to a much-needed resource.

A large portion of the sites (n = 23) did not contain small streams. Fourteen of the remaining sites contained 1 stream, seven contained 2, three contained 3, one contained 4, and two sites contained 5 streams. The mean length of a small stream was 419 m (1,377 ft). Although 23 sites did not contain small streams, this did not correspond directly with a low suitability index. The evaluation results of the Moreau River and stream factors categories for the 50 samples sites can be seen in Table 1.

The minimum slope within the 50 sample sites was 3.1 with a maximum of 57.5. The mean slope of the 50 sample sites was 20.1. Scoring for slope was based on four categories. Only 2 sites fit the 0% to 5% category, with 10 in the 5.1% to 10% category and 11 sites in the 10.1% to 15% category. Twenty-seven of the sites had mean slopes in excess of 15% (Table 1). The Moreau River usually consists of a broad floodplain on one side and a steep cutbank on the other. Since mean slope was calculated for the entire sample site, this may not have been an accurate method for analysis of slope. It might have been more accurate to determine a percentage of each of the three categories to assess an area.

The analysis of aspect showed that the majority of the sites were in the 89° to 178° northwest-facing category (n = 27). The remaining 23 were in the 179° to 269°, northeast-facing category (Table 1). Sites were relativity similar in aspect. This factor seemed to have little influence on the overall site suitability for cottonwood restoration in our selected samples. While aspect may not have an effect on the choice of locations for cottonwood restoration, it may be important in site selection for other woody species. For example, woody type habitats that are not riparian exist on steep north-facing slopes (Severson and Boldt 1978).

Many soil factors contribute to the success of cottonwood restoration. There were 10 soil associations within the study area. Friedman et al. (1995) recommended choosing sites with coarse soil texture and low organic matter to minimize competition. Of the 31 different soil types in the study area, 5 were rated excellent, 5 were good, 4 were fair, and 17 were poor in terms of their suitability for cottonwood restoration. Soils that ranked in the fair and poor categories required too much additional site preparation such as additional irrigation and site manipulation to increase runoff and flooding or fertilization to provide suitable cottonwood restoration, and overall site success was anticipated to be low (Dewey County soil survey). Five of the 50 sample sites lacked either good or excellent soils (Table 1). All of these sites received a low overall ranking. This method represents the significance of soil on cottonwood restoration. The total acreage of good and excellent soils was also calculated and scored (Table 1; Fig. 3).

Half of the sample sites (n = 25) had the presence of deciduous forests. The presence of wetland vegetation was slightly higher with 30 samples sites (Table 1). Twenty-six of the 50 sample sites had excessive grasslands and received a negative score (Table 1). As much as 88% of the land in the study area is in native grass and is grazed (Kalvels and Boden 1979). The sample sites that contained deciduous forests and wetland vegetation directly corresponded with the presence of the Moreau River or streams. The study area was predominantly rural and contained no major urban areas. Therefore, land classified as developed was not considered in the evaluation. The NCLD provides a broad generalization for land use in an area; however, one must consider the age of the data and that land use may have changed. Therefore, the NCLD data were used only as supplemental information and caution was taken not to place too much emphasis on it. This was accomplished by weighting the criteria at a lesser value than other criterion.

An index was developed having three classes of suitability for cottonwood restoration (based on criteria scores). The three classes were scores of -7 to 6 assumed to be low suitability, scores ranging from 7 to 20 assumed to be medium suitability, and scores between 21 and 33 assumed to be high suitability. A suitability map was created based on the suitability indexes (Fig. 4). Of the 50 samples, 8 were low suitability, 35 were medium suitability, and 7 were high suitability (Fig. 5).

Cottonwood restoration sites were selected on a small scale in 2006 based on the developed GIS model. To test the validity of the model, sites were selected from all classes of suitability. A total of five sites were selected: one low suitability, one medium suitability, and three

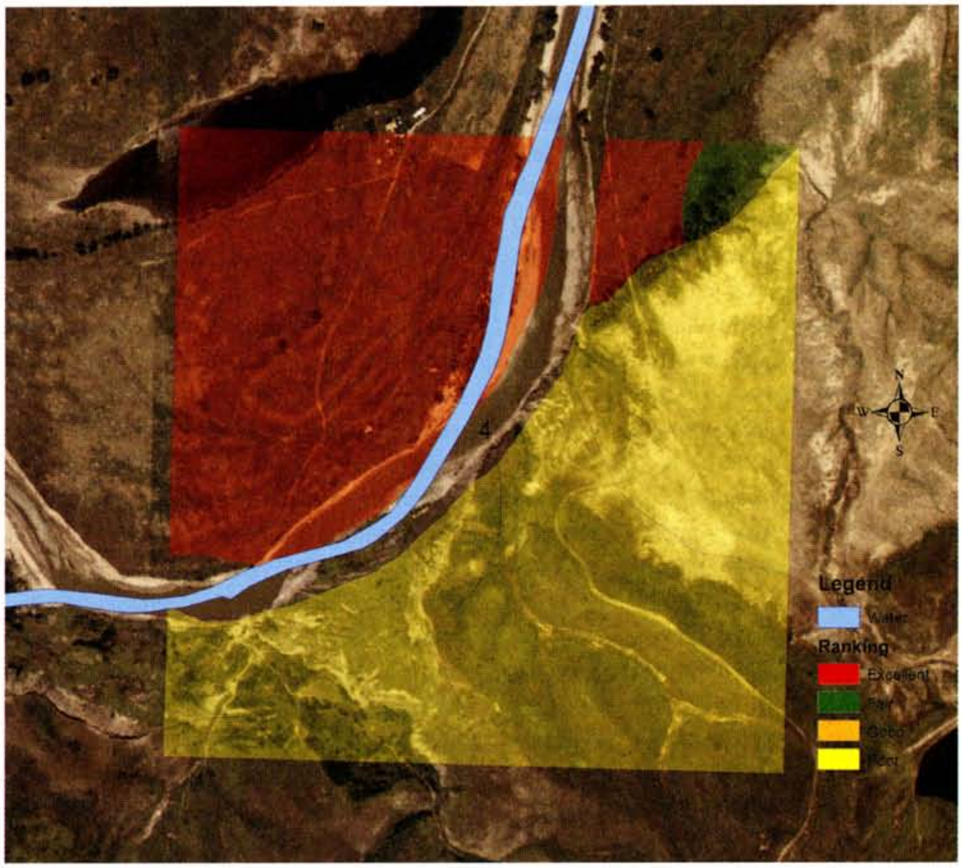

Figure 3. Aerial photo of sample site 4, showing a mix of excellent and poor soils, resulting in medium suitability for cottonwood trees. Map created by Julie Thorstenson, 2005.

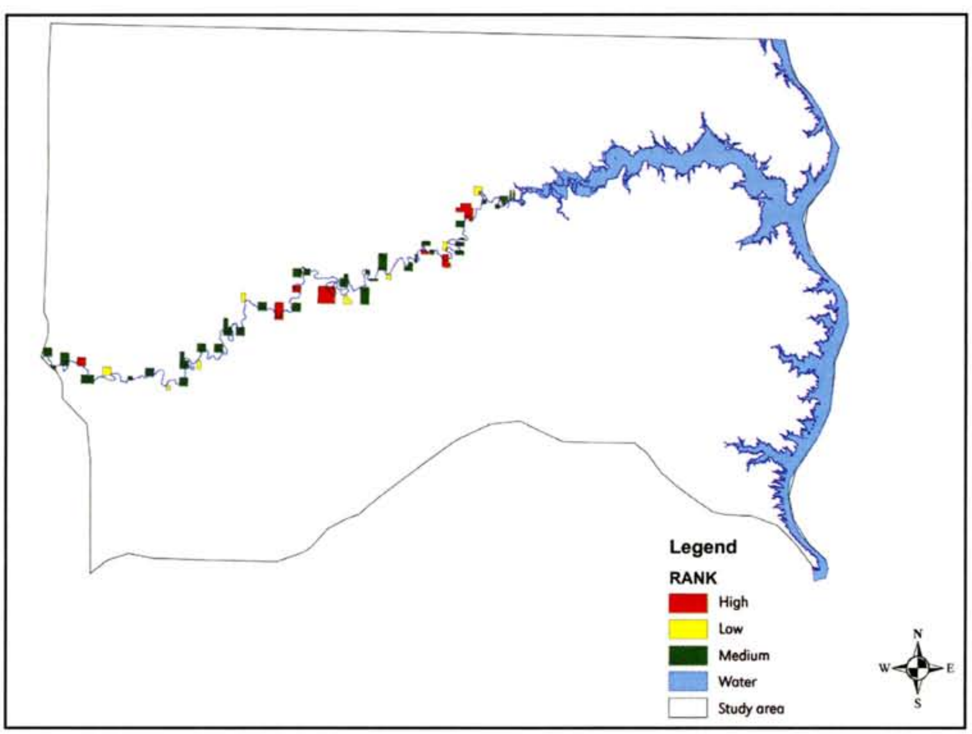

Figure 4. Sample sites by suitability for native cottonwood tree restoration in the northeast quadrant of the Cheyenne River Sioux Reservation, South Dakota. Map created by Julie Thorstenson, 2006.

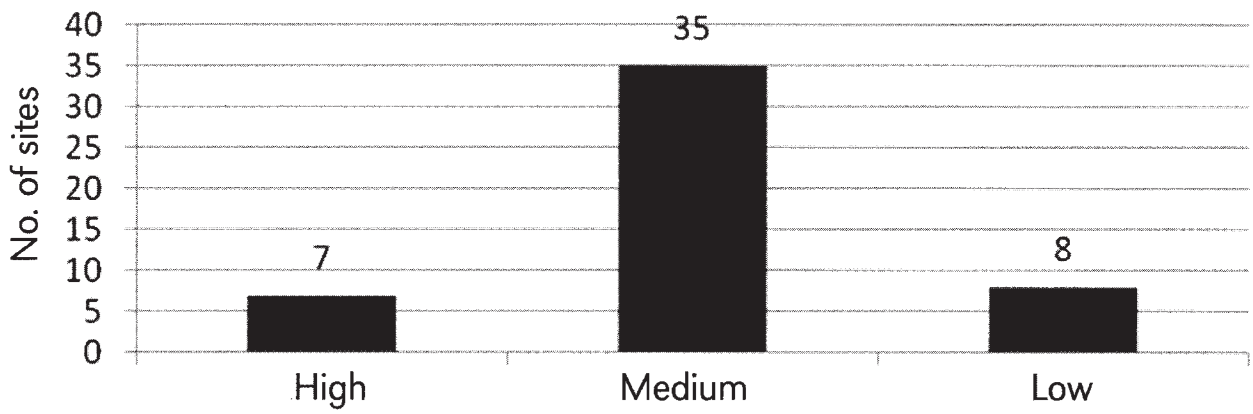

Figure 5. Cottonwood suitability index ranking of 50 sample sites in the northwest quadrant of the Cheyenne River Sioux Reservation, South Dakota.

high suitability. Each of the five sites was randomly hand planted with 3,000 (total) bare root trees. In addition, two L-shaped areas were mechanically planted with bare root trees within the medium suitability site and one of the high suitability sites (1,915 trees total). The growing season in 2006 was droughty, and 50% of the mechanically planted areas were replanted in 2007. Ware and Penfound (1949) found that cottonwood seedlings were vulnerable to drought during their first year, prior to extensive root development. Because of a change in employment, it was not possible to collect further data on survival and growth.

CONCLUSIONS

This study demonstrates how GIS technologies can be used to select sites for native cottonwood restoration on the Cheyenne River Sioux Reservation. It provides a scientific method for cottonwood restoration site selection and can serve as a model for site selection for other conservation and restoration practices.

The most important criterion for selection of sites for cottonwood restoration was presence of the Moreau River. Sample sites that did not contain the Moreau River had a negative rating for this criterion and, overall, were given a low suitability ranking. This is to be expected when dealing with riparian restoration; the proximity of a stream or river is a requirement. Riparian sites bare and moist enough for cottonwood establishment are usually close to the channel and subject to disturbance by the stream (Friedman et al. 1997). The success of cottonwood restoration on the Cheyenne River Sioux Reservation is contingent on locating sites along the Moreau River.

The second critical consideration was soil. The overall results of this study support the findings of Store and Kangas (2001) that permanent factors such as soil characteristics define the habitat potential or, in the case of this study, the site suitability.

The ultimate measure of success of this study would be actual fieldwork. Sites were selected based on the model, and bare root trees were planted. Unfortunately it was not possible to continue data collection to determine survival and growth. In the future, success of restoration efforts could be determined by annual monitoring and comparison with wildlife population surveys that are already being conducted on a yearly basis. This is a lengthy process that was outside the scope of this study. Although the effects of the Pick-Sloan Plan cannot be corrected completely, the restoration of a vital natural resource will help to offset some portion of the overall damage inflicted on riparian habitats.

REFERENCES

Bailey, N., T. Clements, J.T. Lee, and S. Thompson. 2003. Modeling soil series data to facilitate targeted habitat restoration: A polytomous logistic regression approach. *Journal of Environmental Management* 67:395–407.

Baird, K. 1989. High quality restoration of riparian ecosystems. *Restoration and Management Notes* 7:60–64.

Borman, Michael, and Larry Larson. 2002. Cottonwood establishment, survival, and stand characteristics. EM880. Oregon State University Extension Service.

Bradley, C.E., and D.G. Smith. 1986. Plains cottonwood recruitment and survival on a prairie meandering river floodplain, Milk River, southern Alberta and Northern Montana. *Canadian Journal of Botany* 64:1433–42.

Cheyenne River Sioux Tribe. 1999. Terrestrial wildlife habitat restoration plan for Oahe Reservoir on the Cheyenne River Sioux Reservation. Unpublished.

Coues, E., ed. 1893. *The History of the Lewis and Clark Expedition*, vol. 1. Francis P. Harper, New York. Reprint (unabridged), Dover Publications, New York.

Friedman, J.M., M.L. Scott, and G.T. Auble. 1997. Water management and cottonwood forest dynamics along prairie streams. In *Ecology and Conservation of Great Plains Vertebrates*, ed. F.L. Knopf and F.B. Samson, 49–71. Springer-Verlag, New York.

Friedman, J.M., M.L. Scott, and W.M. Lewis Jr. 1995. Restoration of riparian forest using irrigation, artificial disturbance and natural seedfall. *Environmental Management* 19:547–57.

Hodorff, R.A., C.H. Sieg, and R.L. Linder. 1988. Wildlife responses to stand structure of deciduous woodlands. *Journal of Wildlife Managemen*t 52:667–73.

Johnson, W.C. 1998. Adjustment of riparian vegetation to river regulation in the Great Plains, USA. *Wetlands* 18:608–18.

Kalvels, J., and P.M. Boden. 1979. Soil survey of Dewey County, South Dakota. *USDA Soil Conservation Service, National Cooperative Soil Survey.* Washington, DC.

Meyers, J.L., and J.B. Wallace. 2001. Lost linkages and lotic ecology: Rediscovering small streams. In *Ecology: Achievement and Challenge*, ed. N. Press, N. Huntly, and S. Levin, 295–317. Blackwell Science, Oxford, UK.

Moore, R.D., and J.S. Richardson. 2003. Progress towards understanding the structure, function, and ecological significance of small stream channels and their riparian zones. *Canadian Journal of Forest Research* 33:1349–51.

Ormsby, T., and J. Alvi. 1999. Extending ArcView® GIS. ESRI Press, Redlands, CA.

Putman, J.A., G.M. Furnival, and J.S. McKnight. 1960. Management and inventory of southern hardwoods. *U.S. Department of Agriculture, Agriculture Handbook 181.* Washington, DC.

Scott, Michael L., Gregor T. Auble, and Jonathan M. Friedman. 1997. Flood dependency of cottonwood establishment along the Missouri River, Montana, USA. *Ecological Applications* 7:677–90.

Severson, K.E., and C.E. Boldt. 1978. Cattle, wildlife, and riparian habitats in the Western Dakotas. In *Regional Rangeland Symposium: Management and Use of Northern Plains Rangeland*, 91-103. Rocky Mountain Forest and Range Experiment Station, Rapid City, SD.

Store, R., and J. Kangas. 2001. Integrating spatial multicriteria evaluation and expert knowledge for GIS-based habitat suitability modeling. *Landscape and Urban Planning* 55:79–93.

Tansley, A.G. 1939. *The British Islands and Their Vegetation.* Cambridge University Press, Cambridge, UK.

The sundance ceremony, http://www.angelfire.com/co/MedicineWolf/Lakota/sundance.html (accessed November 2, 2010).

U.S. Army Corps of Engineers, Omaha District. 1982. Fish and wildlife mitigation, Lake Oahe and Lake Sharpe, South Dakota. *Omaha (NE): Post Authorization Report (PAR).*

U.S. Geological Survey. 2003. Land Cover Institute, http://landcover.usgs.gov (accessed January 28, 2005).

Ware, G.H., and W.T. Penfound. 1949. The vegetation of the lower levels of the floodplains of the South Canadian River in central Oklahoma. *Ecology* 30:478–84.

Winship, G.P. 1904. *The Journey of Coronado, 1540–1542.* A.S. Barnes, New York.