Near-riparian vegetation of the Colorado River at Colorado Bend State Park and Regency, Texas.

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ABSTRACT

We analyzed the near-riparian zone along the Colorado River in the Lampasas Cut Plain (LCP) of Texas at Colorado Bend State Park (CBSP) as well as private property at Regency, Texas and described species composition and structure of vegetation. Both of these sites had not been grazed by cattle in decades and we compared it to Timberlake Biological Station (TBS), where grazing has occurred for decades, but ended in 2021 as well as creek side vegetation reported from the Blackland Prairie (BP). Our analysis was conducted to provide baseline knowledge on the natural vegetation of this near-riparian zone that has only been examined from Texas in the LCP ecoregion at TBS and the adjacent BP ecoregion. The near-riparian zone of the two sites in this investigation were different from each other with the state park site more similar to TBS and both being less diverse than similar ecosystems reported from the BP. At CBSP the near-riparian zone was comprised of three vegetational layers: 1) upper-canopy of trees including mainly cedar elm (*Ulmus crassifolia*) 2) under-canopy of the lianas saw greenbriar (*Smilax bona-nox*) and poison ivy (*Toxicodendron radicans*), the fern ally scouring-rush (*Equisetum hyemale*) as well as both annual and perennial grasses and forbs. Dominant grasses and sedges at CBSP included switch grass (*Panicum virgatum*), broad-leaf woodoats (*Chasmanthium latifolium*), and Emory's caric sedge (*Carex emoryi*). The dominant forb at CBSP was knotweed (*Polygonum* sp.). At Regency, the near-riparian zone was comprised of three vegetational layers: 1) upper-canopy of trees including mainly sugarberry (*Celtis laevigata*) 2) under-canopy of saw greenbriar (*Smilax bona-nox*) as well as both annual and perennial grasses and forbs. At Regency, the near-riparian was dominated by introduced Johnsongrass (*Sorghum halepense*) and Emory's caric sedge. The dominant forb at Regency was spiny-aster (*Chloracantha spinosa*). CBSP was richer, more even, and had higher Shannon-Weiner Diversity in its woody species but had a similar Shannon-Weiner Diversity value to Regency in their herbaceous species. The near-riparian region was about the same as the bottomland diversity at TBS and on the Bosque River, near Stephenville, Texas. Diversity was lower than that reported in riparian areas of the adjacent BP. The diversity, of these near-riparian sites being higher than bottomland forests from the region, likely reflects the dynamic nature of these ecosystems due to hydrological disturbance and the chance-events of dispersal and successful establishment of plants in this changing environment. *Published online* ***www.phytologia.org*** *Phytologia 105(1): 1-14 (March 21, 2023). ISSN 030319430.*

KEY WORDS: Near-riparian forest, Colorado River, Lampasas Cut Plain, Plant community ecology

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Bottomland forests and their associated near-riparian zones are some of the most widely distributed, species-rich, and productive communities throughout southern regions of North America (Braun 1964;

Messina and Conner 1998; Baker et al. 2004). It has been estimated that over one-half of the bottomland forest ecosystem in Texas has been lost (Barry and Kroll 1999) and most, including the near-riparian area adjacent to the Colorado River in this investigation, have had their hydrology changed due to damming to form reservoirs (Texas Parks and Wildlife (TPWD) 2012). Because of these losses there is interest in restoration and preservation of riparian zones. However, little is known about community composition of the near-riparian zone in Texas, which is defined here as the narrow, dynamic area adjacent to the bottomland and beginning at the water's edge. This region is an extremely important buffer zone for the adjacent bottomland forest and has been shown to differ in species composition from the bottomland in East and North Central Texas (Nixon et al. 1991, 1977; Nixon and Raines 1976; Nelson et al. 2021).

Description of the natural vegetation is an important phase in understanding riparian areas. There has been limited description and vegetational analysis of such communities (TPWD 2012). Only one investigation at Timberlake Biological Station (TBS) (Nelson et al. 2021) in Texas has examined understory quantitatively in near-riparian zones of North Texas.

Other descriptive studies and subsequent qualitative reports of southern floodplain forests (Diamond et al. 1987; Meadows and Stanture 1997; Twedt and Best 2004; Lockhart and Kellum 2006; Twedt et al. 2010; Rosiere et al. 2013; Nelson et al. 2018) indicated the widespread sugarberry-elm-pecan forest type to be highly variable in its composition, especially where it is ecotonal to adjacent cover types. The general forest community as found in Texas was described variously as elm/sugarberry parks/woods (McMahan and Frye 1987), sugarberry-elm series (Diamond et al. 1987), sugarberry-elm floodplain forest (Bezanson 2000), and Edwards Plateau floodplain hardwood forest (Elliott 2013). By these conventions, Nelson et al. (2021) classified the near-riparian at TBS as green ash-elm.

Descriptions of understories of woodlands in eastern and southern forest regions of the United States commonly have been in conjunction with soil surveys under leadership of the Natural Resources Conservation Service (NRCS; (Soil Conservation Service 1967, 1976; NRCS 2003) and, more recently, river authorities (Jones-Lewey 2016). In an attempt to generally describe riparian areas across the state, the Nueces River Authority (NRA) produced a field guide, which included some of the common vegetation found in Texas riparian areas (Jones-Lewey 2016). Descriptions of grazeable woodlands are currently written as forest land ecological sites (NRCS 2003). Forest land ecological site descriptions need greater detail regarding forest vegetation, including that of the understory. Likewise, classification of natural communities such as forest alliances and series (Diamond et al. 1987; McMahan and Frye 1987; Bezanson 2000, Hoagland 2000) as well as the field guide by the NRA (Jones-Lewey 2016) have been largely qualitative with limited quantitative information provided.

Rosiere et al. (2013) and Nelson et al. (2018) described bottomland forests, which aligned with the description of southern floodplain forests described above. Lonard et al. (1997; 1998; 1999; 2000; 2001; 2004), Lonard and Judd (2002), Everitt et al. (1999; 2002), and Zhang et al. (1998) documented riparian vegetation including the near-riparian for the Rio Grande in South Texas, but species composition of the subtropical Rio Grande was too different for comparison to this temperate-region investigation. To our knowledge, the only publications that mentions near-riparian vegetation in temperate North Texas is Nixon et al. (1991) and Nelson et al. 2021). Nixon et al. (1991) investigated creekside forest along Spring Creek, north of Garland, Texas. They found that sugarberry, elms (*Ulmus* spp.), and ashes (*Fraxinus* spp.) were the most important tree species along the creek side. The most prevalent shrubs and small trees were roughleaf dogwood (*Cornus drummondii*), rusty blackhaw (*Viburnum rufidulum*), Carolina buckthorn (*Rhamnus caroliniana*), and eastern red cedar (*Juniperus virginianum*). River grape (*Vitis riparia*), poison-ivy (*Toxicodendron radicans*), and Virginia creeper (*Parthenocissus quinquefolia*) were the most common lianas at the site. Shannon-Weiner diversity was 3.40 and richness was 32. Nelson et al. (2021) reported three vegetational layers of the Colorado River at TBS: 1) upper canopy of trees including mainly green ash (*Fraxinus pennsylvanica*) and about equal amounts of cedar elm (*Ulmus crassifolia*) and American elm (*U. americana*) 2) under canopy of the liana saw greenbriar (*Smilax bona*-nox) as well as both annual and perennial grasses and forbs. Green ash was the dominant tree and saw greenbriar and Virginia Creeper (*Parthenocissus quinquefolia*) were the only two lianas. Dominant grasses and sedges included Canada wildrye (*Elymus canadensis*), switch grass (*Panicum virgatum*) and Emory's caric sedge (*Carex emoryi*). The dominant forb was spiny-aster (*Chloracantha spinosa*). Shannon-Weiner diversity was 1.12 (woody) and richness (woody) was 5.

We conducted this investigation to provide descriptions and analyses of near-riparian forests of the Colorado River in the LCP (Diggs et al. 1999) at places on the river that were less grazed than TBS (Nelson et al. 2021) and more arid than that of the BP (Nixon et al. 1991). Currently there is a need for quantitative data of this forest vegetation, which is lacking for much of Texas (Diamond et al. 1987) and because of ongoing classification and ground-truthing of natural plant communities (Elliott 2013), as well as riparian reclamation and restoration projects.

MATERIALS AND METHODS

The Regency study area, located within the small town of Regency, Texas in southwestern Mills County, is found within the LCP ecoregion (Diggs et al. 1999) and Cross Timbers and Prairies vegetational area (Correll and Johnston 1979; Fig. 1). CBSP is located west of Lampasas in San Saba and Lampasas counties on the former sites of the Gorman and Lemons ranches above Lake Buchanan. Texas Parks and Wildlife Department (TPWD; 2022) purchased part of the park in 1984, and the rest in 1987, which resulted in livestock grazing cessation. The 5,328.3-acre park opened in 1987 with campgrounds and hiking trails (TPWD 2022).

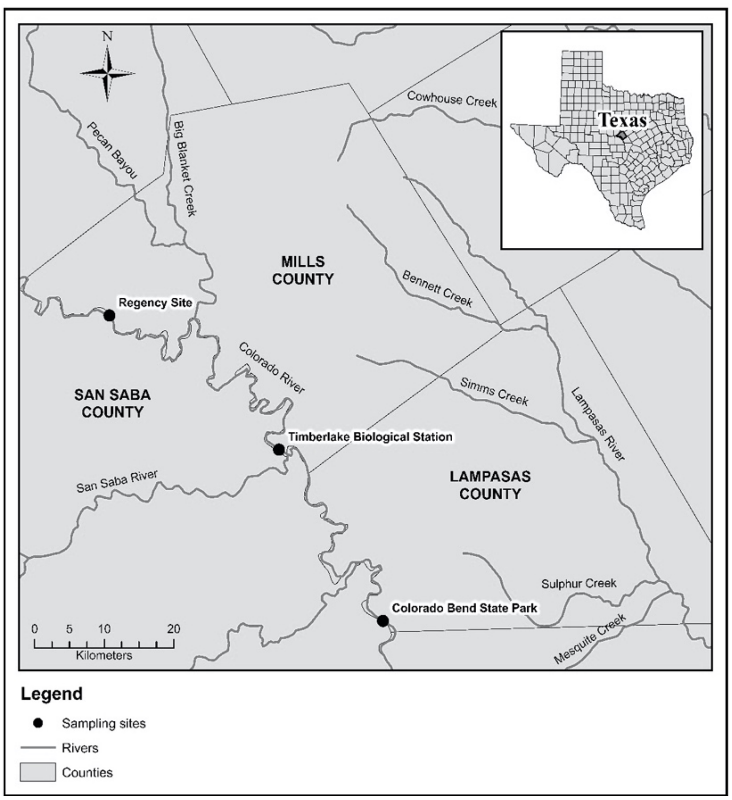

Figure 1. Map showing the Colorado River with study sites labeled, Texas. Inset shows the location of the counties in Texas.

The Colorado River in Texas, which borders the two research sites (Fig. 1) is the longest river confined to the state, beginning in the Caprock Escarpment near Lamesa, Texas, and flows to the Gulf of Mexico at Matagorda Bay (Crisp 2012). Both sites are downstream from Lake O. H. Ivie, which was constructed 27 years ago at the confluence of the Concho and Colorado rivers (Williams 2016), about 145 km south of Abilene, Texas. We sampled vegetation from October, 2016 to April, 2017 using nonpermanent plots, which have been shown to yield few statistically significant differences from permanent plots in riparian vegetation monitoring (Laine et al. 2013).

We used the step-point method (Evans and Love 1957; Bonham 1989) to determine composition of herbaceous and seedling (< 1.0 cm in diameter) species from the near-riparian zone. Plants were sampled randomly with a sharp-pointed pipe and total and relative numbers of hits were recorded. We sampled a total of 956 points in CBSP and 536 in Regency. We sampled the near-riparian within six rectangular quadrants each of which was 2.0 by 50 m with the longest dimension parallel to the river bank as described by Ford and Van Auken (1982) and Wood and Wood (1988, 1989). The six areas were sampled on the east (Regency) and south (CBSP) sides of the Colorado River by wading or using canoes to access sites. Fewer points were sampled at Regency because it was less diverse and our sampling curve flattened and we took fewer samples.

For woody vegetation, we used the same six rectangular quadrants, 2.0 by 50 m to sample all woody species greater than 1.0 cm in diameter. We identified the woody species and measured diameter at breast height (dbh). The dbh was used to calculate basal area. We calculated density (plants/ha), dominance (basal area/ha), and relative-importance values as described by Ford and Van Auken (1982) and Wood and Wood (1988, 1989). Shannon-Weiner diversity, richness, and evenness were calculated according to formulas in Ludwig and Reynolds (1988).

Species of plants were identified and classified using Diggs et al. (1999), which also served as the reference for common and scientific names for this investigation. We deposited voucher specimens in the herbarium (TAC) at Tarleton State University in Stephenville, Texas. Using classifications for the Great Plains ecoregion, wetland indicator status for plants was obtained from Lichvar et al. (2016).

RESULTS

Scientific names are included in Tables 1 and 2 and common names are used for the results and discussion sections of this article. There were 10 woody species greater than 1.0 cm in diameter at CBSP and seven at Regency, all of which were native. For all woody species >1.0 cm in diameter, cedar elm had the highest relative-importance value and greatest dominance as well as the highest relative cover >1.0 cm of any species of tree at CBSP, while sugarberry had the same statistics at Regency. After these two dominants the most common trees, >1.0 cm overall, were green ash at CBSP and American elm at Regency (Table 1). All of the tree species mentioned above had a wetland indicator status of facultative (Table 1). Honey mesquite and western soapberry were facultative upland species and black willow (*Salix nigra*) at both sites was facultative wetland and Regency had common buttonbush (*Cephalanthus occidentalis*), which is classified as an obligate wetland species (Table 1).

There was a total of four species of lianas and five shrubs sampled at CBSP and only three lianas and one shrub (common buttonbush) at Regency. All of the liana and shrub species had a wetland indicator status of facultative or facultative upland with the exception of common buttonbush at Regency, which was an obligate wetland species. There were a number of regenerating tree species that were less than 1.0 cm in diameter at both sites. There were two introduced, woody species sampled, which included, Chinaberry and white mulberry (Table 2). Of the herbaceous species and fern ally, 87.5% were native and 12.5% were introduced (Table 2). Native perennial grasses comprised much of the herbaceous vegetation in the near-riparian zone and were dominated by native switchgrass at both sites, however introduced Johnsongrass was common at Regency. Two forbs were introduced but not common with a native knotweed most common at CBSP and spiny aster more abundant at Regency (Table 2). Hemlock and scouring-rush at CBSP were facultative wetland species; whereas rattlebush and spiny-aster were facultative wetland species at Regency (Table 2). Saw-grass and Emory's caric sedge were obligate wetland species at CBSP, whereas American water-willow, water speedwell, and Emory's caric sedge was obligates at Regency (Table 2). Both sites had similar amounts of bare ground (Table 2). When comparing ecoregions, diversity was higher for the BP ecoregion (Table 3). CBSP was richer, more even, and had higher Shannon-Weiner Diversity in its woody species but had a similar Shannon-Weiner Diversity value to Regency in their herbaceous species (Table 3). The near-riparian region from both sites was about the same as the bottomland diversity at TBS and on the Bosque River, near Stephenville, Texas (Table 3).

Table 1. Density, dominance, and relative importance values (IV) for woody vegetation greater than 1.0 cm diameter breast height of near-riparian zone of Colorado River, Texas at Colorado Bend State Park (CBSP) and Regency, Texas. Wetland classification (Lichvar et al. 2016) is provided for taxa identified to species after the scientific name.

CBSP

Common name (Scientific name)	Wetland classification	Density (plants/ha)	Dominance (m^2/ha)	IV (%)
American elm (*Ulmus americana*)	Facultative	37.1	24.0	3.9
Black willow (*Salix nigra*)	Facultative wetland	0.1	1.3	0.1
Cedar elm (*U. crassifolia*)	Facultative	1036.8	222.7	70.7
Green ash (*Fraxinus pennsylvanica*)	Facultative	204.9	45.3	14.1
Honey mesquite (*Prosopis glandulosa*)	Facultative upland	0.002	1.3	0.1
Pecan (*Carya illinoinensis*)	Facultative	0.01	2.7	0.2
Prickly-pear (*Opuntia* sp.)		16.8	2.7	1.1
Sugarberry (*Celtis laevigata* var. *laevigata*)	Facultative	14.9	25.3	2.9
Texas persimmon (*Diospyros texana*)	Not listed in Lichvar et al. (2016)	0.1	14.7	1.2
Western soapberry (*Sapindus saponaria* var. *drummondii*)	Facultative upland	10.8	46.7	4.5

Regency, Texas

Common name (Scientific name)	Wetland classification	Density (plants/ha)	Dominance (m^2/ha)	IV (%)
American elm (*Ulmus americana*)	Facultative	93.3	4.5	5.5
Black willow (*Salix nigra*)	Facultative wetland	13.3	2.9	1.1
Cedar elm (*U. crassifolia*)	Facultative	13.3	0.002	0.7
Common buttonbush (*Cephalanthus occidentalis*)	Obligate	13.3	0.001	0.7
Pecan (*Carya illinoinensis*)	Facultative	80	4.7	4.8
Sugarberry (*Celtis laevigata* var. *laevigata*)	Facultative	746.7	323.4	86.5
Western soapberry (*Sapindus saponaria* var. *drummondii*)	Facultative upland	13.3	0.2	0.7

Table 2. Species composition as determined by step-point method herbaceous and woody plants (below 1.0 cm diameter) of the near-riparian zone of Colorado River, Texas at Colorado Bend State Park (CBSP) and Regency, Texas. An asterisk indicates an introduced species. Vegetation categories and their totals are in italics. Wetland classification (Lichvar et al. 2016) is provided after the scientific name.

Common name (Scientific name)	Wetland classification	#hits (%) CBSP	#hits (%) Regency
Grasses			
Barley (*Hordeum* sp.)		0.1	0
*Bermuda grass (*Cynodon dactylon*)	Facultative upland	0.3	1.9
Broad-leaf woodoats (*Chasmanthium latifolium*)	Facultative upland	2.4	3.4
Canada wildrye (*Elymus canadensis*)	Facultative upland	0.3	3.9
Hall's panic (*Panicum hallii* var. *hallii*)	Facultative upland	0	0.6
*Japanese brome (*Bromus japonicus*)	Not listed in Lichvar et al. (2016)	0.6	0.2
*Johnsongrass (*Sorghum halepense*)	Facultative upland	1.7	19.0
Silver bluestem (*Bothriochloa laguroides* subsp. *torreyana*)	Not listed in Lichvar et al. (2016)	0	0.6
Southwestern bristle grass (*Setaria scheelei*)	Not listed in Lichvar et al. (2016)	0	0.2
Switch grass (*Panicum virgatum*) Facultative		3.1	0.7
Total Grasses		**8.5**	**30.5**
Grasslike			
Flat sedge (*Cyperus* sp.)		0	2.4
Saw-grass (*Cladium mariscus* subsp. *jamaicense*)	Obligate	0.9	0
Sedge (*Carex* sp.)		0.5	0
Emory's caric sedge (*Carex emoryi*)	Obligate	27.4	10.3
Total Grasslike		**28.8**	**12.7**
Forbs			
American water-willow (*Justicia americana*)	Obligate	0	0.7
Aster (*Aster* sp.)		0	2.6
Boneset (*Eupatorium* sp.)		0.3	0
Buttercup (*Ranunculus* sp.)		0.1	0
Catchweed bedstraw (*Galium aparine*)	Facultative upland	0.1	0
Cocklebur (*Xanthium strumarium* var. *canadense*)	Facultative	0	0.4
Creeping ladies' sorrel (*Oxalis corniculata*)	Facultative upland	0.4	0.2
Frostweed (*Verbesina virginica*)	Facultative upland	0.1	0
Giant goldenrod (*Solidago gigantea*)	Facultative	0	0.4
*Hemlock (*Conium maculatum*)	Facultative wetland	0.6	0
Horseherb (*Calyptocarpus vialis*)	Facultative	0.1	0
Knotweed (*Polygonum* sp.)		1.6	0
Late Eupatorium (*Eupatorium serotinum*)	Facultative	0	2.4
Mustard unknown (Brassicaceae)		0	0.7
Narrow-leaf sumpweed (*Iva angustifolia*)	Not listed in Lichvar et al. (2016)	0	0.4
Old-man's-beard (*Clematis drummondii*)	Upland	0.3	0
Pigeonberry (*Rivina humilis*)	Facultative	0	0.7
*Prickly sow-thistle (*Sonchus asper*)	Facultative	0.2	0
Rattlebush (*Sesbania drummondii*)	Facultative wetland	0	0.2
Shade betony (*Stachys crenata*)	Facultative	0.4	0
Spiny-aster (*Chloracantha spinosa*)	Facultative wetland	0	6.7
Texas thistle (*Cirsium texanum*)	Not listed in Lichvar et al. (2016)	0.2	0
Vetch (*Vicia* sp.)		0.1	0
Water speedwell (*Veronica anagakkis-aquatica*)	Obligate	0.5	0
Wild chervil (*Chaerophyllum tainturieri*)	Facultative	0.7	0
Total Forbs		**5.7**	**15.4**

Table 2 continued

Fern ally			
Scouring-rush (*Equisetum hyemale* subsp. *affine*)	Facultative wetland	6.4	0
Total Fern ally		**6.4**	**0**
Shrubs/lianas			
Gum bumelia (*Sideroxylon lanuginosum*)	Facultative upland	0.4	0
Mustang grape (*Vitis mustangensis*)	Not listed in Lichvar et al. (2016)	0.1	0
Poison ivy (*Toxicodendron radicans*)	Facultative upland	4.4	0.9
Roughleaf dogwood (*Cornus drummondii*)	Facultative	1.2	0
Rusty blackhaw (*Viburnum rufidulum*)	Facultative upland	0.7	0
Saw Greenbriar (*Smilax bona-nox*)	Facultative upland	5.8	2.2
Southern dewberry (*Rubus trivialis*)	Facultative upland	2.3	0
Virginia creeper (*Parthenocissus quinquefolia*)	Facultative upland	1.5	1.1
Whitebrush (*Aloysia gratissima*)	Not listed in Lichvar et al. (2016)	0.1	0
Total Shrubs		**16.5**	**4.2**
Trees			
American elm (*Ulmus americana*)	Facultative	0.3	1.5
Black willow (*Salix nigra*)	Facultative wetland	0.3	0.2
Cedar elm (*Ulmus crassifolia*)	Facultative	2.3	0.6
*Chinaberry (*Melia azedarach*)	Facultative upland	0.1	0
Green ash (*Fraxinus pennsylvanica*)	Facultative	0.7	0
Red mulberry (*Morus rubra*)	Facultative upland	0.1	0
Sugarberry (*Celtis laevigata* var. *laevigata*)	Facultative	0.4	3.2
Western soapberry (*Sapindus saponaria* var. *drummondii*)	Facultative upland	0	0.4
*White mulberry (*Morus alba*)	Facultative upland	0	0.2
Total Trees		**4.2**	**6.1**
Bare ground		**29.6**	**31.2**

DISCUSSION

Quantitative data for woody and herbaceous vegetation in near riparian zones of the LCP, including nonnative species, were provided. At CBSP the near-riparian zone was comprised of three vegetational layers: 1**)** upper-canopy of trees including mainly cedar elm 2) under-canopy of the lianas saw greenbriar and poison ivy, the fern ally scouring-rush as well as both annual and perennial grasses and forbs (Tables 1 and 2). Dominant grasses and sedges at CBSP included switch grass, broad-leaf woodoats, and Emory's caric sedge. The dominant forb at CBSP was a knotweed (Table 2). At Regency, the near-riparian zone was comprised of three vegetational layers: 1**)** upper-canopy of trees including mainly sugarberry 2) under-canopy of saw greenbriar as well as both annual and perennial grasses and forbs (Tables 1 and 2). At Regency, the near-riparian was dominated by introduced Johnsongrass and Emory's caric sedge and the dominant forb at Regency was spiny-aster (Table 2).

The near-riparian community had a depauperate species composition when compared to a creekside community in the BP ecoregion (Nixon et al. 1991). Nixon et al. (1991) found that sugarberry, elms, and ashes were the most important tree species in the near-riparian of Spring Creek in the BP. At TBS, green ash dominated the near riparian instead of the more even distribution of several trees reported for Spring Creek**.** At these two sites, cedar elm and sugarberry were dominants (Table 1). Sugarberry is reported to be frequently browsed by ungulates and its fruits are an important food source for many birds (Linex 2014). Linex (2014) and Jones-Lewey (2016) stated that elms are the most widespread and important riparian trees in Texas, which help protect river banks during flooding. Linex (2014) indicated that cedar elm is frequently browsed by cattle and deer**.** We sampled nine species of tree seedlings at both sites, which was greater than that reported from the near-riparian at TBS (Nelson et al. 2021). Lianas and small shrubs were also more abundant than that found at TBS (Nelson et al. 2021). Based on these data, we hypothesize that cattle grazing removes tree seedlings and understory lianas and shrubs from the near-riparian on the Colorado River at TBS. Recent publications on livestock grazing indicate there may be some successful management strategies but cattle having free range into the areas, as was done at TBS is detrimental (Jones et al. 2022; Derose et al. 2020; Kaweck et al. 2018). Unmanaged cattle grazing is likely the primary factor causing decreased understory diversity at TBS. Lack of cattle grazing for decades has likely increased understory diversity at CBSP and Regency.

Table 3. Richness, Evenness, and Shannon-Weiner Diversity in the Texas Colorado River near-riparian compared to that of other sites reported in the literature. The abbreviation "NR" indicates the statistic was not reported.

	Near-riparian CBSP	**Near Riparian Regency, Texas**	**Near-riparian at Timberlake Biological Station**	**Adjacent Bottomland (Nelson et al. 2018)**	**Bosque River Bottomland (Rosiere et al. 2013)**	**Spring Creek Bottomland (Nixon et al. 1991)**	**Spring Creek Near-Riparian (Nixon et al. 1991)**
Woody Richness > 1.0 cm	10	7	5	13	17	32	29
Richness < 1.0 cm	42	31	22	40	30	NR	NR
Woody Evenness > 1.0 cm	0.83	0.45	0.70	0.59	0.77	NR	NR
Evenness < 1.0 cm	0.67	0.76	0.70	0.66	0.66	NR	NR
Woody > 1.0 cm Shannon-Weiner Diversity	1.91	0.87	1.12	1.51	2.18	3.60	3.40
< 1.0 cm Shannon-Weiner Diversity	2.52	2.62	2.16	2.42	2.26	NR	NR

Green ash has relatively extensive coverage across East, Central, and South Texas and is highly tolerant of disturbance; growing not only along the streamside but on extremely steep channel slopes (Duke 2015). It was the second most common species at CBSP but was not sampled at the Regency site (Table 1). Jones-Lewey (2016) indicated that green ash is important in protecting banks during floods and one of the most common species of ash in the eastern one-third of Texas. Linex (2014) added that it provided fair browse value for deer and was one of the first trees to grow back in abandoned fields adjacent to or replacing bottomlands. Its absence from the Regency study site could be due to modified hydrology after river damming as well as other factors like dispersal or herbivory.

TPWD (2012) and Nelle (2015) listed Chinaberry (*Melia azedarach*), Chinese tallow (*Sapium sebiferum*), Japanese honeysuckle (*Lonicera japonica*), and salt cedar (*Tamarix* spp.) as nonnative species that could be problematic in bottomlands associated with the Colorado River in the Lampasas Cut Plain. TPWD also listed tree of heaven (*Ailanthus altissima*) as an invasive tree. Anderson (2006) listed Chinaberry and chaste tree as non-native species found in the river corridor near Austin and Bastrop, Texas. Only two species of nonnative woody plants, Chinaberry and chaste tree, were observed at the study sites but these were not sampled as adult plants, because they were not common. Chaste tree likely escaped from yards near the river. Chinaberry was a rapid-growing species along the San Antonio River (Bush and Van Auken 1984) and a species associated with sugarberry and cedar elm (Van Auken and Bush 1985). Richardson et al. (2007) explained that rivers were very susceptible to invasion by alien plants because hydrologic dynamics and frequent disturbances of streams make them especially effective for dispersal of plant propagules. Bush and Van Auken (1984) commented that Chinaberry along with sugarberry and native colonizing tree species likely become established following flooding. Chinaberry may be considered invasive and spreads rapidly along riparian areas (Jones-Lewey 2016). To date, it is only a minor component of the woody vegetation at this study sites.

Previous investigations (Bush and Van Auken 1984; Diamond et al. 1987; McMahan and Frye 1987; Bezanson 2000), generally placed less emphasis on shrubs and provided little data and analysis of herbaceous layers of bottomland-hardwood forests. By contrast, this investigation and Nelson et al. (2021) included the understory of the forest sampled in the near-riparian. Density and dispersion of trees combined with the small numbers of lianas and relatively low number of seedlings and saplings of trees formed a canopy sparse enough for development of an herbaceous understory dominated by native perennial grasses along the Colorado River at all three sites. Herbaceous layers of the forest along the near-riparian of the Colorado River at CBSP and Regency were similar to those reported for bottomland forests of the West Cross Timbers in Texas (Rosiere et al. 2013; Nelson et al. 2018) and TBS with the exception of dominance by switchgrass at both CBSP and Regency and high amounts of Johnsongrass at Regency. Nixon et al. (1991) reported more shrubs for a creek forest in the BP ecoregion, but most of these shrubs, other than lianas, were absent from the forest adjacent to the Colorado River at TBS (Nelson et al. 2021) but more were present at CBSP and Regency. This could be due to extensive grazing and browsing by herbivores (whitetail, beaver, cattle), which may remove shrub seedlings at TBS (Nelson et al. 2021).

Switchgrass was the most common native grass in the understory at both sites and was common at TBS (Nelson et al. 2021). Canada wildrye and broadleaf wood oats were dominants in a West Cross Timbers bottomland (Rosiere et al. 2013) and broadleaf woodoats is common on the floodplains along rivers in the Texas Hill Country (Gustafson 2015), whereas Canada wildrye was the most common grass in the understory at TBS in the floodplain forest (Nelson et al. 2018). They are viewed as dominants in late-seral to climax vegetation along streams and floodplains throughout much of Oklahoma (Tyrl et al. 2008) and Texas (Gould 1975). However, it appears from our spatially-limited investigation of the near-riparian zone, that Switchgrass is more common there and helps to stabilize the dynamic erosional nature of the near-riparian (Linex 2014). The most common sedge at CBSP and Regency as well as TBS (Nelson et al. 2021) was Emory's caric sedge, which is an obligate wetland species, and may indicate negative changes in hydrology when reduced or absent (Jones-Lewey 2016).

TPWD (2012) listed Bermuda grass (*Cynodon dactylon*), as a nonnative species that could be problematic in the Colorado River in the Lampasas Cut Plain but did not mention Johnsongrass, which is also problematic (Nelson, personal observation). There were two introduced grasses with Bermuda grass being the most common on the Colorado River and Japanese brome being less common at TBS (Nelson et al. 2021), however, both were infrequent in the near-riparian region. The most common introduced grass in the near-riparian zone at CBSP and Regency was Johnsongrass, which occurs in large colonies on the uplands associated with these sites and likely spread into the near-riparian zone.

Spiny-aster was a facultative wetland species that was the most common forb in the near-riparian at TBS (Nelson et al. 2021) and at Regency. Its rhizomes help stabilize river banks and young plants are eaten by deer and cattle (Linex 2014). Knotweed was the most common at CBSP and although it was vegetative and we could not identify it to species, it is often associated with wetland areas. The only introduced forbs in the near-riparian of the Colorado River at CBSP and Regency were prickly sow-thistle and hemlock, which were both sampled from CBSP.

Nelson et al. (2021) concluded that herbivory is likely affecting regeneration of woody species and perennial herbs in the near-riparian of the Colorado River at TBS. Beaver are not common in the Hill Country (Gustafson 2015) but appear to be common and detrimental at this study site on the Colorado River in the LCP at TBS (Nelson et al. 2021), as well as at Regency, which had less tree diversity and dominance than CBSP.

Improperly managed white-tailed deer can cause significant damage to riparian vegetation by their consumption of forbs and shrubs as browse (Nelle 2015). White-tailed deer were observed in the Colorado River bottomland and near-riparian frequently. Nelson Dickinson and Van Auken (2016) reported that large vertebrate herbivores, mainly white-tailed deer, significantly affected the survival and density of juvenile bigtooth maple (*Acer grandidentatum*) at Lost Maples State Park in Texas. Cogger et al. (2014) tabulated that at bottomland forest restoration sites along the Upper Mississippi River and its tributaries, white-tailed deer browsed 46% of tree seedlings and preferred American elm over green ash, which could be a reason that green ash is more dominant in the near-riparian of the Colorado River.

Feral pigs are considered detrimental to Texas ecosystems (TPWD 2012) and livestock grazing has affected almost all riparian areas in the state and is considered one of the most significant disturbances affecting them (Nelle 2015). Removal of cattle from riparian areas in the Northwestern Great Basin resulted in dramatically increased coverage in riparian vegetation (Batchelor et al. 2015; Jones et al. 2022). One instance of beneficial impacts reported for cattle grazing was that ephemeral wetland diversity increased with cattle grazing, which removed exotic grasses from the wetlands (Marty 2005). In the stretch of the near-riparian of the Colorado River sampled, there were few to no ephemeral wetlands and our data suggested that herbivory by deer, and beaver activity may have impeded regeneration of trees and shrubs at Regency (Table 2). CBSP had deer browse but we saw no evidence of beaver activity in the areas we sampled.

Another possibility for reduced regeneration of woody species and herbaceous perennials is low flow hydrology. Low flow hydrology during droughts and flood flow events have been documented in changing riparian vegetation (Hardy and Davis 2015). Most river ecosystems have been disrupted by dams, which separate and isolate remnant floodplains changing riparian biodiversity (Johnson 2002). This part of the Colorado River was most changed by the construction of a dam near the confluence of the Colorado and Concho rivers, which became Lake O. H. Ivie (Crisp 2012; Williams 2016). The Colorado River near-riparian was not dominated by wetland species. Alldredge and Moore (2014) reported this to be true of the Sabine River in East Texas as well. Riparian areas should contain a mix of obligate wetland, facultative wetland, and facultative species depending on water availability and it is important that riparian areas have species from the facultative group to provide stability due to hydrological change (Asher et al. 2015). The Colorado River near-riparian zone at CBSP and Regency had a few facultative wetland and obligate species but was not dominated by wetland species, being mostly facultative upland and upland species with the only dominant obligate and facultative wetland species present in the Colorado River being Emory's caric sedge and spiny aster, respectively at Regency for both and at CBSP for the former. Based on these dominants and a few other wetland species (Tables 1 and 2), CBSP and Regency have a more stable hydrology than TBS (Nelson et al. 2021).

Diversity at CBSP and TBS on the Colorado River were different from that reported at TBS (Nelson et al. 2021) and from a near-riparian zone in the BP (Nixon et al. 1991). CBSP was richer, more even, and had higher Shannon-Weiner Diversity in its woody species but had a similar Shannon-Weiner Diversity value to Regency in their herbaceous species. The near-riparian region was about the same as the bottomland diversity at TBS (Nelson et al. 2021) and on the Bosque River, near Stephenville, Texas (Rosiere et al. 2013). Species diversity was lower than that reported in riparian areas of the adjacent BP (Nixon et al. 1991), which receives much more precipitation than that of the LCP ecoregion. The diversity of these near-riparian sites being higher than bottomland forests from the region likely reflects the dynamic nature of these ecosystems due to hydrological disturbance and the chance-events of dispersal and successful establishment of plants in this changing environment.

ACKNOWLEDGEMENTS

We thank landowners, Dr. Lamar Johanson and his wife Marilyn, for access to the Timberlake Ranch. Becky Nelson provided valuable assistance in the field and John Roberts helped with data verification. The paper was improved by reviews from Jeff Brister and Ricky Linex. We appreciate their input.

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