HABITAT CONDITIONS

Channel Alterations

According to the Missouri Water Atlas (1986), the main stem Bourbeuse River has no channelized segments in its 147 stream miles, nor are any major segments impounded. Some tributaries such as Brush Creek with Indian Lake and the upper Bourbeuse River with Towell Lake (see Hydrology Section, Dam and Hydropower Influences) are impounded. Also, Noser Mill near Highway 185 and Goodes Mill below Highway 50 have dams that behave as grade controls. Similarly, an untold number of bridges and fords on secondary streams can change stream gradient on smaller order tributaries, and in general, alter discharge rates.

Dredging, Gravel Mining

In-channel mining has the potential to artificially accelerate a stream's natural geomorphic processes by increasing channel slope, channel water velocity, and sedimentation. A stable stream is in dynamic equilibrium. A section of stream gravel removed from a location, resulting in stream disequilibrium, will cause erosion upstream from the nick-point (removal area) and within the nick-point. As the stream seeks new mass-balance equilibrium, a nick-point will eventually erode away and migrate upstream in a process known as "head-cutting" (Patrick et al. 1993). In an effort to control erosion, landowners sometimes resort to "channel reaming," a process of plowing out a straight and uniform new channel in the stream bed or gravel bar, followed by blocking off the old channel with gravel or debris, and often accompanied by pushing loose gravel against eroded banks. The Bourbeuse River and its tributaries have segments altered by these detrimental activities (see Land Use Section, Mining).

Unique Habitat

Natural Features Inventory

The Missouri Natural Features Inventory is completed for Franklin (Kurz 1981), Phelps (Ryan 1992), Gasconade, and Maries (Currier 1991), and Crawford (Ryan 1993) counties. The objective of the MDC statewide Natural Features Inventory was to locate, describe, classify, and rank high quality elements of Missouri's natural habitat. With this knowledge, Missourians protect the state's outstanding features through inclusion to the state natural-areas system by voluntary landowner agreements or by providing informed management decisions in ecologically sensitive areas already in public ownership.

Identifying sites within the Bourbeuse River watershed and adjacent areas involved surveying seven categories:

* *natural communities* (undisturbe assemblages of plants and animals),
* *state-listed species habitats* (rare and endangered species),
* *habitats of relict species*,
* *outstanding geologic features*,
* *areas for nature studies*,
* *other unique features*,and *aquatic communities*.

The natural community, geologic feature, and aquatic community sites were further classified using the Terrestrial Natural Communities of Missouri (Nelson 1987) and the Geologic Natural Feature

Table 15. Sensitive animal species known from the Bourbeuse River watershed (printout of the Missouri Natural Heritage Database 1998).

Sensitive Animal Species	Federal Status	# of Locations
Birds		
***Accipter cooperii* (Cooper's hawk)**		**2**
Fish		
***Carpiodes velifer* (Highfin carpsucker)**		**1**
***Alosa alabamae* (Alabama shad)**		**1**
Mammals		
***Myotis grisescens* (Gray bat)**	**E**	**2**
Mollusks		
***Anodontoides ferussacianus* (Cylindrical papershell)**		**3**
***Cumberlandia monodonta* (Spectaclecase)**		**1**
***Alasmidonta marginata* (Elktoe)**		**1**
***Epioblasma triquetra* (Snuffbox)**		**16**
***Leptodea leptodon* (Scaleshell)**		**5**
***Plethobasus cyphyus* (Sheepnose)**		**10**
***Simpsonaias ambigua* (Salamander mussel)**		**1**

Federal Status: E=Endangered

Classification System for Missouri (Hebrank 1989). Following the classification, biologists graded sites for their natural quality, and ranked them to provide a means of comparing similar features for their preservation value (Ryan 1993; Currier 1991). Rankings were in three categories: significant, exceptional, or notable (Ryan 1993; Currier 1991). According to Ryan (1993), areas that he defined as significant natural features should receive a form of protection (possible inclusion in the Missouri natural areas system), and areas that he defined as exceptional are not of natural area quality but deserving of some protection. Lastly, notable areas on private land do not merit special management or protection. Kurz (1981) ranked the potential natural features sites differently. Areas were either special natural features or notable.

In Gasconade County, several upland forest types were identified as rare Dry-Mesic Limestone/Dolomite Forests (T41N, R6W, Sec. 1, 2; T40N, R5W, Sec. 6, 7) near the Mint Spring Area of Gasconade County (Currier 1991). Mint Spring, designated a Missouri Natural Area in 1982, has an acid seep (T40N, R6W, Sec. 13), a forested acid seep (T40N, R6W, Sec. 13), and a mesic bottomland forest with a natural Ozark headwater stream. In Maries County, a 0.5-acre pond swamp (called Ash Pond, T40N, R7W, Sec. 22) has an unusual community association, dominated by green ash, buttonbush, and sedges. An intermittent slough in a young to mature bottomland forest along the Bourbeuse River (T34N, R7W, Sec. 23, 24) was identified as potential wetland. Finally, Gasconade County, besides several other counties, has glades that are worthy of protection. These glades are usually dry south-facing slopes with unique wild flowers and grasses, prickly pear cacti, few trees, and numerous lizards.

Franklin County is the third largest county in the state. Kurz (1981) noted that most of the county has been cleared and plowed or grazed, leaving only the northern- and southern-extreme part of the county having the natural features. Several of the sites visited by Kurz included the areas within the Meramec River watershed. In the Bourbeuse River watershed portion of Franklin County, several small streams such as the large portions of the Little Bourbeuse River were notable natural systems (Kurz 1981). This notable portion of the Little Bourbeuse River began with T41N, R4W, Sec. 26 and extended into Crawford County. In the Crawford County survey, Ryan (1992) noted the unique sandstone and shale geological features of Little Bourbeuse River watershed (T40N, R4W, Sec. 13, 35), near Argo. Large portions of the Bourbeuse River near Strain (T42N, R4W, Sec. 27) thru Noser Mill (T42N, R2W, Sec. 28 thru Sec. 2) to Union (T43N, R1W, Sec. 26) were noted by Kurz as an outstanding example of an Ozark border stream. Kurz (1981), also noted the outstanding example of Kratz Spring (T41N, R2W, Sec. 4). Both Ryan and Kurz found outstanding upland sandstone/shale capped bluffs.

Rare & Endangered Species

MDC Natural History inventories documented a total of 43 sites with species of conservation concern within the Bourbeuse River watershed (Table 15). The *Alosa alabamae* (Alabama shad) and the *Carpiodes velifer* (highfin carpsucker) are the only state-listed fish species in the Natural Heritage Database (see Biotic Section for recent MDC collections). The Alabama shad was collected by Dr. Brooks Burr, Southern Illinois University, Carbondale. The mussel species listed in the Natural Heritage Database as critically imperiled (5 or fewer occurrences statewide) were the *Anodontoides ferussacianus* (cylindrical papershell), *Epioblasma triquetra* (snuffbox), *Plethobasus cyphyus* (sheepnose), and *Simpsonaias ambigua* (salamander mussel). Additional information regarding state-listed mussel species can be found in the Biotic Section.

Improvement Projects

MDC fisheries biologists use cedar tree revetments, corridor reforestation, streambank re-vegetation, willow staking, and rock blankets (rip-rap) as stream bank erosion control treatments. These techniques contribute to improved water quality and fish habitat. Once installed, a project on public land can also serve as a local demonstration site of proper stream management techniques and correction (Fantz et al. 1993). The same is true with private land, although the demonstration site aspect depends on the installation agreement with the landowner, as the landowner retains the right to refuse trespass. In 1994, Conservation Department used a cedar tree revetment to stabilize the 396-foot streambank on the Bourbeuse River at T38N, R7W, S12 (Table 16). Another streambank stabilization project was installed in 1996 on Robinson Creek, a third-order tributary to the Bourbeuse River watershed. That revetment was installed on a 95-foot long eroding streambank that was 4-6 feet in height.

Stream Habitat Assessment

Site Selection

Following Bovee (1982), the methodology for stream habitat assessment site selection of segments, sub-segments, and representative reaches was based on stream order, flow, and stream complexity within the hydrologic units. Fisheries personnel evaluated habitat on all third-order and larger streams (Figure 6). In addition, the site selection procedures, which were similar to those employed for fish community selection, consisted of : (1) constructing gradient plots of potential areas to aid in the selection of sites with various gradients, (2) consulting a topographic map or aerial photos for surrounding land use and access to sites, and (3) viewing video tapes of the watershed areas. Final selection was based on relative differences of the areas, access to the sites, and previously sampled fish community sites. For ease of stream assessment and avoidance of trespass, a ford or a bridge was often near or part of a site. The average length of sites in streams greater than or equal to order 3 was 669 feet. Third- and fourth-order stream sample sites averaged 378 feet in length, and fifth- and six-order stream sample sites averaged 745 feet in length. A sample site or reach consisted of a segment of stream that began with a riffle or pool and ended with a riffle.

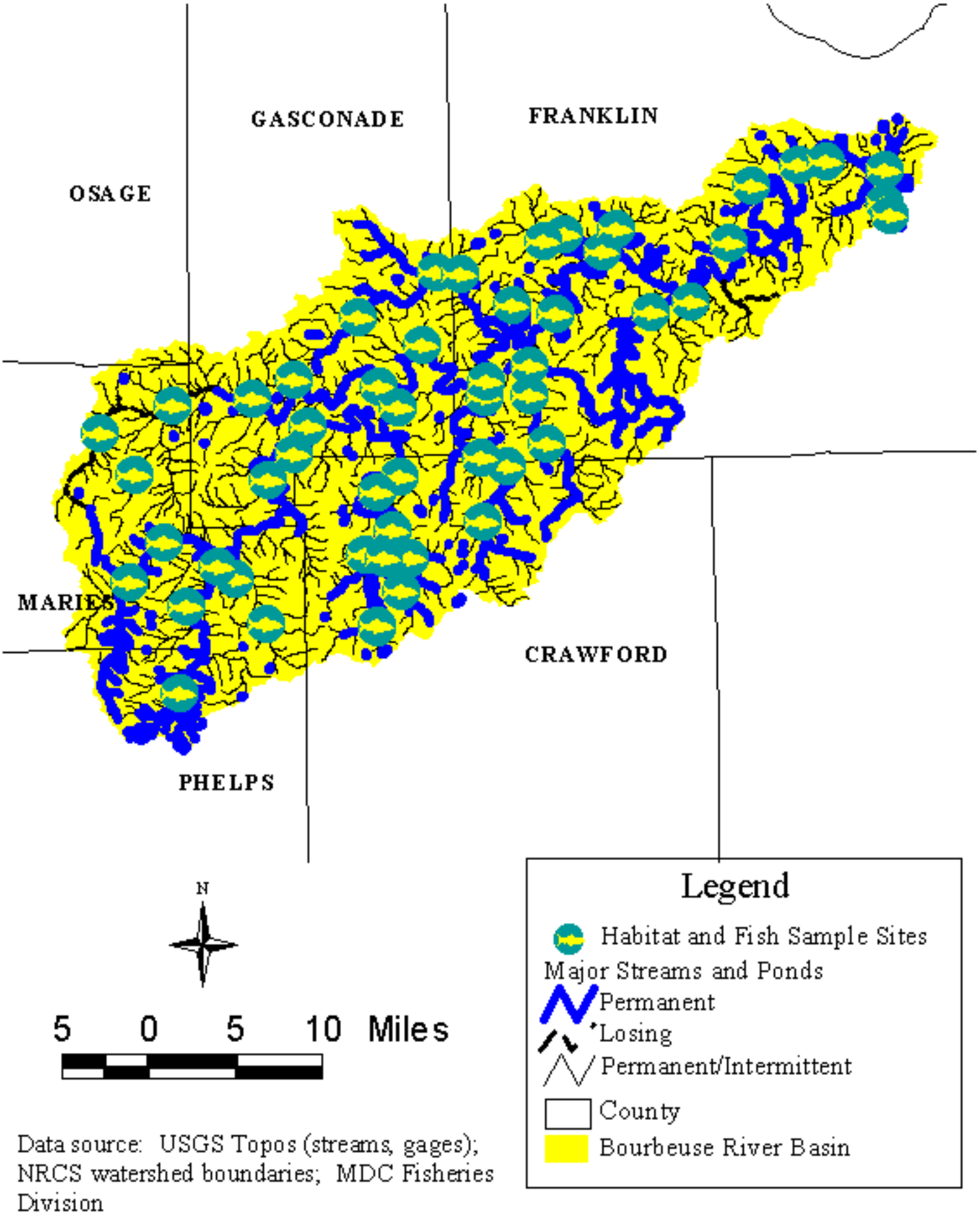
Habitat Evaluation

Erosional, Corridor, and Land Use Conditions

Soil types, stream corridor, and land use conditions ultimately affect the erosional characteristics of a stream. Silty clays, silty clay loams, and silty loams have an soil erodibility factor of 0.24, 0.37, and 0.43, respectively, representing moderately to highly erodible soils (Table 1; Geology Section, Soil Types). Soil types in the Ozark Region are similar to the Ozark Border Region (USDA and SCS 1979). The Soil Survey of Franklin County, Missouri (1989) describes the area that parallels the river as the Haymond-Pope soil association that is composed of alluvium with water erodibility factors of 0.28-0.43. Similarly, the Gasconade County survey in the western portion of the watershed lists the Nolin-Cedargap soil association as the floodplain soil type. Likewise, its water erodibility factors range from 0.10 to 0.43.

Soils along the Bourbeuse River are very deep, well drained, silty, loamy alluvium to somewhat fine sandy loam subsurface layers in some areas or gravelly basal deposits in other subsurface layers (SCS 1989). Following Olsen (1983), soils within the habitat assessment sites were categorized with primary soil descriptors such as gravel (G), sand (S), silt (M), clay (C), organic (O), and peat (Pt), and with secondary descriptors such as well graded (W), poorly graded (P), non-plastic fines (M), plastic fines (C), low plastic fines (L), high plasticity (H), and (BR) bedrock (Olsen 1983). The streambank was

Figure 6. Fish and habitat sample sites in the Bourbeuse River watershed.



Data source: USGS Topos (streams, gages); NRCS watershed boundaries; MDC Fisheries Division

Map Production: Todd Blanc, Missouri Department of Conservation, December 1998

Table 16. Description of stream improvement projects in the Bourbeuse River watershed, Missouri (Misssouri Department of Conservation, unpublished data).

Stream	Technique/Program	County Twn-Rng-Sec	Completion	Comments
Bourbeuse River	Cedar Tree Revetment[1]/ CS[3]	Phelps T38N-R7W-Sec12	1994	396-ft eroding bank, 4-14 ft height.
Robinson Creek	Cedar Tree Revetment[1]/ EL[2]	Phelps T39N-R6W-Sec25	1996	95-ft eroding bank, 4-6 ft height

[1]Anchoring of trees along an eroding bank to control erosion.

[2]EL--Equipment Loan

[3]CS--Costshare

broken into soil profile inch groups and assigned descriptors based on the soil's characteristics. The most common soil type was clay loam (Figure 7, 8, 9).

Erosion protection comes from a combination of soil type and vegetative characteristics of the stream corridor. Streambank erosion protection was assessed on the left and right streambank within a sample site. Within the entire Bourbeuse River watershed (Figure 10, 11), sampled sites had 36 streambanks that were completely vegetated with no erosion, 39 streambanks – only isolated bare spots, 17 streambanks – about one-half vegetated, 13 streambanks – most of streambank unvegetated, and three streambanks – completely unvegetated. Comparing Bourbeuse River hydrologic units, the sampled sites in the Upper Bourbeuse River hydrologic unit have the best overall streambank protection and the Little Bourbeuse River hydrologic unit, the worst overall streambank protection.

The bottomland trees and riparian vegetation help protect against erosion especially in areas having highly erodible soils. According to the Franklin County Soil Survey in areas that have the Haymond-Pope soil association, 80% of this association has been cleared of trees and used for cropping and pasture. Within the entire Bourbeuse River watershed (Figure 12, 13), sampled sites had 45 corridors that were unbroken and more than one tree in width, 10 corridors--a contiguous row of trees along sample sites, 14 corridors--broken along 50% of the corridor length, 17 corridors--limited, present along portion of sample corridor, and 22 corridors--no corridor. Comparing hydrologic units, the sampled sites in the Lower Bourbeuse River hydrologic unit and the Middle Bourbeuse River hydrologic unit have the best overall riparian corridor width and the Little Bourbeuse River hydrologic unit, the worst overall riparian corridor width. Stream roughness components from vegetation and tree roots within a streambank are vital part of the erosion coverage.

Land use on floodplains in the Bourbeuse River watershed is mainly limited to agricultural uses and forested areas. Corn, soybean, wheat, and hay are grown in abundance. Because floodplains are level, they are often chosen for the production of crops (SCS 1989). Observed land use within sampled sites in the Lower Bourbeuse River hydrologic unit showed the predominant uses were from greatest to least: 1) forested lands with livestock excluded, 2) land with row crop and pasture, and 3) home sites and developed land. The lower watershed areas are more urbanized when compared to the Spring Creek, Boone Creek, Red Oak Creek, and the Little Bourbeuse River hydrologic units that are devoted to cattle production. Within these hydrologic units many floodplain areas that were observed contained hayfields, pasture, old fields, and to a lesser degree, forest. Similarly, the Upper Bourbeuse River hydrologic unit was pasture, hayfield, old field, and lastly, forested areas, from most to least observed. Row cropping consumes a major portion of the land use in the Middle Bourbeuse River hydrologic unit.

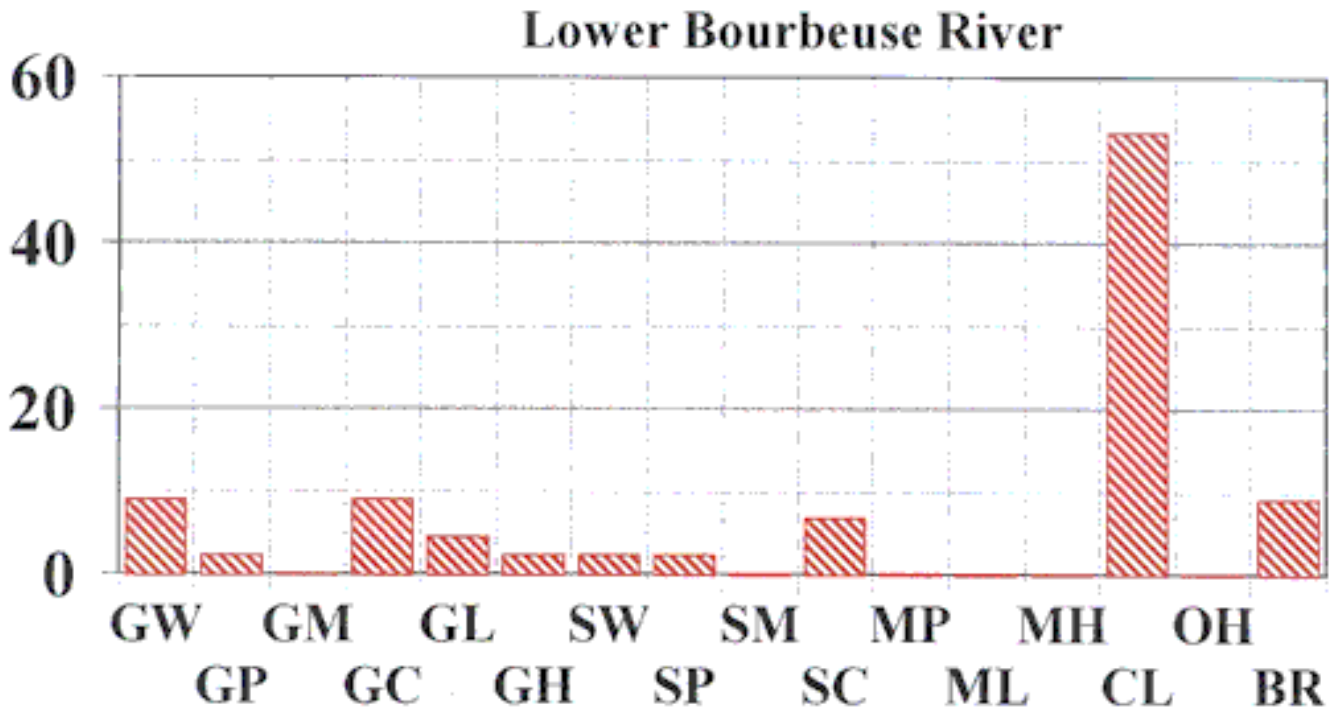
Channel Condition

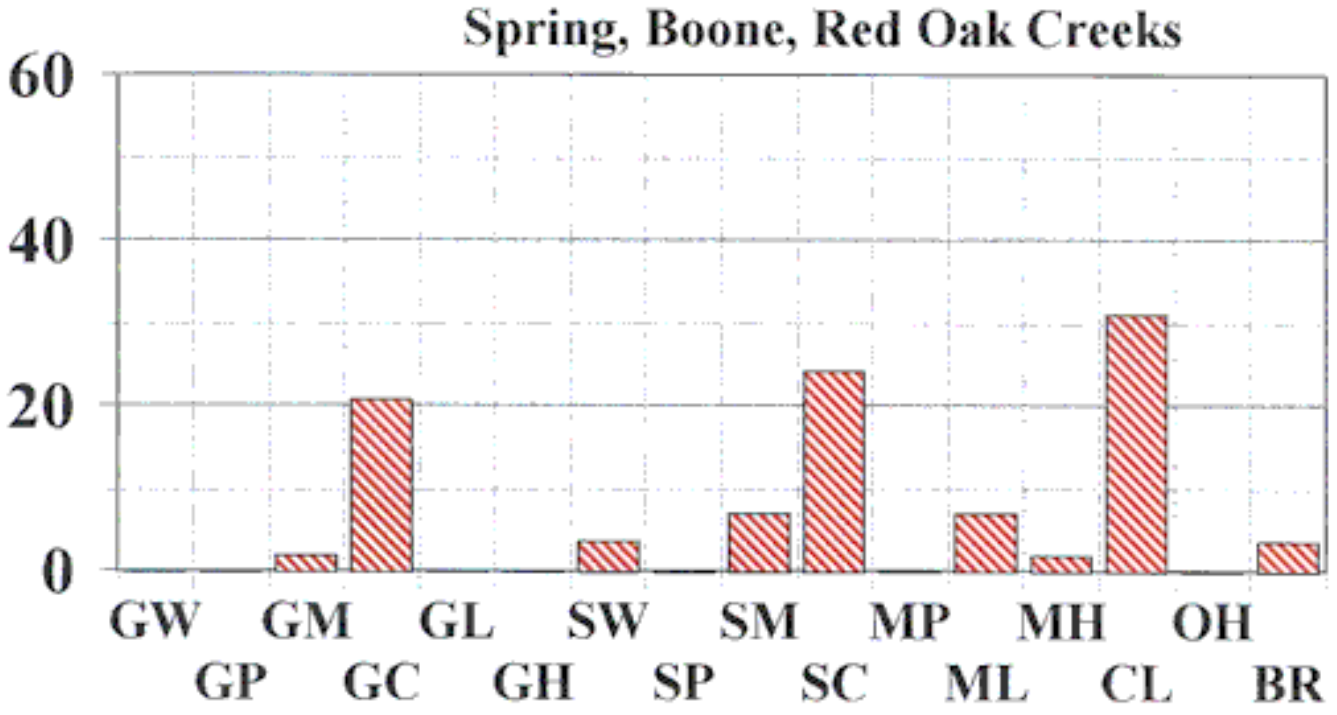
Channel condition of sampled streams was characterized by evaluating the gravel bar vegetation status. A stable gravel bar contains early succession woody stems. Likewise, an unstable gravel bar has no vegetation or may have annual plants or grasses. Gravel bar stability is a good indicator of overall stream reach stability.

Gravel bars are numerous in the Bourbeuse River watershed. An average of three gravel bars per site of various sizes and with various amounts of vegetation was found within all hydrologic units (HUs). Within habitat sample reaches of the Lower Bourbeuse River HU, 57%, 26%, and 17% of total gravel bars had early successional or woody stems, grasses and sedges, and no vegetation, respectively (Table 17). Within the Spring, Boone, Red Oak Creek HU are smaller-order tributaries to the Bourbeuse River.

Figure 7. Streambank soil types of the Bourbeuse River watershed habitat assessment sites. Summarized is the percentage (total soil type/total sampled soil layers) X 100] found within sampled streambank soil layers of the shown hydrologic units. Soil layers within the streambank were categorized by starting at the water line of the streambank to the top. See primary and secondary despriptors of the soil type.

Primary soil descriptors are gravel (G), sand (S), silt (M), clay(C), organic (O), and peat (Pt). The secondary descriptors are well graded (W), poorly graded (P), with nonplastic fines (M), with plastic fines (C), or low plastic fines (L), and of high plasticity (H) (Olson 1983). BR--bedrock





HC08

Figure 8. Streambank soil types of the Bourbeuse River watershed habitat assessment sites. Summarized is the percentage (total soil type/total sampled soil layers) X 100] found within sampled streambank soil layers of the shown hydrologic units. Soil layers within the streambank were categorized by starting at the water line of the streambank to the top. See primary and secondary despriptors of the soil type.

Primary soil descriptors are gravel (G), sand (S), silt (M), clay(C), organic (O), and peat (Pt). The secondary descriptors are well graded (W), poorly graded (P), with nonplastic fines (M), with plastic fines (C), or low plastic fines (L), and of high plasticity (H) (Olson 1983). BR--bedrock

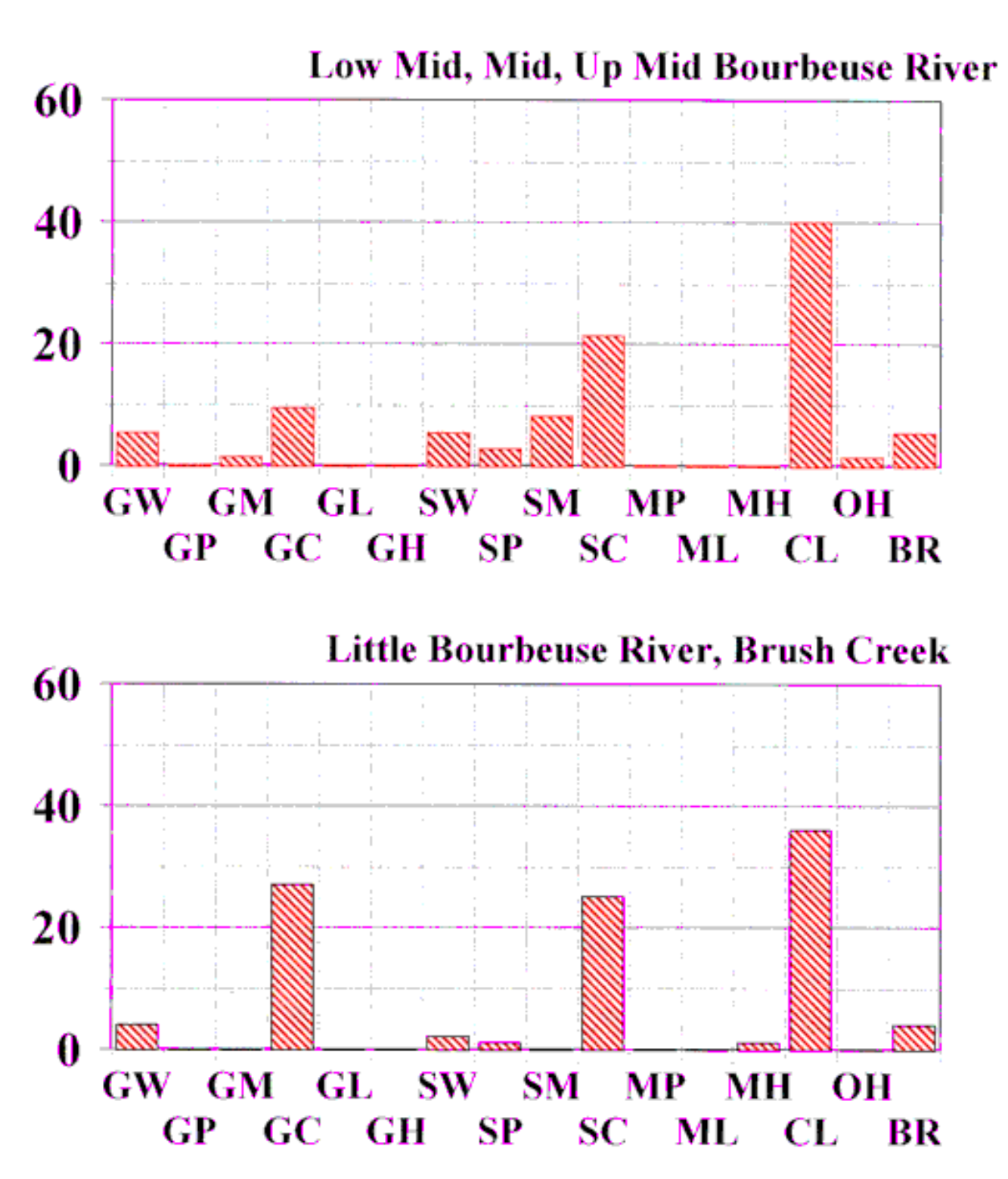
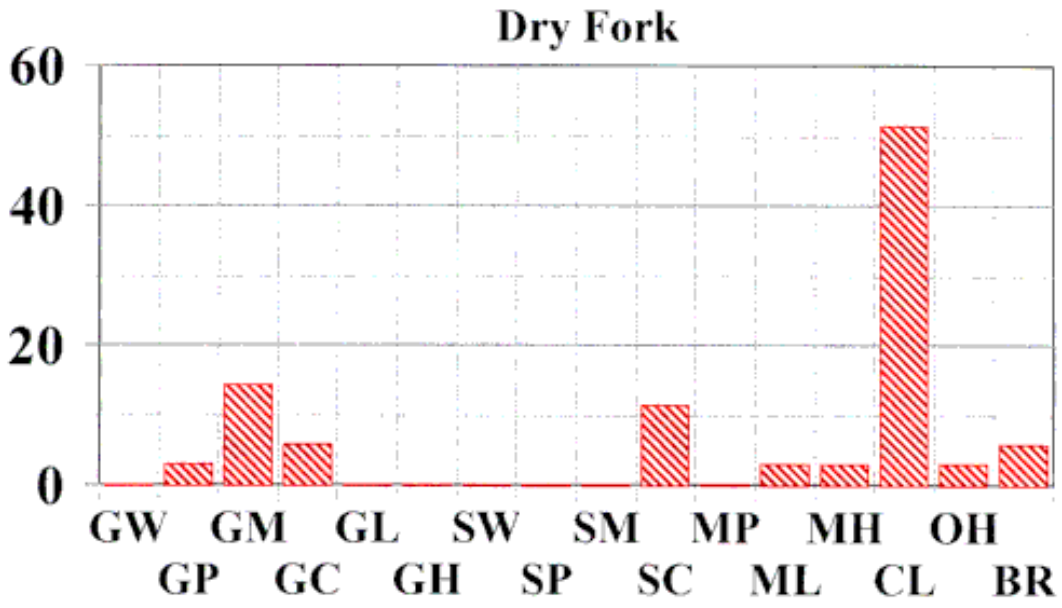


Figure 9. Streambank soil types of the Bourbeuse River watershed habitat assessment sites. Summarized is the percentage (total soil type/total sampled soil layers) X 100] found within sampled streambank soil layers of the shown hydrologic units. Soil layers within the streambank were categorized by starting at the water line of the streambank to the top. See primary and secondary despriptors of the soil type.

Primary soil descriptors are gravel (G), sand (S), silt (M), clay(C), organic (O), and peat (Pt). The secondary descriptors are well graded (W), poorly graded (P), with nonplastic fines (M), with plastic fines (C), or low plastic fines (L), and of high plasticity (H) (Olson 1983). BR--bedrock



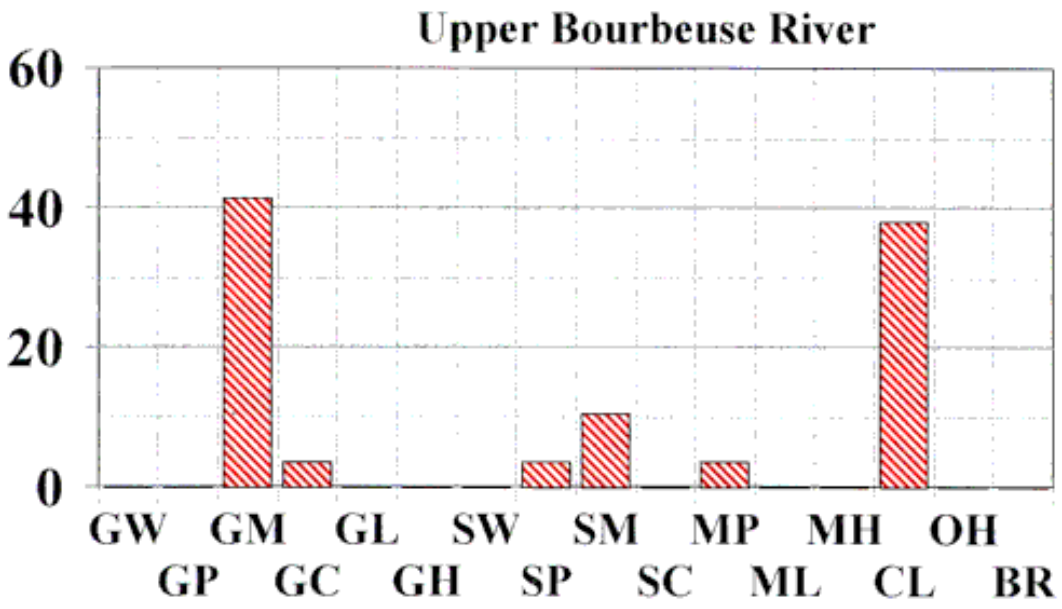


Table 17. Gravel bar vegetation observed on habitat sample sites located in the Bourbeuse River watershed (*hydrologic unit # 07140103-) Missouri, 1997. Values represent stream bar numbers within defined categories. Total # of bars = A + B + C.

Gravel Bar Vegetation Status Land Use

Stream Order	Total # of Bars[A]	(A) Early successional or woody strems[1]	(B) Grasses and sedges[2]	Large bars[3]	(C) No veg.bars[4]	% of sites with forest, urban, or woodland[5]	% of sites with cropland or grassland land use[5]
LOWER BOURBEUSE HYDROLOGIC UNITS*-100-001,002							
6	23	13	6	7	4		
		57%	26%		17%	50%	50%
SPRING, BOONE, RED OAK CREEK HYDROLOGIC UNITS* -090-007,006,005							
3	2			1	2		
					100%		
4	20	1	10	10	9		
		5%	50%		45%	63%	37%
MIDDLE BOURBEUSE HYDROLOGIC UNITS* -090-008,004,001							
3	1						
			1				
			100%				
4	1			1	1		
					100%		
5	12	4	5	5	3		
		33%	42%		25%		
6	22	11	8	5	4		
		50%	36%		18%	67%	33%
LITTLE BOURBEUSE RIVER HYDROLOGIC UNITS* -090-002,003							
3	3		2		1		
			67%		33%		
4	31	10	10	7	11		
		32%	32%		35%		
5	8		4		4		
			50%		50%	46%	54%

DRY FORK HYDROLOGIC UNITS* -040-002,001							
2	3				1	3	
						100%	
3	5	1			1	4	
		20%				80%	
4	14	4	2	7	8		
		29%	14%		57%	50%	50%

UPPER BOURBEUSE HYDROLOGIC UNITS* -020-002,003,001

3	2		2	ND			
			100%				
4	14	4	2	4	8		
		29%	14%		57%		
5	6	4		2	2		
		67%			33%	57%	43%

[A] Representing all bars in the sample reach (not the row total). [1] Early successional (< 1" diameter stems) to woody (< 1" diameter stems). [2] Number gravel bars with grasses/sedges. [3] Number of large gravel bars out of total number. [4] Bars with no vegetation, easily disturbed. [5] Land use surrounding the site as possible reason for gravel deposition (30-meter resolution TM satellite imagery).

The percentage of the total number of gravel bars within the fourth-order tributaries was 5% early successional or woody stems, 50% grasses and sedges, and 45% no vegetation. Within the Middle Bourbeuse River HU, the sixth-order Bourbeuse River had more stable gravel bars (50% early successional woody stems). Conversely, the smaller-order tributaries generally had more unstable gravel bars with grasses or no vegetation. Combining third to fifth orders within the Middle Bourbeuse River (Table 17), 10 out of the 14 gravel bars had grasses and sedges or no vegetation, compared to four out of 14 gravel bars with early successional or woody stems. The same relationship was noted within the Upper Bourbeuse River HU. Approximately 57% of the gravel bars within fourth-order tributaries had no vegetation. Conversely, the main stem Upper Bourbeuse River (fifth order) had 67% of its gravel bars with early successional or woody stems. Sampled gravel bars within stream orders of the Dry Fork and the Little Bourbeuse River HUs indicated that sample site position within the HU was an important determinant in the presence or absence of vegetation on gravel bars. Of the gravel bars sampled, 57% of those within fourth order segments had no vegetation. Although slightly more stable, the fifth-order sample reaches of the Little Bourbeuse River had 50% of the gravel bars with grasses and sedges and 50% gravel bars with no vegetation.

Channel Stability

Gravel bars with early successional plants or woody stems are considered more stable than those with grasses or no vegetation. Those gravel bars with little more than grasses or no vegetation are receiving deposition from shifting bed loads from upstream areas and reflect relatively unstable channel conditions. Channel stability, as well as fish habitat, is influenced by a variety of factors such as bed load and gradient. The observation that smaller-order streams have less vegetated gravel bars may suggest that bed load is moving through these streams to the larger-order streams. Stream gradient within the smaller order tributaries is usually higher than larger-order streams. For example, as stream gradient increases upstream from 8-14.5 feet/mile within sample reaches of the Middle Bourbeuse River HU, the number of non-vegetated gravel bars increases. Lower gradient areas are places of gravel deposition and will have both vegetated and non-vegetated gravel bars. For instance, Brush Creek at river mile 8.3 has a gradient of 5.3 feet/mile and several gravel bars with no vegetation and one large bar. A downstream sample site at river mile 5.15 has lower gradient and vegetated gravel bars and few non-vegetated gravel bars. A similar pattern of gravel bars with no vegetation was present in the Dry Fork HU, especially in the losing portion. The sample site at river mile 19.0 had large gravel bars with no vegetation and a gradient of 6.9 feet/mile. The channel is more stable downstream at river mile 8.45 with more large, woody-stem vegetated gravel bars.

Land Use

Without knowledge of the gravel bar disturbance history, correlating the presence or absence of gravel bar vegetation with land use is somewhat tenuous. However, some evidence of this relationship was suggested in research on the Little Piney River by Jacobson and Primm (1994) and Jacobson and Pugh (1995). According to Jacobson and Primm, prior to European settlement, historic changes in streambed elevations appear to correlate with climatic shifts that suggests a destablization of streams and an influx of gravel. However, research suggests a greater deposition of gravel since European settlement, which is thought to be related to land-use changes after European settlement.

Gravel bars with little or no vegetation may be influenced by land use that affect sheet and rill erosion rates within the watershed (see Geomorphology Section). Changes in the stream channel are influenced

Figure 10. Bourbeuse River watershed streambank erosion protection assessmnet for sampled sites. summarized by hydrologic units with values representing right and left streambanks.
Covered - Streambank completely covered--no erosion
Bare spots- Streambank has only isolated bare spots
50% covered- About half streambank covered
25% covered- Most of streambank uncovered-- little protection
All uncovered-Streambank completely uncovered

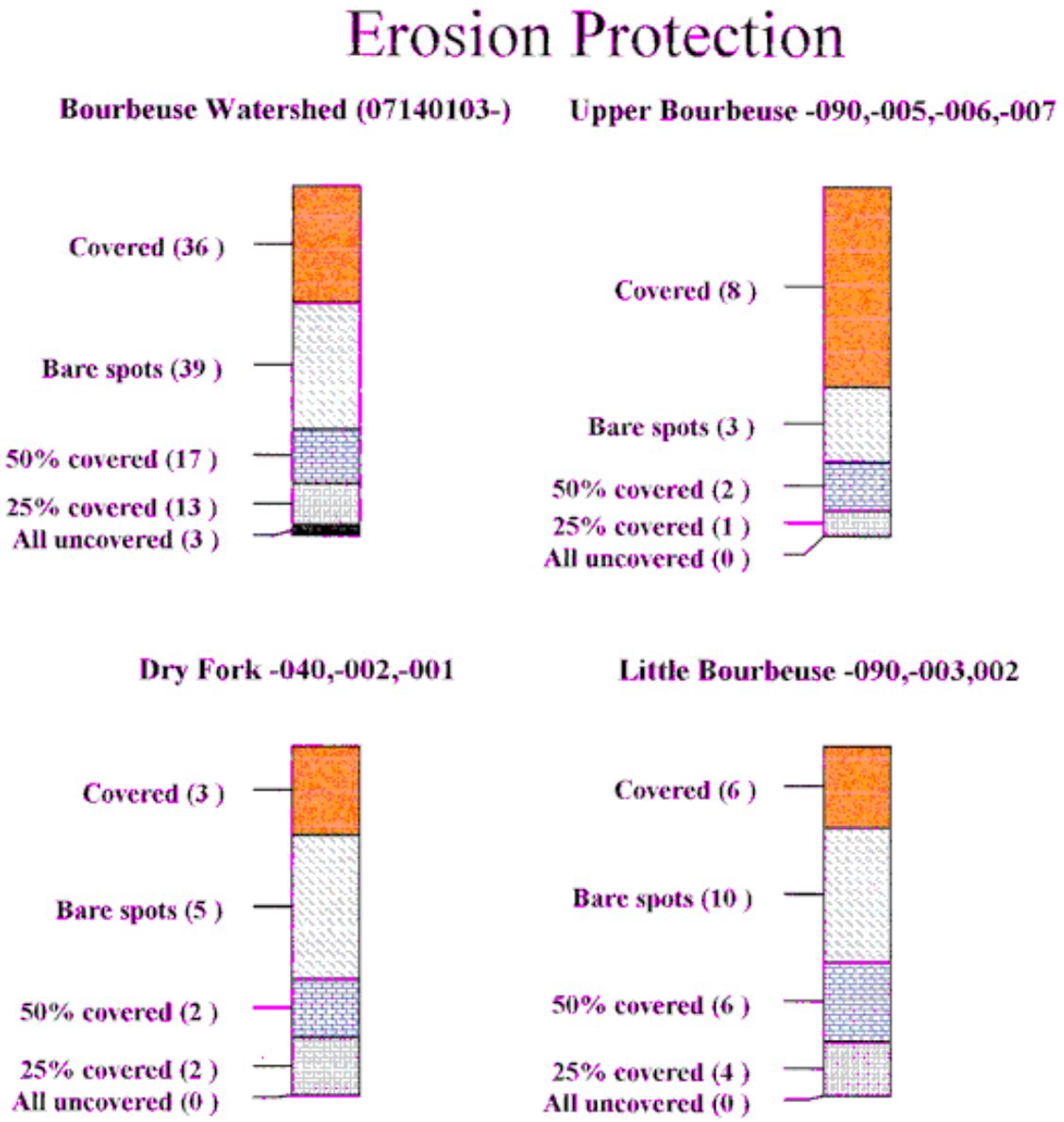
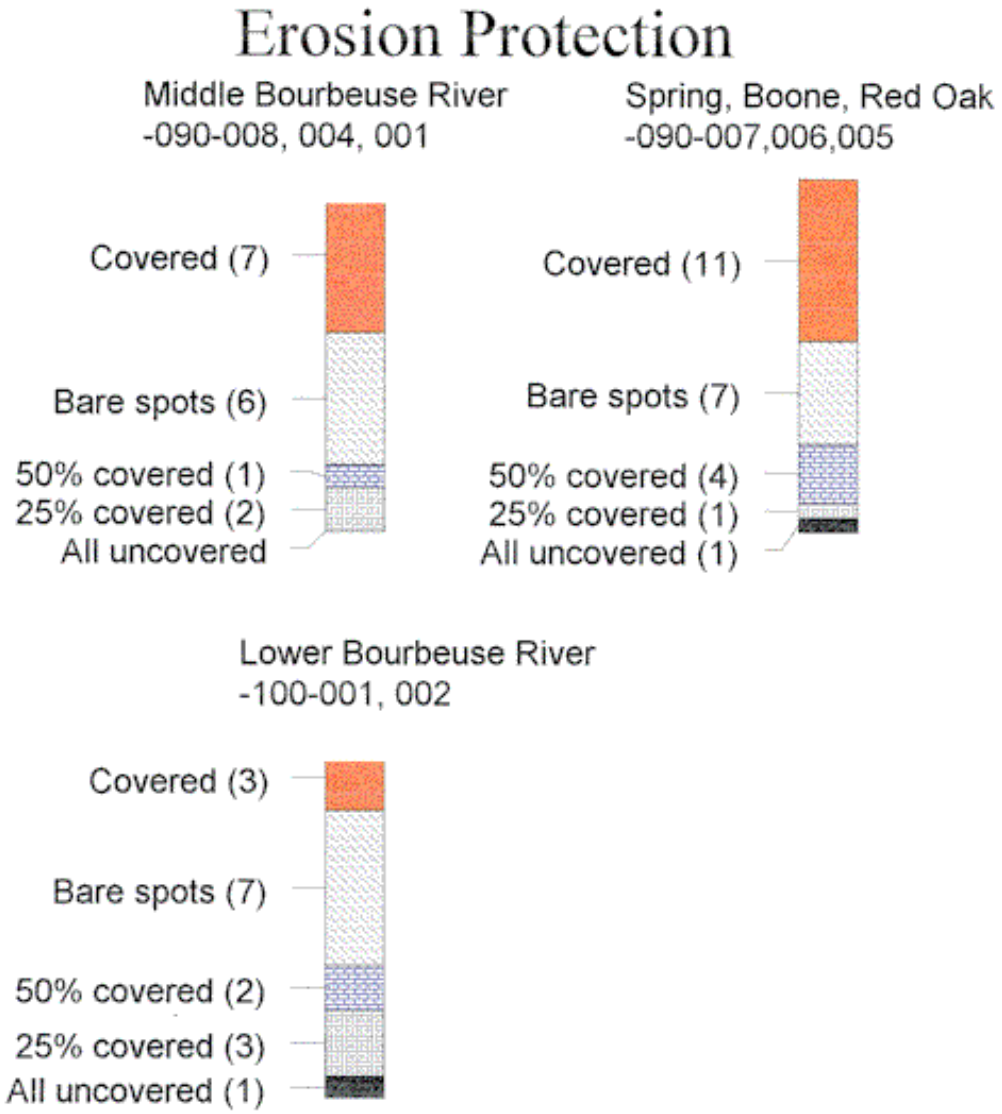


Figure 11. Bourbeuse River watershed streambank erosion protection assessment for sampled sites summarized by hydrologic units with values representing right and left streambanks.

Covered = Streambank completely protected--no erosion
Bare spots = Streambank has only isolated bare spots
50% covered = About half streambank protected
25% covered = Most of streambank uncovered--little protection
All uncovered = Streambank completely unprotected



by shifting bed load from smaller-order streams. For these reasons, using MoRAP 30-meter resolution TM satellite imagery, an estimate of dominant land use surrounding (generally upstream) the sample sites was determined. From this estimate, a percentage of sites with forest, urban, or woodland and a percentage of sites with cropland or grassland land use for the each HU was determined. The land-use combination is based on the similarity of each in hydraulic properties and erosion resistance. The Lower Bourbeuse River HU had 50% of the land use in cropland/grassland and 50% in forest/urban/woodland (Table 17). Compared to other HUs, the Lower Bourbeuse River HU (sixth order) had fewer unstable gravel bars with no vegetation. Other HUs with similar land-use percentages were the Dry Fork HU (fourth order) and the Little Bourbeuse River HU (fifth order). Both of these HUs had unstable gravel bars with grasses or no vegetation. A result which does not necessarily support the relationship between land use and gravel bar stability. The Upper Bourbeuse River HU sample sites appear to have stable gravel bars and more sites with forest/urban/woodland as land use. The observation of streams in the Spring, Boone, and Red Oak creeks hydrologic unit reveals gravel bars with mostly grasses (Table 17). Many sample sites in Boone Creek and Red Oak Creek were characterized by pasture or row cropping as the surrounding land use. 37% of the sampled sites had cropland/grassland as land use, considered a potential source of gravel deposition in streams (Table 17). Showing a good relationship between land use and gravel bar stability, the Middle Bourbeuse River HU had 67% of the land use as forest/urban/woodland and more early successional or woody-stem vegetated gravel bars than gravel bars with grasses or no vegetation.

These results indicate that while some sampled sites had stable gravel bars and dominant surrounding land use encouraging good soil stability, other sample sites showed little relationship between surrounding land use and gravel bar stability. The results reinforce the concept that the transport and deposition of bed load in streams is influenced by a complex of factors within a watershed. Factors such as channel pattern (straight, meandering, or braided), channel gradient, land use, land cover, flood events, soil types, etc. affect gravel bars, making the analysis of the cause of their instability or stability quite complex.

Channel Habitat

McCain et al. (1990) developed a channel habitat classification system based on stream channel morphological features and pool-riffle and step-pool formation. A tally of these features was made to provide an estimate of the habitat diversity represented as a percentage composition of habitat types (Figure 14). A number of the classifications are good descriptors of Ozark streams. The 22 original McCain et al. (1990) classifications and one additional classification, backwater pool associated with gravel bar (BWPG), were used to describe stream channel morphology (Table 18).

McCain et al. (1990) divided habitat types into three categories based on water depth: riffle, run, and pool. Further pool category distinction is based on pool position in the stream (secondary channel, backwater, lateral, and main channel) or the cause of the scour (obstruction, blockage, constriction, or merging flow). Riffle and run are differentiated based on gradient and velocity. Using the river mile and average gradient for the stream segment, we distinguished between low gradient riffle and high gradient riffles.

The low gradient riffle category (LGR) was identified as 22% of the cumulative total types within all sample sites. This was expected because sampling, when possible, included a segment of stream that began with a riffle or pool and ended with a riffle. At times the stream segment sample included two

Figure 12. Bourbeuse River watershed riparian corridor width descriptions for sampled sites are summarized by hydrologic units with values representing both right and left corridor segments.

>one row = unbroken corridor more than one tree width.
One row trees = contiguous row of trees along sample site.
50% present = *broken along 50% of corridor length.
<50% present = limited, present along portion of sample site.
Absent = no corridor

(#)--values represent number of corridors sampled--right and left corridor.

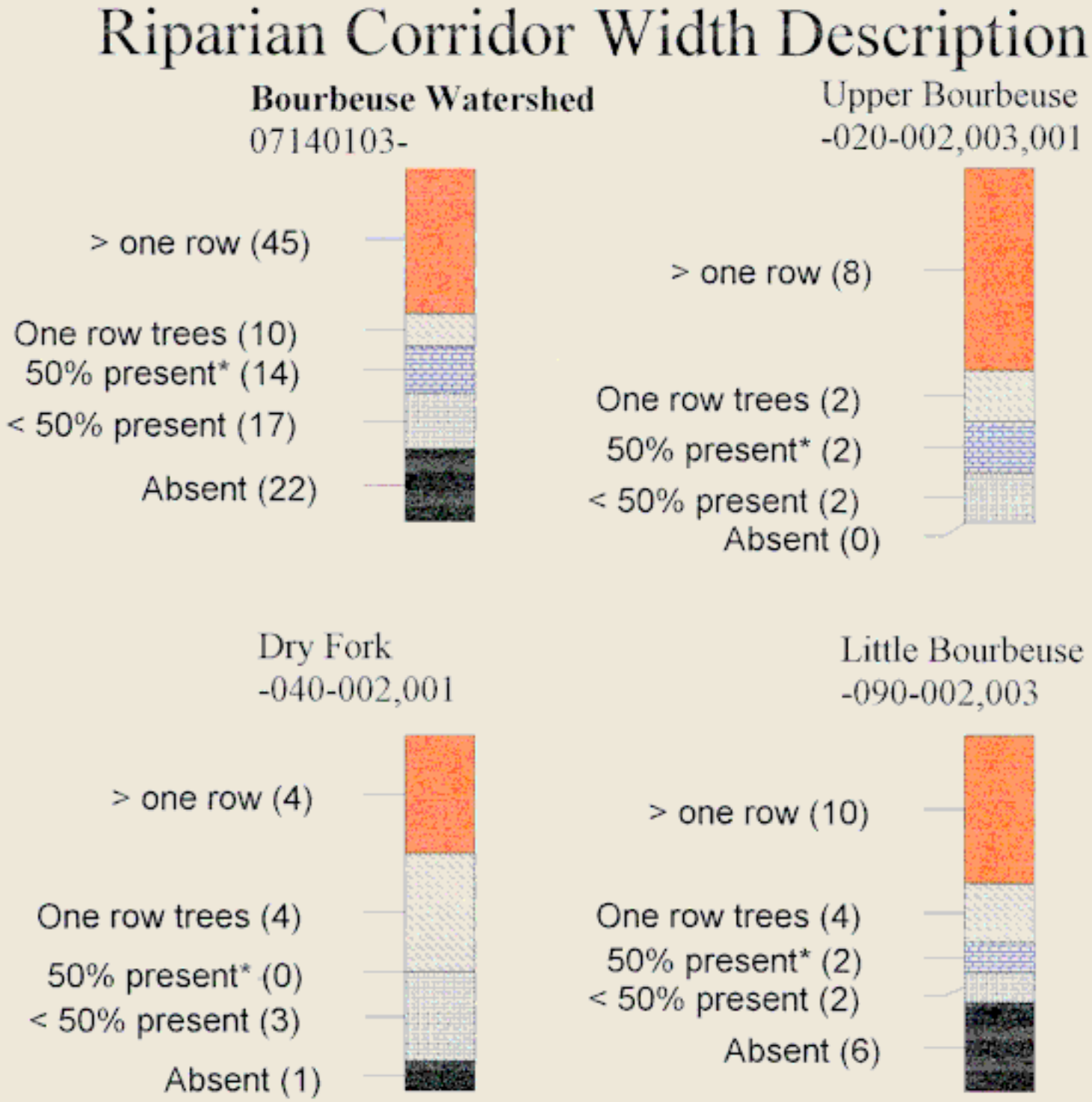


Table 18. List of habitat features and definitions used in the Bourbeuse River watershed habitat assessment based on McCain et al. 1990.

Low Gradient Riffles (**LGR**) - shallow reaches with swiftly flowing, turbulent water with some partially exposed substrate. Gradient < 4%, substrate is usually cobble dominated.

High Gradient Riffles (**HGR**) - steep reaches of moderately deep, swift, and very turbulent water. Amount of exposed substrate is relatively great. Gradient is > 4%, and substrate is boulder dominated.

Cascade (**CAS**) - The steepest riffle habitat, consists of alternating small waterfalls and shallow pools. Substrate is usually bedrock and boulders.

Secondary Channel Pool (**SCP**) - pools formed outside the average wetted channel. During summer, these pools will dry up or have very little flow. Mainly associated with gravel bars and may contain sand and silt substrates.

Backwater Pool, Boulder Formed (**BWPB**) - found along channel margins and caused by eddies around boulders. These pools are usually shallow and are dominated by fine-grain substrates. Current velocities are quite low.

Backwater Pool, Rootwad Formed (**BWPR**) - found along channel margins and caused by eddies around rootwads. These pools are usually shallow and are dominated by fine-grain substrates. Current velocities are quite low.

Backwater Pool, Log Formed (**BWPL**) - found along channel margins and caused by eddies around woody debris. These pools are usually shallow and are dominated by fine-grain substrates. Current velocities are quite low.

Backwater Pool, w/ associated gravel bar (**BWPG**) - found along channel margins and caused by eddies around gravel bars. These pools are usually shallow and are dominated by fine-grain substrates. Current velocities are quite low.

Trench/Chute (**TRC**) - channel cross sections typically U-shaped with bedrock or coarse grained bottom flanked by bedrock walls. Current velocities are swift and the direction of flow is uniform. May be pool-like.

Plunge Pool (**PLP**) - found where stream passes over a complete or nearly complete channel obstruction and drops steeply into the streambed below, scouring out a depression, often large and deep. Substrate size is highly variable.

Lateral Scour Pool, Log Formed (**LSPL**) - formed by impinging against one streambank or against a partial obstruction of a log or other woody debris. The associated scour is confined to < 60% of wetted channel width.

Lateral Scour Pool, Rootwad Formed (**LSPR**) - formed by impinging against rootwads creating a partial channel obstruction. The associated scour is confined to < 60% of wetted channel width.

Lateral Scour Pool, Bedrock Formed (**LSPB**) - formed by impinging against bedrock creating a partial channel obstruction. The associated scour is confined to < 60% of wetted channel width.

Lateral Scour Pool, Boulder Formed (**LSP**) - formed by impinging against boulders that create a partial

channel obstruction. The associated scour is confined to < 60% of wetted channel width.

Dammed Pool (**DPL**) - water impounded from a complete or nearly complete channel blockage (debris jams, rock landslides, or beaver dams). Substrate tends toward smaller gravels and sand.

Glides (**GLD**) - a wide shallow pool flowing smoothly and gently, with low to moderate velocities and little or no surface turbulence. Substrate usually consists of cobble, gravel and sand.

Run **(RUN**) - swiftly flowing reaches with little surface agitation and no major flow obstructions. Often appears as flooded riffles. Typical substrates are gravel, cobble and boulders.

Step Run (**SRN**) - a sequence of runs separated by short riffle steps. Substrates are usually cobble and boulder dominated.

Mid-Channel Pool (**MCP**) - large pools formed by mid-channel scour. The scour hole encompasses more than 60% of the wetted channel. Water velocity is slow, and the substrate is highly variable.

Edgewater (**EGW**) - quiet, shallow, area found along the margins of the stream, typically associated with riffles. Water velocity is low and sometimes lacking. Substrate varies from cobbles to boulders.

Channel Confluence Pool (**CCP**) - large pools formed at the confluence of two or more channels. Scour can be due to plunges, lateral obstructions or down scour at the channel intersections. Velocity and turbulence are usually greater than those in other pool types.

Pocket Water (**POW**) - a section of swift flowing stream containing numerous boulders or other large obstructions which create eddies or scour holes (pockets) behind the obstructions.

Corner Pool (**CRP**) - lateral scour pools formed at a bend in the channel. These pools are common in lowland valley bottoms where streambanks consist of alluvium and lack hard bottoms.

riffles, and possibly, a number of small pools of any given type as described above, separated by a run (7% watershed-wide total) or glide (5% watershed-wide total). Of course, in the smaller-order systems the riffle-pool continuum was closer together; therefore, these segments may have included a pool-riffle-pool-riffle.

During this survey, distinguishing pool types from stream order to stream order improved with experience. Among pool formations, lateral scour was dominant over other pool formations. The lateral scour pool rootwad type was a dominant pool habitat type, accounting for nearly 8% of the habitat types (Figure 14). This numerical dominance illustrates the role of a healthy terrestrial-aquatic interface in shaping streams and providing habitat for fish species. The role channel blockage and obstruction from logs and boulders plays in scour pool development is further illustrated by a relative composition of 4.2% (LSPL) and 4% (LSPB), respectively (Figure 14).

Other pool types were mid-channel pool, backwater pool, secondary channel pool, and the corner pool, channel confluence pool, and pocket water pools. First, the mid-channel pool (6.4% watershed-wide total) was a middle channel scour area with low water velocity that may be a transitional area created by shifting bedload. Along with lateral scour pools, these areas are used during fall and winter low water periods. Second, backwater pools ranged in relative composition from 2.1-5.5% watershed-wide total. Mostly used by larval fish and juvenile fish, these were out of the main flow and have low current velocities. These habitats were formed during high flow by rootwad (2.1%), boulders (or in some case concrete; 3.6%), logs (3.9%), or gravel (5.5%). Third, secondary channel pool, formed by merging-flow scour, were fairly common with a composition of 5% watershed-wide total. Fourth, corner pools (3% watershed-wide total) were found in many of the 6th-order stream segments of the Bourbeuse River. Because corner pools are formed by scour and are of large size, they were identified mainly by topographic map. Fifth, the channel confluence pool accounts for 2.1% of the watershed-wide total. Lastly, the pocket water pool was rare in the Bourbeuse River watershed. It accomprised < 1% of the watershed-wide total. This habitat was found at the base of the dam at Noser Mill, where numerous large boulders created small pocket pools from the high flow of the falls.

In addition to the backwater pools, the edgewater areas were important nursery areas for juvenile fish. They typically had emergent vegetation such as waterwillows and are adjacent to riffles or mid-channel pools. Edgewater areas were numerous (8.3% watershed-wide total).

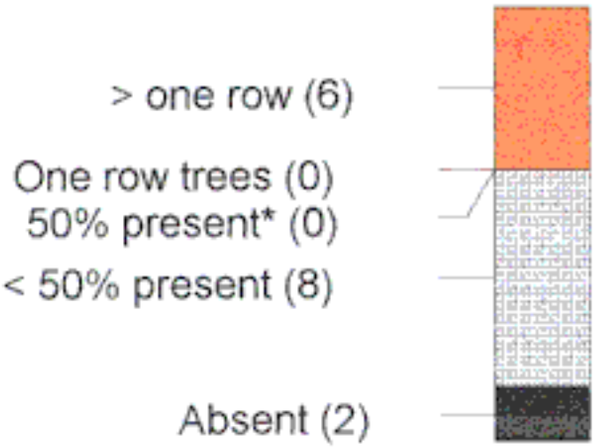
Channel Alterations

We categorized the human activities in the Bourbeuse River hydrologic units at or near the stream sample sites into 19 categories (Table 19). Most sampling was done where low-water crossing or roads were found; therefore, this alteration was noted at many sites.

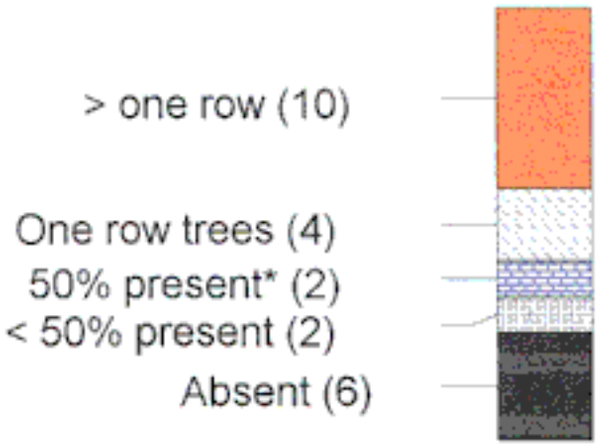
Agricultural activities were found at nearly all watershed sample sites. First, livestock had access to streams in five of the seven hydrologic unit sample sites. Seven of the thirteen sample sites in the Little Bourbeuse River hydrologic unit had livestock access to streams, making stream sample sites in this watershed the most heavily used by livestock. The Little Bourbeuse River hydrologic unit had the worst riparian corridor and erosion protection condition as compared to other hydrologic units (see Habitat Evaluation Section, Erosion, Corridor, and Land Use Conditions). Although it is difficult to prove relationships between the livestock access and filamentous algae, most sites with livestock access to streams had abundant or some algae (Table 19). Lastly, concentrated animal farms were within two of the seven watersheds. The Middle Bourbeuse River and the Little Bourbeuse River hydrologic units had

Riparian Corridor Width Description

Middle Bourbeuse River
-090-008,004,001



Spring, Boone, Red
Oak -090-007,006,005



Lower Bourbeuse River
-100-001,002

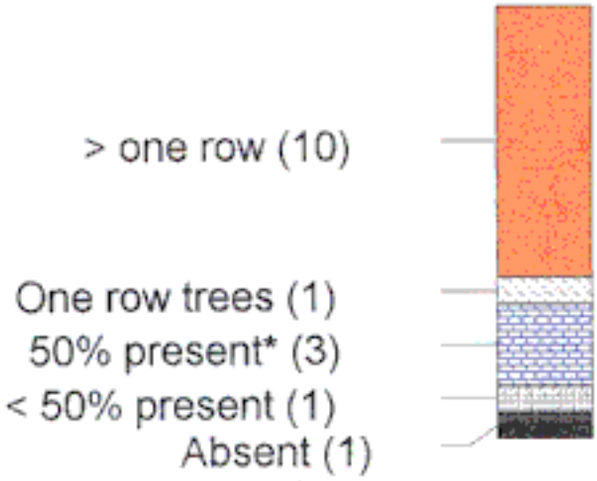


Figure 13. Bourbeuse River watershed riparian corridor width descriptions for sampled sites are summarized by hydrologic units with values representing both right and left corridors segments.

> one row = unbroken corridor more than one tree width.
One row trees = contiguous row of trees along sample site.
50% present = *Broken along 50% of corridor length.
<50% present = limited, present along portion of sample site.
Absent = no corridor.

(#)--values represent number of corridors sampled--right and left corridor.

Table 19. Human activities at or near the sample site and the presence or absence of aquatic vegetation in the Bourbeuse River watershed (hydrologic unit (HU) # 07140103-). Activity values are codes defined on the last page.**

Id-# [1]	HU**		Stream Name	Activity[2] 1	2	3	4	5	Aquatic Vegetation [3]
LOWER BOURBEUSE HYDROLOGIC UNIT**-100-001, 002									
31	100	2	Bourbeuse River	14	19				1,2E,4A
29	100	2	Bourbeuse River	12	15	16			1,2S,4A
48	100	2	Bourbeuse River	14	19				1,4S
56	100	2	Bourbeuse River	14					1S,2S
55	100	2	Bourbeuse River	16					1S,2E,4E
30	100	1	Bourbeuse River	1	14				2E,4E
28	100	1	Bourbeuse River	6	14				1,4S
32	100	1	Bourbeuse River	6	19	16			1,2R,3R,4A
SPRING, BOONE, RED OAK CREEK HYDROLOGIC UNIT**-090-007, 006, 005									
1	90	7	Spring Creek	6	16				2E,4R
50	90	6	Boone Creek	2	4	7	16	1	2E,3R,4R
51	90	6	Boone Creek	6	19				2
52	90	6	Boone Creek	1	3	6	7	19	2R,4S
4	90	5	Red Oak Creek	6	15				1A,2E,4S
3	90	5	Red Oak Creek	6	11	16	19	1	2A
2	90	5	Red Oak Creek	1	19				2S
5	90	5	Red Oak Creek	2	15				1S,2A,4S
MIDDLE BOURBEUSE HYDROLOGIC UNIT** -090-008, 004, 001									
33	90	8	Bourbeuse River	2	6	9	14	19	1,2S,4S
34	90	8	Bourbeuse River	2	3	14			124
43	90	8	Bourbeuse River	19					1,4S
54	90	8	Big Creek	2	6	19			2S,4R
53	90	8	Big Creek	6	19				2S,4S
37	90	4	Bourbeuse River	6					1,2S,4A
35	90	4	Bourbeuse River	1	6	15	19		1,2R,3R,4A
46	90	4	Bourbeuse River	6	19				2S,4
42	90	4	Bourbeuse River	6	14				124
40	90	1	Bourbeuse River	6					2R,4S
41	90	1	Bourbeuse River	6	19				1S,4S

49	90	1	Bourbeuse River	5	6				1,2A,3R,4S
LITTLE BOURBEUSE RIVER HYDROLOGIC UNIT**-090-003, 001									
9	90	3	Little Bourbeuse River	1	5	6	9		2A,4S
8	90	3	Little Bourbeuse River	1	6	19			1R,4A
6	90	3	Little Bourbeuse River	6	7	19			1,2S,4A
7	90	3	Little Bourbeuse River	1	6	19			1R,4S
22	90	2	Prairie Creek	6	7	19			3E,4S
23	90	2	Praire Creek	1	6	19			2,4S
20	90	2	Pleasant Valley Creek	6	7	19			2S,3R
21	90	2	Pleasant Valley Creek	1	6	7	19		2S,4R
24A	90	2	Br.Noname/Brush/20.	1	6	7			2S,4S
26	90	2	Brush Creek	1	6	19			4
27	90	2	Brush Creek	1	6	7			4A
24B	90	2	Brush Creek	1	6	7			2
25	90	2	Brush Creek	6	19				1,4S
DRY FORK HYDROLOGIC UNIT**-040-002, 001									
13	40	2	Dry Fork	1	2	4	6		2A,4R
12	40	2	Dry Fork	6					2
14	40	2	Dry Fork	6	14	19			2R,3R,4A
16	40	2	Dry Fork	1	6	7	19		2S,4R
15	40	2	Dry Fork	6					2A
17	40	1	Upper Peavine Creek	1	6	7			1S,2A,4R
UPPER BOURBEUSE HYDROLOGIC UNIT**-020-002, 003, 001									
19	20	3	Clear Creek	19					2S
18	20	3	Clear Creek	6	19				4
39	20	3	Bourbeuse River	6	16				2S
38	20	3	Bourbeuse River	2	19				24
10	20	2	Ltl. Bourbeuse Creek	6	7	19			2A,4S
11	20	2	Ltl. Bourbeuse Creek	3	6	7			2A,4R
36	20	1	Bourbeuse River	6	10	19			2A,4R

[1]ID# = SITE INDENTIFICATION NUMBER

[2]Activities Code: [3]Aquatic vegetation:

1- Streambank stablization 7- Livestock access 13- Human sewage untreated 1- Planktonic algae

2- Gravel mining-past 8- Livestock waste runoff 14- Floodplain development 2- Filamentous algae

3- Gravel mining-current 9- Concentrated animal farm 15- Levee 3- Submergent macrophytes

4- Gravel mining equipment 10- Pipe line crossing 16- Waste (refuse) disposal 4- Emergent macrophytes nearby

5- Channel snagging 11- Streamside clearing 17- Irrigation Aquatic veg. abundance: R-rare,

6- Slab crossing or road 12- Sewage lagoon 18- Industry 19-Other S-some, A-abundant, E- excessive.

one site each with this activity.

The Middle Bourbeuse River and the Little Bourbeuse River hydrologic units have the most need for management based on the observed scarcity of streambank protection and intact riparian corridors. When comparing across hydrologic units, the Upper Bourbeuse River and the Spring, Boone, and Red Oak Creek hydrologic units may have the best overall watershed conditions within or near riparian zones.