APPENDIX A
HABITAT SUITABILITY INDEX MODEL SELECTION

US Army Corps of Engineers
Fort Worth District

San Marcos Aquatic Ecosystem Restoration Project
Habitat Suitability Index Model Selection for use in Habitat Evaluation Procedures

April 2011

U.S. Army Corps of Engineers
Fort Worth District

SAN MARCOS AQUATIC EOCOSYSTEM RESTORATION PROJECT
HABITAT SUITABILITY INDEX MODEL SELECTION
FOR USE IN HABITAT EVALUATION PROCEDURES

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of Engineers®
Fort Worth District

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1.0 INTRODUCTION

The Continuing Authorities Program (CAP) and Section 206 of the Water Resources Development Act of 1996 authorizes the U.S. Army Corps of Engineers (USACE), Fort Worth District (CESFW) to participate in the development and implementation of projects to restore terrestrial and aquatic habitats that have been significantly disturbed, degraded, or altered. CESFW and the local sponsor, the City of San Marcos, have prepared a Preliminary Restoration Plan (PRP) proposing measures for the restoration of the aquatic and riparian habitats along the San Marcos River between Rio Vista Dam and Cumming's Dam (Figure 1). Measures proposed for the restoration of aquatic habitats include the control of non-native plants, planting of native plants, creation of wetlands or wet-ponds to treat stormwater, and modification of one or more of the check dams within the project area. Measures proposed for the restoration of riparian habitats include controlling recreational access to reduce trampling of vegetation and degradation of stream banks, removing hard surfaces, and converting maintained grasslands into forested habitats.

The existing and future suitability of the aquatic and riparian habitats will be assessed using Habitat Evaluation Procedures (HEP). HEP provide standards and guidelines to be used for documenting and projecting the quality and quantity of available habitat for selected wildlife species. HEP are based on the assumption that habitat for selected wildlife species can be described by a Habitat Suitability Index (HSI). This Model Selection Report documents the criteria and assumptions used to select HSI models for application of HEP to the San Marcos aquatic ecosystem restoration project.

2.0 SELECTION OF POTENTIALLY APPLICABLE MODELS

All certified Habitat Suitability Index (HSI) models were reviewed to determine which models assess habitats for species whose distribution overlaps with the project area. The selected models included 17 fishes, one amphibian, two reptiles, four waterfowl, two upland game birds, one raptor, four song birds, and five mammals. The scientific names, general habitat preferences, and applicable cover types for each model are presented in Appendix 1. To be selected for assessment of existing and future habitat conditions, a model must be applicable to the existing and future cover types in the project area. Grassland cover types are not, and have

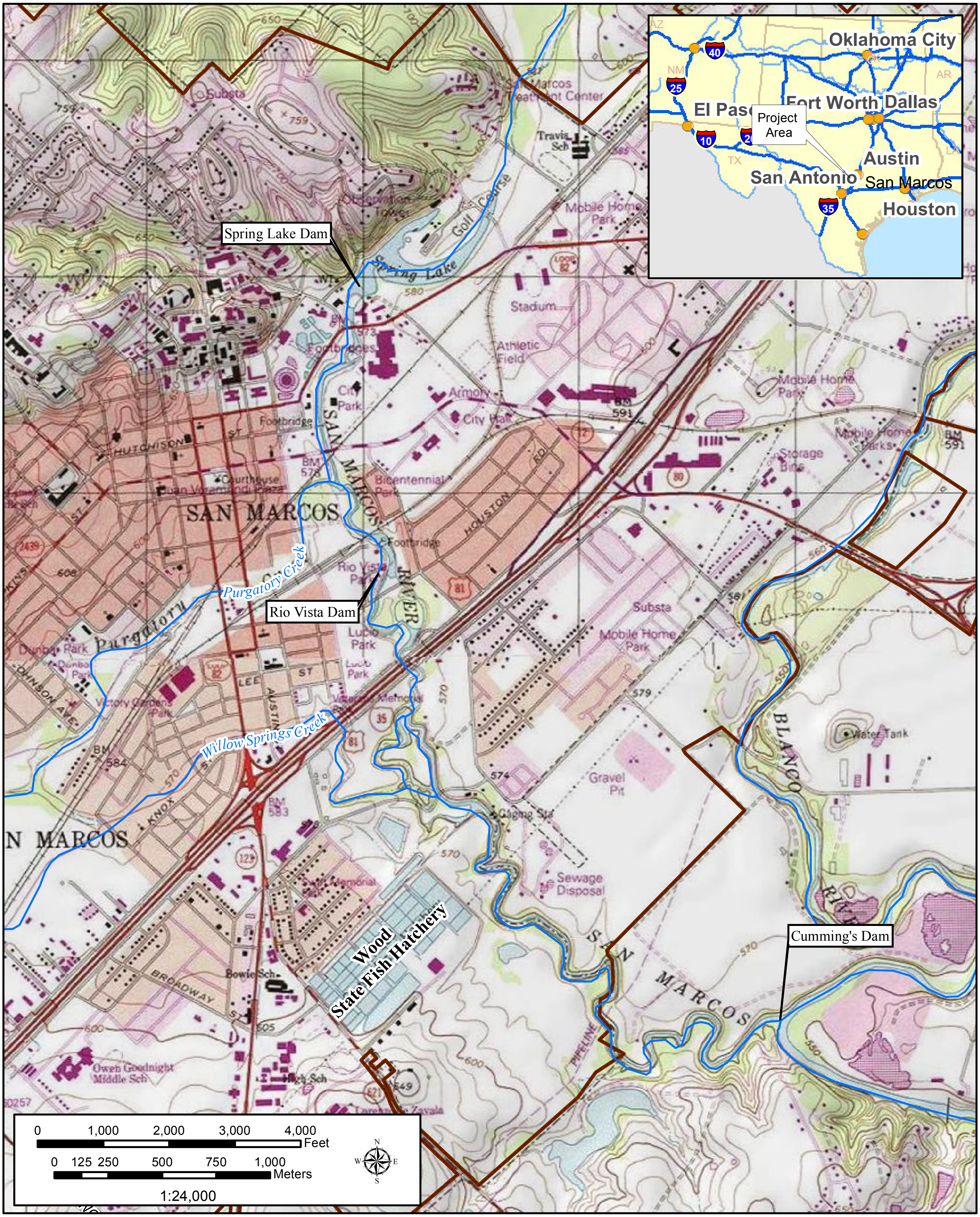

Figure 1: Vicinity Map

March 2011

not historically been, a substantial part of the San Marcos River ecosystem. Therefore, models that require the presence of grassland cover types for optimal suitability were eliminated from further consideration.

Each of the remaining models is applicable to at least one aquatic, wetland, or upland cover type, and at least one model must be selected to assess habitat suitability for each of these cover type groupings. For each cover type grouping, the list of applicable models was reviewed to determine the likely effect of measures listed in the PRP on model output. Those models which are likely to result in a net gain of habitat suitability as a result of implementing measures identified in the PRP were selected for further consideration. During this review, models which provide opportunities to create habitat output through possible restoration measures not included in the PRP were also carried forward for further consideration.

Non-certified models representing Federally endangered, endemic species, Texas wild-rice (*Zizania texana*) and fountain darter (*Etheostoma fonticola*), were also considered. Because these species are endangered, there distribution is limited, which limits the ability to identify preferred habitat conditions. As with most rare species, habitats considered potentially suitable are often not occupied by these species for unknown reasons. For a model to be certified, all of the conditions which affect abundance must be identified and included in the model. Although the models for these species represent the best available approach to predicting the species abundance and for identifying opportunities to improve conditions for these species, the models do not meet the requirements for certification. Two of the variables considered in the models, velocity and depth, are dependent primarily on the rate of discharge from the Edwards Aquifer and would not be substantially affected by measures identified in the PRP. Furthermore, because the models would only be applicable to the San Marcos River and would be used just once, they would be assigned the lowest priority for review and certification. For these reasons, the Texas wild-rice and fountain darter models were excluded from further consideration as models for use in HEP.

It was noted in a coordination meeting held on March 8, 2011 that the HEP analysis need not be exclusive of habitat preferences of these endemic species. The U.S. Fish and Wildlife Service (USFWS) HEP: 102 Ecological Services Manual and USACE Engineering Regulation 1105-2-104 require that other factors, including endangered species and cultural resources, be considered in the development and evaluation of restoration measures and plans. Thus, a measure which is not shown to be cost-effective through the HEP and Incremental Cost Analysis (ICA) processes can be included in the final plan selection if benefits to these endangered, endemic species can be shown.

2.1 Aquatic Habitats

Of the applicable fish models, 10 represent species known to occur in the reach of the San Marcos River between Rio Vista Dam and the confluence with the Blanco River: black bullhead, bluegill, channel catfish, common carp, gizzard shad, green sunfish, largemouth bass, redbreast sunfish, redear sunfish, and warmouth. All of these models, except the redbreast sunfish, represent species with a preference for slower, deeper mesohabitats such as pools and backwater areas. The redbreast sunfish is adapted to swifter waters associated with riffles and runs. Applicable models of fish species not documented within the project area include the black crappie, creek chub, flathead catfish, slough darter, smallmouth bass, smallmouth buffalo, and white crappie. Of these models, the creek chub, flathead catfish and smallmouth bass, represent species more adapted to swift water habitats. The group of selected models should include at least one model that represents a species preferring pools and one species preferring riffles and runs.

Although existing water quality conditions are near optimum for most of the applicable fish models, some models are tolerant of, or prefer, slightly turbid or warmer waters when compared to other models. These include channel catfish, common carp, flathead catfish, gizzard shad, slough darter, smallmouth buffalo, and white crappie. Clear water and cool temperatures are the historical condition for the San Marcos River ecosystem, are the preferred conditions of endemic species, and should be the goal of ecosystem restoration. Measures to reduce the input of sediment from storm water or tributaries would not result in net benefits as evaluated using these fish models. Therefore, models which assume that relatively higher water temperatures or turbidity are tolerable or preferred were eliminated from further consideration.

The fish models' habitat conditions generally include measures of hydrology (such as velocity, gradient, percent pool area, etc.), water quality (such as temperature, dissolved oxygen, turbidity, etc.), substrate, vegetative cover, and hard cover (e.g., boulders and in-stream woody material). The primary difference between fish models is found in the range of conditions considered optimal for a given species. With the exception of slightly cooler water temperatures and faster velocities, the existing conditions of the San Marcos River in the project area would be evaluated as optimal to near optimal using the available, certified HSI models. Models representing species that are known to occur in the project area and are not tolerant of warm or turbid waters were carried forward for more detailed assessment (Table 1). Models representing species that are not known to occur in the project area, but are not tolerant of warm or turbid waters and prefer riffle/run mesohabitats were also carried forward for more detailed assessment.

Table 1. Presence and General Habitat Preference of Applicable Fish Models

Model	Present in Project Area	Tolerant of turbidity or warm water	Preferred Mesohabitat	Carried Forward
black bullhead	yes	no	pools	yes
black crappie	no	no	pools	no
bluegill	yes	no	pools	yes
channel catfish	yes	yes	pools	no
common carp	yes	yes	pools	no
creek chub	no	no	riffle/run	yes
flathead catfish	no	yes	riffle/run	no
gizzard shad	yes	yes	pools	no
green sunfish	yes	no	pools	yes
largemouth bass	yes	no	pools	yes
redbreast sunfish	yes	no	riffle/run	yes
redear sunfish	yes	no	pools	yes
slough darter	no	yes	pools	no
smallmouth bass	no	no	riffle/run	yes
smallmouth buffalo	no	yes	pools	no
warmouth	yes	yes	pools	no
white crappie	no	yes	pools	no

Several models are suitable for evaluating aquatic cover types and wetland cover types. Although these models include an aquatic component, riverine habitats are not necessary to provide suitable conditions. These models are considered below in Section 2.2. The belted kingfisher model is the only non-fish model that is only applicable to aquatic cover types. The model assumes that clear, shallow, relatively open streams provide optimal habitat. Measures which remove canopy cover over the river would result in increased habitat suitability for this species; thus, the model is carried forward.

2.2 Wetland Habitats

Wetland cover types include forested, scrub-shrub, and herbaceous wetlands. Forested and scrub-shrub wetlands are limited within the project area, but could be created by improving connection of the river to the floodplain. The creation of wetlands or shallow ponds within the project area would increase the area of herbaceous wetland habitats. Most of the models applicable to herbaceous wetland cover types are also applicable to aquatic cover types, and these models are assessed here. Models that are applicable to wetland and upland cover types are discussed below under upland habitats. One fish model, the white crappie, is applicable to wetland cover types, but was eliminated from further consideration due to a tolerance of turbid waters. One waterfowl model, the great blue heron, assumes that human disturbance results in unsuitable habitat conditions, and this model is eliminated from further consideration. One mammal model, the beaver, was eliminated because of the species' tendency to alter stream hydrology and consequent incompatibility within an urban setting. A second mammal model, the swamp rabbit, requires wetlands greater than 250 acres in size with suitable upland refuge. It is unlikely that 250 acres of suitable wetland habitat would be created as a result of the project; thus, the swamp rabbit model is excluded from further consideration.

The amphibian model (bullfrog) and both reptile models (slider turtle and snapping turtle) assume that optimum conditions are provided by slow, warm waters with abundant vegetative cover. Creation of wetlands or shallow ponds within the floodplain or along tributaries would likely result in a net gain of habitat suitability as evaluated by these three models. The American coot, red-winged blackbird, and muskrat each consider herbaceous wetlands with moderate vegetative cover and normally inundated to be optimal. Of these three models, the American coot is most tolerant of dry periods while the muskrat is least tolerant of dry periods. The American coot model assumes that suitability increases with increasing length of the vegetation/open water edge, where linear ditches lined with vegetation provide the least suitable habitats. The red-winged blackbird and muskrat models are indifferent to spatial heterogeneity, but require that at least 80 percent of emergent vegetation be persistent broad-leaved monocots such as bulrush or cattails. The red-winged blackbird model is very similar to the muskrat model, but also considers the presence or absence of Odonata species (i.e., damselflies and dragonflies). Because the model suggests that the presence of Odonata species must be based on empirical evidence, projecting future conditions would be spurious. For these reasons, the red-winged blackbird model is excluded from further analysis.

2.3 Terrestrial Habitats

Each of the four terrestrial models that have not been eliminated (i.e, barred owl, downy woodpecker, hairy woodpecker, and fox squirrel) assumes that mature forest communities provide optimum habitat suitability. Each model includes a measure of mean (average) tree size. The downy woodpecker, hairy woodpecker, and fox squirrel models assume that a mean tree size greater than 14 inches in diameter at breast height (dbh) provides optimum conditions. While the barred owl assumes that a mean tree size greater than 20 inches dbh and more than 2 trees per acre with a 20 inch or greater dbh are required to provide optimum conditions. Both woodpecker models assume that snags are necessary to provide optimum conditions, with the downy woodpecker model favoring a larger number of small snags compared to the hairy woodpecker model.

The barred owl model states that data used to develop suitability index curves for tree size are based on studies conducted in northwestern and eastern coastal areas, and that calibration of the model for regional variation is appropriate. Without suitable data for calibration of the model to regional conditions, the barred owl model would likely underestimate habitat suitability. Other terrestrial models would not require calibration; therefore, the barred owl model is eliminated from further consideration. The fox squirrel model assumes that a canopy cover greater than 60 percent will result in declining habitat suitability, and that at least 40 percent of canopy cover is provided by mast-producing species. Factors limiting tree canopy cover such as fire or frequent inundation are absent from the San Marcos riparian zone. Creating optimal conditions, as assessed by the fox squirrel model, would require thinning of the existing canopy, replacement with mast-producing species, and long-term canopy maintenance to ensure that suitable conditions are maintained. For these reasons, the fox squirrel model is also eliminated from further consideration.

3.0 COMPARISONS OF POTENTIALLY SELECTED MODELS

Of the 36 HSI models considered applicable based on the species' range and preferred habitat types, 20 were removed from further consideration based on the criteria described above. The remaining 16 potentially selected models (Table 2) were discussed with USACE, USFWS, and Texas Parks and Wildlife Department (TPWD) at a meeting held on March 8, 2011.

Table 2. Potentially Selected Models

Aquatic		Wetland		Terrestrial
riffle/run	**pool**	**shallower**	**deeper**	
creek chub	black bullhead	snapper turtle	bullfrog	downy woodpecker
redbreast sunfish	bluegill	American coot	slider turtle	hairy woodpecker
smallmouth bass	green sunfish	muskrat		
	largemouth bass			
	redear sunfish			
belted kingfisher				

Because ecosystem degradation in the project area is primarily limited to the increasing abundance of non-native aquatic plants, controlling these plants is one of the primary objectives of ecosystem restoration. Measures to remove non-native plants and plant native species are included in the PRP; therefore, at least one model should be sensitive to the cover of submerged and emergent species.

The list of species included in Table 2 was reviewed by USFWS and TPWD, and the following models were recommended based primarily on the sensitivity of the models to the cover of submerged and emergent plants: black bullhead, green sunfish, bullfrog, and slider turtle. However, because the black bullhead is considered to be a species more tolerant of poor water quality conditions, the channel catfish was recommended as an alternative. It was also recommended that the longear sunfish (*Lepomis megalotis*) replace the green sunfish; however, there is not an approved model for the longear sunfish. A comparison of the optimum conditions for the black bullhead and channel catfish (Attachment B) shows that the channel catfish is more sensitive to changes in the cover of aquatic vegetation; therefore, the channel catfish is suggested as a selected model. The channel catfish is more dependent on pools and backwater areas than riffle/run mesohabitats. Because the San Marcos River was historically a riffle/run dominated system, a model which considers conditions related to these mesohabitats should be included. A similar comparison of the bluegill and green sunfish model identified the bluegill model as being more sensitive to vegetative cover, and the bluegill is recommended for selection. From the list provided in Table 2, the smallmouth bass is also suggested for inclusion. Although this species is not native to the Guadalupe Basin, it is similar to the Guadalupe bass (*Micropterus treculii*) and prefers swift, clear, cool rivers similar to the San Marcos.

Although the bullfrog and slider turtle HSI models would apply to the riverine habitats of the San Marcos River, they would primarily be used to evaluate herbaceous wetland habitats created along tributaries. The bullfrog requires permanent water at a depth of greater than 5 feet, and optimum conditions are not likely to be created by these wetlands. The slider turtle is more tolerant of fluctuations in water levels, and optimum conditions are met at a minimum depth of 3.3 feet. Conversely, the American coot model does not have a minimum depth requirement, and optimum conditions are met by semi-permanently flooded wetlands. It is suggested that both the slider turtle and American coot models be included for evaluation of herbaceous wetlands. These two models will also be used to evaluate potential changes in the cover of emergent vegetation within the San Marcos riparian zone as a result of measures included in the PRP.

Other than creating additional habitat in the riparian zone, there are few measures which would result in improved conditions of terrestrial habitats as evaluated by certified HSI models. Of the two terrestrial models listed in Table 2, future conditions are likely to be most suitable for the downy woodpecker, and this model is suggested for selection. One other bird, the belted kingfisher, is also recommended for selection. The belted kingfisher is known to occur in the project area and prefers open waterways. The PRP includes a measure to remove overhanging trees from the river to reduce impacts on submerged aquatic vegetation resulting from recreational activities. The belted kingfisher model would evaluate this measure as a beneficial impact.

4.0 SUGGESTED HSI MODEL SELECTION

A total of seven HSI models are suggested for application of HEP to the San Marcos aquatic ecosystem restoration feasibility study (Table 3). The slider turtle and American coot are selected for their tolerance of shallow wetlands and occasional exposure of wetland substrates. These two models will provide a means of evaluating the proposed creation of wetlands along tributaries of the San Marcos River. Three fish models are suggested: channel catfish, bluegill, and smallmouth bass. Combined, these three fish models will be sensitive to any change in vegetative cover regardless of existing conditions. Each of the models is sensitive to substrate types in pools, and two of the three models are sensitive to changes in current velocity. The channel catfish and bluegill are more dependent on conditions found in pool mesohabitats.

Table 3. Recommended HSI Model Selection based on PRP Habitat Restoration Measures

HSI Model	Riverine/Herbaceous Wetland	Herbaceous Wetland	Deciduous Forested Wetland
Channel Catfish	X		
Smallmouth Bass	X		
Bluegill	X		
Slider Turtle	X	X	
American Coot	X	X	
Belted Kingfisher	X		
Downy Woodpecker			X

At least one species which is more dependent on conditions found in riffle/run habitats should be included in the selected models. Although the smallmouth bass is not native to the Guadalupe Basin, it prefers small, clear, cool, swift streams, is more dependent on riffle/run habitats, and is similar to the Guadalupe bass, which is a native fish.

Two avian models are suggested for evaluation of riparian habitats. The belted kingfisher prefers open water courses and would benefit from proposed measures to reduce overhanging vegetation, while the downy woodpecker would benefit from proposed measures to increase the area of forested riparian areas.

ATTACHMENT A
Potentially Applicable Models

Model	General Habitat Preference	Aquatic		Wetland			Upland					
		Lacustrine	Riverine	Forested	Scrub-Shrub	Herbaceous	Forest	Savanna	Shrubland	Grassland	Pasture	Cropland
FISHES												
Black bullhead *Ameiurus melas*	mixture of low-velocity pools with moderate cover and riffle/run areas	x	x									
Black crappie *Pomoxis nigromaculatus*	slower waters of pools, backwaters, and cut-offs	x	x									
Bluegill *Lepomis macrochirus*	slower waters of pools, backwaters, and cut-offs	x	x									
Channel catfish *Ictalurus punctatus*	warmer (> 21 °C) waters and tolerant of turbidity up to 100 ppm	x	x									
Common carp *Cyprinus carpio*	shallow, warm, sluggish waters with mud or silt substrate	x	x									
Creek chub *Semotilus atromaculatus*	small, clear, cool streams with moderate to high gradients		x									
Flathead catfish *Pylodictis olivaris*	large, slow, turbid rivers	x	x									
Gizzard shad *Dorosoma cepedianum*	warm, shallow waters with soft mud bottoms and high turbidity	x	x									
Green sunfish *Lepomis cyanellus*	pools in small to medium streams	x	x									
Largemouth bass *Micropterus salmoides*	prefers lakes or large, slow moving rivers	x	x									
Redbreast sunfish *Lepomis auritus*	low gradient, moderate-sized streams providing areas of hard cover	x	x									
Redear sunfish *Lepomis microlophus*	large, clear, low gradient streams with sluggish current and some vegetative cover	x	x									
Slough darter *Etheostoma gracile*	warm, turbid waters with little or no flow, mud or silt bottoms, and some cover	x	x									
Smallmouth bass *Micropterus dolomieu*	cool, clear, mid-order streams with abundant shade and cover, deep pools, moderate current, and gravel or rubble substrate.	x	x									
Smallmouth buffalo *Ictiobus bubalus*	deep, clear, warm waters of larger streams	x	x									
Warmouth *Lepomis gulosus*	slow moving waters with soft substrate and dense aquatic vegetation or other cover	x	x									
White crappie *Pomoxis annularis*	low gradient rivers, tolerant of turbidity	x	x	x	x	x						
AMPHIBIANS												
Bullfrog *Lithobates* (*Rana*) *catesbeiana*	slower waters with abundant emergent and shoreline cover	x	x	x	x	x						
REPTILES												
Slider turtle *Trachemys scripta elegans*	quiet water, 3 to 6 feet deep, with soft bottom and abundant vegetation	x	x	x	x	x						
Snapping turtle *Chelydra serpentina*	slow, shallow, turbid waters flowing over soft substrates	x	x	x	x	x						
WATERFOWL/SHOREBIRDS												
American coot *Fulica americana*	moderate cover of emergent vegetation, semi-permanently flooded	x	x			x						
Belted kingfisher *Megaceryle alcyon*	clear, shallow, relatively open streams	x	x									
Great blue heron *Ardea herodias*	general habitat requirements, but intolerant of disturbance	x	x	x	x	x						
Great egret *Ardea alba*	forages in shallow (< 9 inches) water with abundant cover; nests in trees over water	x	x	x	x							

Model	General Habitat Preference	Aquatic		Wetland			Upland					
		Lacustrine	Riverine	Forested	Scrub-Shrub	Herbaceous	Forest	Savanna	Shrubland	Grassland	Pasture	Cropland
GAME BIRDS												
Eastern wild turkey *Meleagris gallopavo silvestris*	mix of wooded and grassland upland habitats greater than 2,200 acres in area			x			x	x	x	x	x	x
Northern bobwhite *Colinus virginianus*	mix of wooded and grassland upland habitats greater than 12 acres in area						x	x	x	x	x	x
RAPTORS												
Barred owl *Strix varia*	expansive forest area with mature and decadent trees			x			x					
SONGBIRDS												
Downy woodpecker *Picoides pubescens*	mature woods greater than 10 acres			x			x					
Eastern meadowlark *Sturnella magna*	grasslands with perch opportunities									x	x	
Hairy woodpecker *Picoides villosus*	mature woods greater than 10 acres			x			x					
Red-winged blackbird *Agelaius phoeniceus*	wetlands dominated by broad-leafed monocots	x	x			x				x	x	
MAMMALS												
Beaver *Castor canadensis*	streams with less than 15 percent gradient and moderate canopy cover of shrubs and small trees	x	x	x	x	x						
Eastern cottontail *Sylvilagus floridanus*	mix of forest, shrub, and grassland habitats						x	x	x	x	x	x
Fox squirrel *Sciurus niger*	open forest habitats with a variety of mast trees			x			x	x				
Muskrat *Ondatra zibethicus*	herbaceous wetlands and low gradient streams with bulrush and cattail		x			x						
Swamp rabbit *Sylvilagus aquaticus*	large wetlands (> 250 acres) with adequate refuge during flood events			x	x	x						
SAN MARCOS ENDEMICS												
Texas wild rice *Zizania texana*	shallow (1 to 3 feet) slow (0.25 to 2 feet/second) streams		x									
Fountain darter *Etheostoma fonticola*	deeper (> 2.25 feet), slower (< 0.6 feet/second) streams with abundant cover of prefered substrates		x									

ATTACHMENT B
Comparison of Channel Catfish and Black Bullhead

HSI Variable	Optimum Conditions		Best Match to PRP*	Assumptions
	Channel Catfish	Black Bullhead		None
% pools during summer flow	40 to 60	50 to 75	CC	Measures to restore riffle/run dominance would have greater benefit for CC
% cover (vegetation, logs boulders, cavities, brush, debris, or standing timber)	> 40	> 25	CC	CC is most sensitive to reduction in cover below 40%
% cover during spawning	Not Provided	> 20	CC	None
Average current velocity at 0.6 m during average summer flow	Not Provided	< 4 cm/sec	?	The optimum current velocity (with respect to protected species) at this depth is known, but has not been identified
Average current velocity in cover areas during summer flow	< 12 cm/sec	Not Provided	?	The optimum current velocity (with respect to protected species) in areas of cover is known, but has not been identified
Food production potential by substrate type	fines not common in riffle/runs; aquatic vegetation abundant (>30%) in pools	Not Provided	CC	Assumes that removal of fines from riffle/runs would be cost-effective
Dominant substrate type in spawning areas	Not Provided	fines dominant	CC	Assumes that removal of fines from pools would be cost-effective
Maximum midsummer water temperature in pools	Not Provided	18 to 29 °C	N	Assumes that existing conditions are optimum and/or would not be substantially affected by any measure
Average midsummer water temperature in pools	26 to 29 °C	29 to 30 °C	N	Assumes that existing conditions are optimum and/or would not be substantially affected by any measure
Average midsummer water temperature in pools (Juvenile)	28 to 30 °C	Not Provided	N	Assumes that existing conditions are optimum and/or would not be substantially affected by any measure
DO range in pools	Not Provided	Seldom < 6 mg/l	N	Assumes that existing conditions are optimum and/or would not be substantially affected by any measure
Average minimum DO in pools	> 7 mg/l	Not Provided	N	Assumes that existing conditions are optimum and/or would not be substantially affected by any measure
pH range during the year	Not Provided	usually 6.5 to 8.5	N	Assumes that existing conditions are optimum and/or would not be substantially affected by any measure
Maximum salinity during summer	< 1.5	< 2 ppt	N	Assumes that existing conditions are optimum and/or would not be substantially affected by any measure
Maximum salinity during summer (fry, juvenile)	< 5 ppt	Not Provided	N	Assumes that existing conditions are optimum and/or would not be substantially affected by any measure
Maximum salinity during spawning	Not Provided	< 3 ppt	N	Assumes that existing conditions are optimum and/or would not be substantially affected by any measure
Maximum monthly average turbidity during growing season	< 110 ppm	25 to 100 ppm	N	Assumes that existing conditions are optimum and/or would not be substantially affected by any measure
Average spawning water temperature in pools	26 to 27.5° C	20 to 22° C	N	Assumes that existing conditions are optimum and/or would not be substantially affected by any measure

PRP = Preliminary Restoration Plan
CC = Channel catfish
N = neither
BB = Black bullhead
? = best match to PRP not documented