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Bexar County Karst Primer
Zara Environmental 16-Sept-2010

Karst- A terrain characterized by landforms and subsurface features such as sinkholes and caves, which are produced by the slow dissolution of calcium carbonate from limestone bedrock by mildly acidic groundwater. Karst areas commonly have few surface streams; most water moves through cavernous openings underground.

Surface Drainage Basin- Refers to the land area from which surface runoff drains into a cave, sink or other karst feature.

Subsurface Drainage Basin- Refers to the groundwater catchment area associated with a particular cave, sink or other karst feature. Both the surface and subsurface drainage basins play an important role in the health and maintenance of the karst ecosystem.

Critical Habitat Unit (CHU) - Critical habitat is defined as a specific geographic area(s) that contains features essential for the conservation of a threatened or endangered species and that may require special management and protection. Critical habitat may include an area that is not currently occupied by the species but that will be needed for its recovery. In Bexar County, 22 CHUs have been designated, totaling 1,063 acres. A total of 31 caves known to contain one or more of the listed species are located within these CHUs.

Karst Fauna Region (KFR) - A geographic area defined through the examination of geologic and hydrologic characteristics that may potentially restrict karst invertebrate migration. Bexar County has six Karst Fauna Regions. These are: Stone Oak, UTSA, Helotes, Government Canyon, Culebra Anticline and Alamo Heights (Figure 1).

Karst Fauna Area (KFA) - is a geographic area known to support one or more locations of an endangered species and is distinct in that it acts as a system that is separated from other KFAs by geologic and hydrologic features and/or processes that create barriers to movement of water, contaminants, and troglobitic fauna. A high quality KFA should be 60-90 acres (USFWS 2008).

Karst Zones- An area defined by geologic restrictions on the distribution of cave fauna and the locations of known caves. Veni (1994) delineated five karst zones in Bexar County that reflect the likelihood of finding any of the Bexar County listed troglobites (and other rare or endemic karst species). It should be noted, however, that due to the complexities of karst, it is impossible to predict with certainty the areas where the listed fauna may reside within zones 2, 3 and 4 (Veni 1994). The five Bexar County karst zones are defined as:

Zone 1: Areas where listed species are present and where geologic factors indicate continuity of the zone's karst and no restrictions to its fauna.

Zone 2: Areas having a high probability of suitable habitat for listed karst invertebrates or other endemic cave fauna

Zone 3: Areas that probably do not contain listed karst invertebrates or other endemic cave fauna

Zone 4: Areas that require further research, but are generally equivalent to Zone 3, although they may include sections that could be classified as Zone 2 or Zone 5.

Zone 5: Areas with outcrops of non-karstic units that do not contain listed karst invertebrates or other endemic cave fauna.

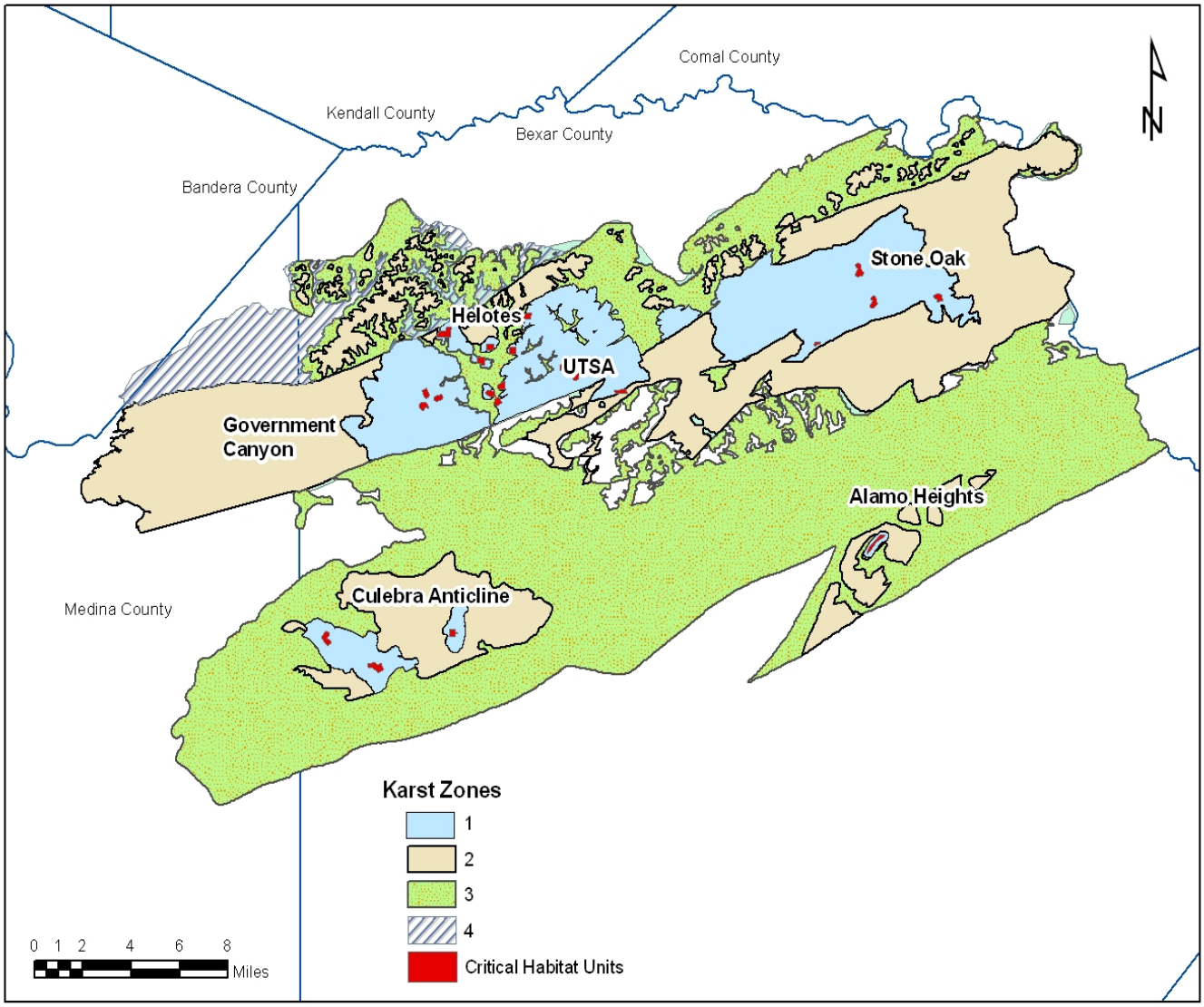


Figure 1. Bexar County Karst Zones and KFRs (Veni 2003)

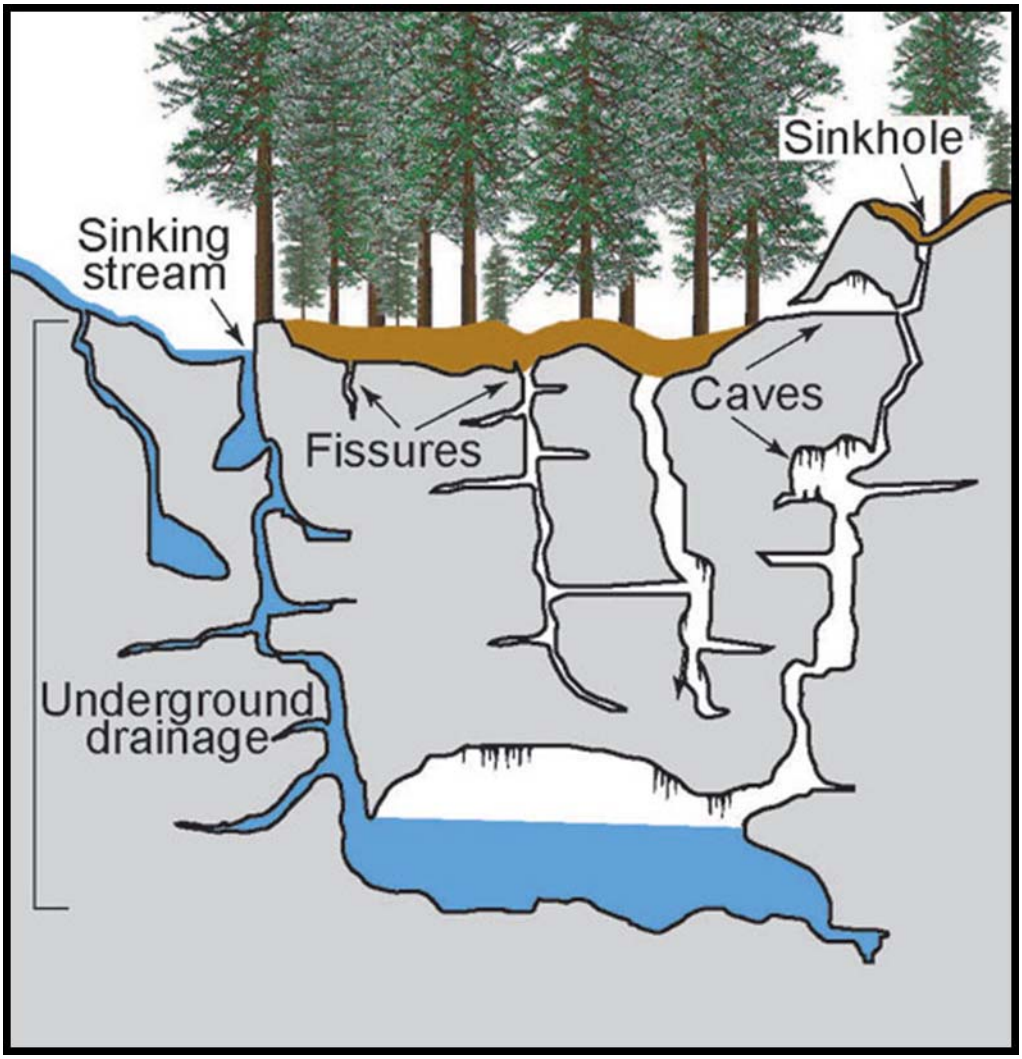


Figure 2. The Features of a Karst System (Robin Gary for Environmental Science Institute, University of Texas at Austin. www.esi.utexas.edu/outreach/caves)

Snapshot of recovery possibilities for karst invertebrates
Zara Environmental 7-Aug-2010

1. Directives to meet recovery as outlined in the recovery plan - # of KFAs

The recovery plan states that, among other things, a certain number of KFAs are needed in each KFR to ensure recovery.

Table 1. Distribution of species in KFRs, showing corresponding number of KFAs to protect. Bold taxa are SEPHCP category 1.

Species	KFR	Number of KFAs to protect
Rhadine exilis	**Government Canyon**	**12**
	UTSA	
	Helotes	
	Stone Oak	
Rhadine infernalis	**Government Canyon**	**15**
	UTSA	
	Helotes	
	Stone Oak	
	Culebra Anticline	
Batrisodes venyivi	Government Canyon	8
	Helotes	
Texella cokendolpheri	Alamo Heights	6
Neoleptoneta microps	Government Canyon	6
Cicurina baronia	Alamo Heights	6
Cicurina madla	**Government Canyon**	**12**
	UTSA	
	Helotes	
	Stone Oak	
Cicurina venii	Culebra Anticline	6
Cicurina vespera	Government Canyon	8
	UTSA	

2. Directives to meet recovery as outlined in the recovery plan - Quality of KFAs

Reaching recovery goals for cave species means protecting a certain number and quality of caves (KFA's - may be clusters of caves) in certain areas. This is the second table from the recovery plan that spells that out.

Table 1. This table shows various options for the minimum number of high quality KFAs that need to be preserved in their own KFA for a species to be considered for downlisting. The left column indicates the number of KFRs each species could occur in, the center column illustrates the configuration of the different quality KFAs within the possible total number of KFRs, and the right column indicates the total number of KFAs required to consider downlisting.

# of KFRs per species	Configuration of KFAs within KFRs					Total No. of KFAs
1	KFR #1: 3 High (H) + 3 Medium (M)					6
2	KFR #1: HMM	KFR #2: HHM			In either KFR: MM	8
3	KFR #1: HMM	KFR #2: HMM	KFR #3: HMM		In either KFR: M	10
4	KFR #1: HMM	KFR #2: HMM	KFR #3:HMM		KFR #4: HMM	12
5	KFR #1: HMM	KFR #2: HMM	KFR #3: HMM	KFR #4: HMM	KFR #5: HMM	15

3. Possibility of reaching the goals of recovery based on currently known localities

Data for Table 3 were obtained from USFWS (2008) recovery plan, note that the numbers in the cells are the most liberal interpretation of localities. The information in the recovery plan is explicitly tentative, with many sites lacking full verification of historic species presence and lacking any verification of continued species persistence, therefore the quality and quantity of the dataset for each species is inconsistent and this should be considered only a generalization.

Table 3 shows that for seven out of nine of the species, indicated by the cells in red, there are not enough sites currently known from every KFR to consider recovery for those species (data from USFWS 2008 recovery plan that defines a minimum of three sites needed from each Karst Fauna Region). The cells in green (Table 3) show regions where most of the localities occur in Camp Bullis and Government Canyon State Natural Area, therefore they have some level of current protection, however they are not necessarily protected in perpetuity. Cells in yellow are simply the remainder of localities, many of which are not assessed for quality of habitat and are not receiving current protection.

Table 3. Bexar County Listed Karst Invertebrates and number of known localities in each of the six Karst Fauna Regions. Seven out of the nine endangered species, noted with the cells in red, do not even have the potential for recovery given there are less than three sites known from each Karst Fauna Region. Cells in green indicate those areas with some form of existing protection from Government Canyon State Natural Area or Camp Bullis.

Karst Fauna Region	***Rhadine exilis***	***Rhadine infernalis***	*Batrisodes venyivi*	*Texella cokendolpheri*	*Neoleptoneta microps*	*Cicurina baronia*	***Cicurina madla***	*Cicurina venii*	*Cicurina vespera*
SEP HCP Category	**1**	**1**	**2**	**2**	**2**	**2**	**1**	**2**	**2**
Alamo Heights				**1**		**1**			
Culebra Anticline		**8**						**1**	
Govt. Canyon	**6**	**14**	**3**		**2**		**8**		**1**
Helotes	**5**	**6**	**4**		**1**		**7**		
Stone Oak	**28**	**4**					**2**		
UTSA	**11**	**7**	**1**				**7**		

Comparison of Karst Conservation Strategy for two other Regional HCPs
Zara Environmental 16-Sept-2010

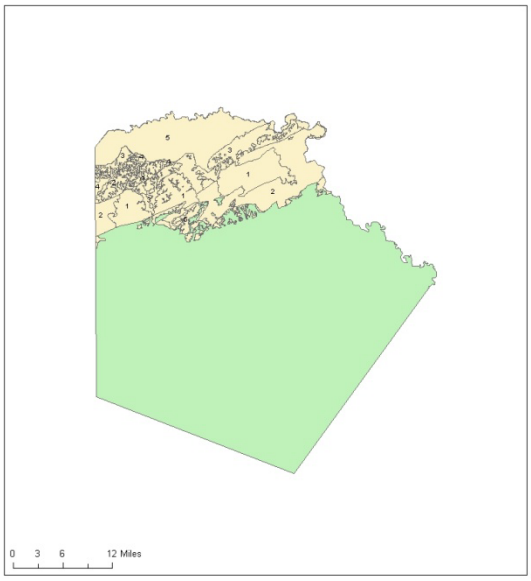
SEPHCP Draft Karst Conservation Strategy- A Comparison Between Balcones Canyonlands Conservation Plan RHCP and Williamson County RHCP				
Model	**How Impacts Are Determined**	**Estimated Covered Take Over Life of RHCP**	**Participation Fee Structure**	**Mitigation or Conservation Measures**
BCCP	Karst Zones 1 & 2 1,320 feet or less from a 62 BCCP-listed karst feature	Loss of 38,349 acres of potential karst habitat (85%) and subsequent loss of currently undiscovered species and sites All caves other than the 62 BCCP-listed caves* are covered for take. *These features contain 2 endangered species and 25 species of concern	Karst Zones 1 & 2: **$1,000/acre** (until September 30, 2010) Near the 62 BCCP-listed karst features: **No permits** will be issued for development **within 1,320 feet** of any of the 62 BCCP-listed features without documentation of the surface and subsurface drainage basin.	Goal to protect 62 species-occupied cave features with no timeline to achieve goal To date, 35 of the BCCP-listed features contain endangered species and the remaining 27 contain species of concern
WILCO	• The Karst Zone: Karst Zones 1 and 2 Impacts to species-occupied caves based on effects to cave moisture regime (surface recharge area) and nutrient input (primarily cave cricket foraging area) measured in distance from cave.	210 species-occupied caves, including: Impact Zone A: 150 caves. Impact Zone B: 60 caves (including one previously undetected species-occupied void per year discovered and destroyed during construction).	Karst Zone (includes impacts to previously undetected species-occupied voids and other direct and indirect incidental take outside of Impact Zones A and B, below): **$100/acre** Species-occupied caves: • Disturbance in	By Year 10 acquire and manage 9 to 15, 40-acre to 90-acre KFAs totaling approximately 700 acres (a minimum of three KFAs in each of the three KFRs occupied by the covered karst species). To qualify as Service-approved, long-term, viable KFAs, the KFAs may be newly established or may be existing karst conservation areas enlarged and/or put under permanent

	Number of species-occupied caves in two zones: • Impact Zone A (50–345 ft from cave footprint). • Impact Zone B (within 50 ft of cave footprint).		Impact Zone A: **$10,000/acre** • Disturbance in Impact Zone B (does not include impacts to previously undetected species-occupied voids): **$400,000 flat fee.**	management. To enhance RHCP efforts towards recovery of listed invertebrates, preserve up to six additional KFAs acquired with Endangered Species Act section 6 funds or other sources. Assume management/monitoring of 10 of the 22 existing karst conservation areas.

Karst Impact Analysis
Zara Environmental 14-Sept-2010

Bexar County has not been thoroughly surveyed for karst features or potential karst invertebrate habitat. The only way to do those surveys is to perform transects with boots on the ground in order to identify small holes and other features that may indicate karst invertebrate habitat below. Those surveys have only been done in limited areas, the largest of which is Camp Bullis. For this reason we propose to use the Camp Bullis data as a "gold standard" of surveys, and extrapolate this data to the rest of the county with similar geologic characteristics.

A preliminary cave and karst feature density analysis for northern Bexar County was performed based on detailed karst information that exists for Camp Bullis. Numerous years of studies funded by the Department of Defense at Camp Bullis provides a unique opportunity to characterize the surface and subsurface related to caves and karst features, including the association of these features with occurrence of endangered karst invertebrate species. A preliminary extrapolation based on existing data from within the boundaries of Camp Bullis was performed to estimate the number of karst features, caves, and endangered species caves in applicable zones of northern Bexar County. This was completed by calculating the density of each of these categories (karst features, caves, and endangered species caves) relative to the number of each located in the Bexar County USFWS karst fauna zones (KFZs) within Camp Bullis. This value was then applied to the remainder of KFZ areas in northern Bexar County that fall within similar geologic settings (Edwards and Glen Rose, shown below in yellow), but not within younger rocks (Austin Chalk) that also contain caves with endangered species. These areas were excluded because stratigraphic and diagenetic equivalents are not present in the Camp Bullis area, thus an accurate extrapolation of karst feature density could not be applied. The following map shows the area of Bexar County included in the karst feature density extrapolation. Only KFZs 1,2,3, and 5 were calculated since no KFZ 4 exists within Camp Bullis.


0 3 6 12 Miles

The following table shows the results of the density extrapolation throughout the areas included.

Bullis Statistics								
Karst Zone	**Karst Features**	**Caves**	**EndSp Caves**	**Area sq_mi**	**KF_Density acres**	**KF_Density sq_mi**	**Cave_Density sq_mi**	**EndSp_Cave Density_sq_mi**
1	375	43	24	5.04	0.12	74.43	8.53	4.76
5	362	34	0	25.49	0.02	14.20	1.33	0.00
3	52	8	0	9.55	0.01	5.45	0.84	0.00
2	59	4	0	2.28	0.04	25.82	1.75	0.00

Northern Bexar Statistics				
Karst Zone	Area_sq_mi	Est Number of KF	Est Number of Caves	Est Number of EndSp Caves
1	61.52	4579.09	525.07	293.06
5	98.48	1398.50	131.35	0.00
3	55.06	299.93	46.14	0.00
2	89.39	2308.13	156.48	0.00
TOTALS:	**304.45**	**8585.66**	**859.05**	**293.06**

These data and related analysis are preliminary and should be reviewed and revised accordingly.

Suggested Approach for the Karst Impacts Analysis:

- Karst habitats may be impacted by new development and redevelopment activities. Not all land in a karst zone will be associated with occupied caves.
- Assess take by estimating the amount of karst habitat affected by development activities
    - We have estimates for new land development; need to establish appropriate estimates for redevelopment (W. Davis is currently working on these numbers)
- Using data from Camp Bullis and TSS, estimate the density of occupied caves for each karst zone. (Group Karst Zones 1+2 and 3+4; consider southern KFR's separately - see Zara Summary for more on estimating cave density). Calculate the estimated number of occupied caves in each land use sector.
    - We are currently working to refine cave density estimates to include some likelihood of encountering occupied caves in Zones 3+4 (expected to be very low – maybe no more than 5 occupied caves encountered over 30 years), and to estimate cave density for karst zones in the southern KFR's
- Assume that development will affect occupied caves in proportion to the amount of development activity in a land use sector.
- Acres of development activity (new development and redevelopment) *density of occupied caves = estimated number of occupied caves that my be affected by development

Literature cited

U.S. Fish and Wildlife Service (USFWS). 2008. Draft Bexar County Karst Invertebrate Recovery Plan. U. S. Fish and Wildlife Service, Albuquerque, New Mexico. 125 pp.

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