PROJECT FINAL REPORT

Range-wide Modeling of Golden-cheeked Warbler Habitat

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Several workers have provided estimates of Golden-cheeked Warbler (GCW; *Dendroica chrysoparia*) nesting habitat using remote sensing results (McKinney 1995, Diamond and True 1999, 2002). Workers have also suggested local and landscape scale variables that impact habitat quality (Pulich 1976, Ladd 1985, Wahl et al. 1990, Beardmore 1994, Engels 1995, Coldren 1998, Horne and Anders 2000, DeBoer and Diamond 2007, Peak 2007, Fuller et al., *in press*). Our objective was to model GCW habitat quality throughout the range by (1) identifying variables most important to GCW habitat quality, (2) identifying which of those important variables can be assessed using available GIS data, and (3) using GIS methods to model habitat quality.

Approach

We used an expert steering committee approach to facilitate habitat quality modeling. The Steering Committee was involved in the following:

(1) an initial email-screening of potential important habitat variables that influence GCW habitat quality,

(2) a meeting to discuss and select variables for modeling (February 8, 2006),

(3) interim email communications and a WebEx meeting (May 25, 2006),

(4) a second meeting at which important variables were again addressed and initial examples of habitat quality models were reviewed, but not in an interactive way (October 13, 2006),

(5) a final meeting at which draft models were presented and reviewed in an interactive way using GIS software and suggestions for improvement were made (June 26, 2007), and

(6) emails and communications after the June 26 meeting, during which time a new habitat modeling software was applied and a short manuscript comparing different modeling techniques was drafted (Fuller et al. *in press*).

Appendix A lists the initial invitees and contains agendas and notes from the meetings.

Variables Important to GCW Habitat Quality

Studies that link habitat variables to GCW demographic parameters are best for assessing habitat quality, but few of these have been conducted or are planned (van Horne 1983, Vickery et al. 1992, Peak 2007). Therefore, studies that link presence or absence of GCWs to habitat variables have been relied upon (e.g. Wahl et al 1990, Magness et al. 2006, DeBoer and Diamond 2007). The Steering Committee reviewed the literature and relied on their own expertise to develop a list of variables (Tables 1 and 2) likely to influence GCW habitat, and ranked these variables for importance at the initial Steering Committee meeting.

Table 1. Data form for local scale variables evaluated for their influence on GCW habitat quality. Numbers were assigned by each worker.

	Influence on
Stand Characteristic	**Habitat (1-5)[1]**
percent Ashe juniper canopy cover	
age of Ashe juniper	
percent deciduous canopy cover	
total canopy cover	
canopy height	
variance of canopy height in stand	
land cover diversity within patch	

species composition (specific)	
percent slope	
solar insolation	
slope aspect	
land position (high or low)	
soil depth and type	
ecological land type (range site)	
[1]1=highly positive; 2=positive; 3=neutral; 4=negative; 5=highly negative	

Table 2. Landscape scale variables evaluated for their influence on GCW habitat quality.

Landscape Variable	**Influence on Habitat (1-5)**[1]
patch size	
patch shape	
distance to edge	
distance to urban land cover	
distance to roads	
distance to water	
land cover context (100 m circle)	
land cover context (500 m circle)	
landform context (100 m circle)	

landform context (500 m circle)	
distance to "large" patch <100 m	
distance to "large" patch >500 m	
distance to protected land	
precipitation	
[1]1=highly positive; 2=positive; 3=neutral; 4=negative; 5=highly negative	

The Steering Committee selected a subset of these variables that were most important (see Appendix A). Local scale variables such as the species composition of stands and canopy height and density could not be addressed with available data.

Development of GCW Habitat Quality Models

The Steering Committee selected variables for possible incorporation into GCW habitat quality models (see Appendix A for notes on these variables derived from the committee meetings). Following is a discussion of each variable.

Suitable vegetation was identified as the most important factor that defines GCW habitat. Habitat has to have some threshold level of Ashe juniper mixed with deciduous trees. Available remotely sensed data only distinguishes evergreen, mixed, and deciduous forest/woodland, but few pixels are identified as 'mixed' within the breeding range of the warbler. GCWs do not occupy deciduous forest/woodland unless it is within a short distance of mixed or evergreen Ashe juniper forest/woodland, so remote sensing data was manipulated using GIS software to remove deciduous forest that is too far (more than 100 m) from evergreen forest. The USGS also used a new algorithm to estimate percent canopy cover for each pixel in their most recent National Land Cover Dataset (NLCD; see http://erg.usgs.gov/isb/pubs/factsheets/fs10800.html; Homer et al. 2004). Beyond that, no relevant, uniform data are available range-wide at the time this report is being written. However, the Texas Department of Transportation has commissioned a private consultant to develop a data layer on suitable vegetation from air photos. Those data should be evaluated as they become available.

Patch size was suggested as the second most important variable, although the Steering Committee did point out that the species is found in linear patches that are not large. Based on evaluation of the land cover dataset produced for this report, more than 70% of all GCW habitat is found in patches over 250 hectares.

Distance to a large patch was discussed as important, although the Steering Committee pointed out that dispersal distance is not known, so the importance of distance to large patch may be difficult to quantify. Patch shape index (e.g. larger patches with less edge) was an important variable in landscape scale models developed by DeBoer and Diamond (2007).

Solar insolation is a measure of how much sun strikes a spot, and thus integrates slope percent and slope exposure. The Steering Committee felt that wet slopes may support taller, denser forests and thus might represent better habitat for GCWs versus dry slopes, which may support less dense, shorter, more Ashe juniper-dominated woodlands. Most forested areas are so topographically complex that use of this variable appears unwarranted. Often, the distance across canyons in forested landscapes is less than 100 m, and solar insolation values vary from extremely low (wet) to extremely high (dry). Thus, an individual nesting pair of GCWs might easily range across wet slopes, dry slopes, bottoms, and ridges. A related variable, **ecological site type,** was also found to vary across short distances.

Precipitation and related variables such as **evapotranspiration** were suggested as factors that might be used to segment the range of the warbler at larger scale. In this regard, it was suggested that threshold values could be selected and rules written such that areas with lower precipitation and higher evapotransportation could be designated as lower quality, whereas wetter areas could be designated as higher quality. We gathered data from reporting weather stations and interpolated a precipitation surface, and also gathered data from PRISM, a digital compilation of environmental data. The wide spacing of reporting weather stations, and the scale of variation in the distribution of vegetation and site types versus precipitation patterns, makes the use of these data seem dubious. We elected not to include them in our models.

Likewise, we evaluated the use of **geology** data from the Geological Atlas of Texas to stratify GCW habitat and assign different quality to different types of surfaces. Based on an evaluation of known GCW locations and vegetation against the geology, we elected not to use this in our range-wide models, although it may prove useful in any given local area (see results of the WebEx meeting, Appendix A).

Landscape context, calculated as the amount of forest surrounding a given pixel, was suggested as a variable that integrates edge density, patch size, and distance among patches. The fact that >70% of all habitat occurs in patches larger than 250 ha, and that landscape context does integrate a number of important variables, made this variable most useful. Also, a study by Magness, et al. (2006) also used landscape context to define GCW habitat quality.

GCW Habitat Quality Models

We initially grouped forest into habitat patch size classes (not presented here) and this approach may prove useful for further analyses. We developed thirteen models and investigated their utility for defining GCW habitat quality. These models addressed landscape context, patch size, edge, urban edge, and solar insolation (slope and aspect) in different ways. We addressed the concept of 'appropriate vegetation' by ensuring that all areas identified as habitat were mainly evergreen forest/woodland (most mixed evergreen-deciduous vegetation falls within the evergreen class in remotely sensed classifications of this region), or mixed or deciduous forest/woodland within 100 m of evergreen. Also, all models masked out non-forest (except Model L, which was done by Loomis Austin, see below) as well as deciduous and mixed forest/woodland greater than 100 m from evergreen forest, as not habitat.

Results of the original nine models (Table 3) were presented to the Steering Committee on July 26, 2007. The group selected several areas that were well-known to participants and visually evaluated the models, including the known location of GCW presence/absence from DeBoer and Diamond (2007). Based on these evaluations, coupled with earlier analyses described above and in Appendix A, we made the following decisions:

1. Precipitation and geology are too coarse in resolution to prove useful for modeling GCW habitat quality at finer resolutions.

2. SSURGO soils (digital county soils surveys) are not uniformly delineated from county to county, and so cannot be used range-wide, but may be useful for a given smaller region (a county or two).

3. Data on solar insolation, which integrates slope percent and slope aspect, is not useful because much GCW habitat is in landscapes where nesting territories might easily circumscribe narrow canyons (wet and dry slopes), bottoms, and ridges.

4. Models that are based on landscape context, using a neighborhood analysis, were appealing because they integrate patch size, fragmentation, and edge density indirectly, and these variables were thought by the Committee to be important in defining GCW habitat quality.

5. The Steering Committee could not definitively describe the influence of urban edge versus other types of edge. That is, the extent to which urban edge may be more deleterious to habitat quality versus other types of edge could not be convincingly quantified with available data on reproductive success. At the GCW symposium on June 27, Jennifer Reidy's results seemed to show that urban land cover was not more deleterious than other edges, whereas a study by Cindy Sperry suggested the opposite.

6. We initially used a 1 square km neighborhood (a circle with radius 564 m) to define forested landscapes, but also had test results using other neighborhood sizes. The Steering Committee felt that a smaller neighborhood size was more appropriate.

7. Loomis Austin had completed a Golden-cheeked Warbler habitat quality model using a neighborhood analysis of canopy density from the most recent NLCD (contact Loomis Austin for details). This analysis was appealing in that it used a 7-pixel square

Table 3. Golden-cheeked Warbler Habitat Quality Model Definitions

Model	Model Definition	Ranking Rules	Primary Factors Addressed
1	% forest within a 1 sq km neighborhood	rank 0 (worst, 0 to 20% forest), 1 (20% to 40% forest), 2 (40% – 60%%), 3 (60% to 80%), 4 (best, 80% to 100% forest)	landscape context (indirectly addresses patch size and edge density)
2	model 1 and distance from edge	similar to model 1 but distance to edge added to rank (plus 1 - less than 50m from an edge, plus 2 - 50 to 100m, plus 3 - 100 to 200 m, plus 4 - >200m)	landscape context, edge addressed explicitly in several categories
3	model 2 and distance from urban	similar to model 2 but % urban in a 1 sq km neighborhood added to the final rank ranked plus 0 (worst, 80% - 100% urban), plus 1 (60% to 80%), plus 2 (40% - 60%), plus 3 (20% - 40%), plus 4 (best, 0 to 20% urban)	landscape context, edge density, and urban all addressed
4	model 3 and solar insolation	similar to model 3 but solar insolation added to the rank, plus 1 (worst, driest 10% of slopes), plus 2 (10 - 50% solar insolation values), plus 3 (50 - 90%), plus 4 (best, wettest 10% of slopes)	landscape context, edge density, urban, and slope exposure and percent all addressed
5	forest within 1 km of a forest patch >=5 ha	no ranking of quality	landscape context and patch size
6	forest within 1 km of a forest patch >=250 ha	no ranking of quality	landscape context and patch size
7	% forest within a 1 sq km neighborhood, adjusted for edge, weighted by % forest	model 1 times 2, minus 1 if <50 m from an edge	landscape context weighted and adjusted for edge

8	% forest in a 1 sq km neighborhood, edge, urban, and solar insolation	model 1 minus 1 if <50m from an edge, minus 1 if >25%urban in the neighborhood, plus 1 if on one of the 10% of the wettest slopes, minus 1 if on one of the 10% if the driest slopes	landscape context, urban, edge, and slope percent and exposure all addressed
9	% forest in circle with 1 sq km neighborhood, adjusted for edge (not weighted)	model 1 minus 1 if <50 m from an edge	landscape context and edge addressed directly
A	model 1 re-done using a smaller neighborhood (circle of radius 200 m)	rank 0 (worst, 0 to 20% forest) to 4 (best, 80% to 100% forest)	landscape context (indirectly addresses patch size and edge density)
B	evergreen forest within 200 m of >=250 ha patches of landscapes >20% forested (from Model A)	no ranking of quality	landscape context and patch size
C	model 9 re-done using a smaller neighborhood (circle of radius 200 m)	model A minus 1 if <50 m from an edge	landscape context and edge
D	model C with percent canopy cover considered	model C minus 1 if canopy cover from NLCD was < 30% and plus 1 if canopy cover was >80%	landscape context, edge, and canopy cover
L	average percent canopy cover in a neighborhood of 7, 30 m square pixel, with rank reduced for areas of low canopy that are not near areas of at least 50% canopy	1 (low - average neighborhood canopy cover 30 - 50% and within 90m of high or medium quality habitat), 2 (medium - average neighborhood canopy cover 50 - 70%), 3 (high - average neighborhood canopy cover 70 - 100%)	landscape context and average canopy cover

neighborhood (about 10.9 acres, roughly equivalent to the size of a larger GCW territory) and was based primarily on the average canopy closure within the neighborhood.

Hence, we decided based on the meeting to do four new models (Figures 1-4, Appendix B), and examine the model provided by Loomis Austin (Figure 5), for final presentation. The four completed models were as follows: (1) Model A, a landscape context model using a smaller neighborhood, (2) Model B, a patch size-based model using the results from Model A (using >=20% forest in the neighborhood as the basis for identification of patches), (3) Model C, a landscape context model using the smaller neighborhood adjusted for edge, and (4) Model D, which used results from Model C modified considering canopy closure directly. Again, we also decided to evaluate the model provided by Loomis Austin (Model L) alongside other models (Table 4).

Table 4. Comparison of model results (Model L was completed by Loomis Austin)

Mod	Model Concept	Total Area	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5
A	percent forest/woodland within a circle of radius 200 m	1,999,534	224,236	374,178	529,080	872,040	N/A
B	evergreen forest within 200 m of >=250 ha patches of landscapes with >20% forest from Model A	1,580,393	N/A	N/A	N/A	N/A	N/A
C	percent forest/woodland within a circle of radius 200 m adjusted for edge	1,771,883	305,044	340,750	370,921	755,168	N/A
D	model C with reduction for low canopy cover and addition for high canopy cover	1,721,949	286,059	301,477	326,176	522,530	285,707
L	average canopy cover in a 7, 30 m pixel neighborhood with adjustments for proximity to heavy canopy	1,679,513	645,961	651,285	382,268	N/A	N/A

Figure 1. GCW Model A

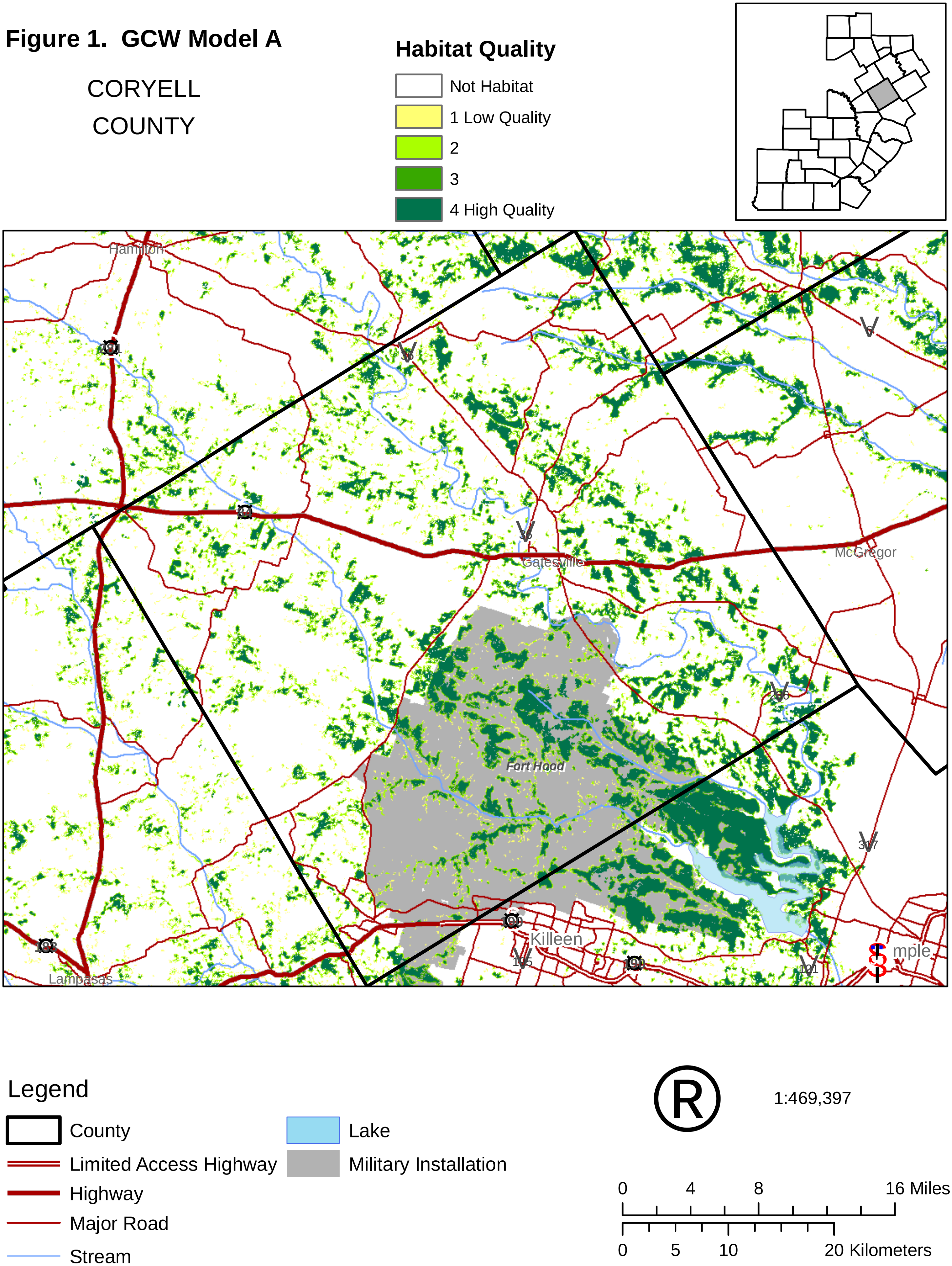
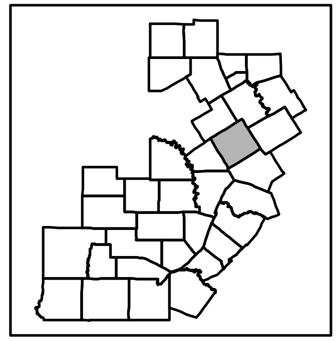


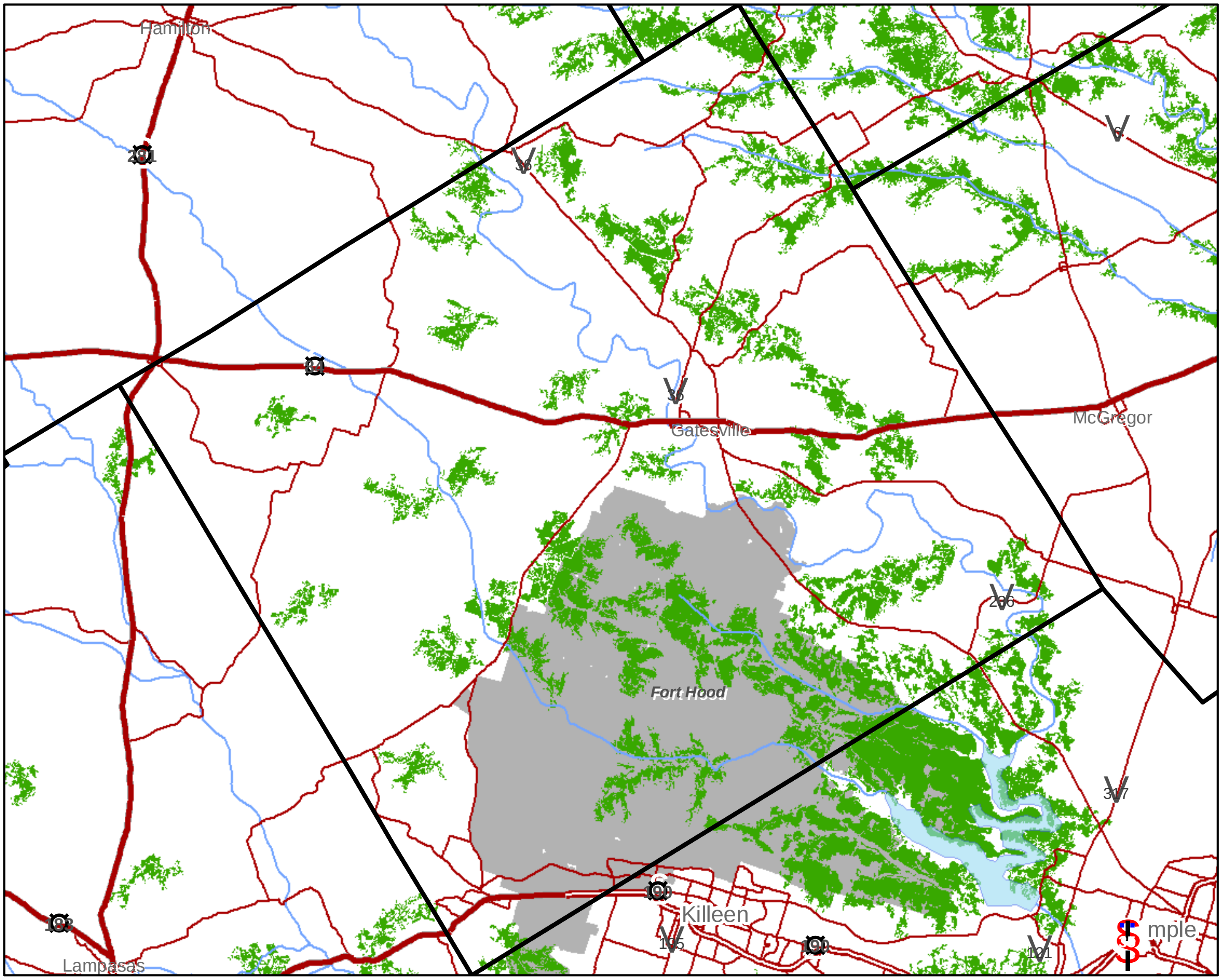
Figure 2. GCW Model B

CORYELL

COUNTY

Habitat





Legend

County

Limited Access Highway

Highway

Major Road

Stream

Lake

Military Installation

1:469,397

0 4 8 16 Miles

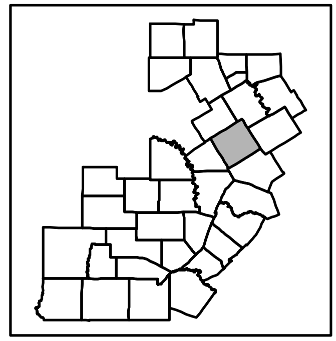
0 5 10 20 Kilometers

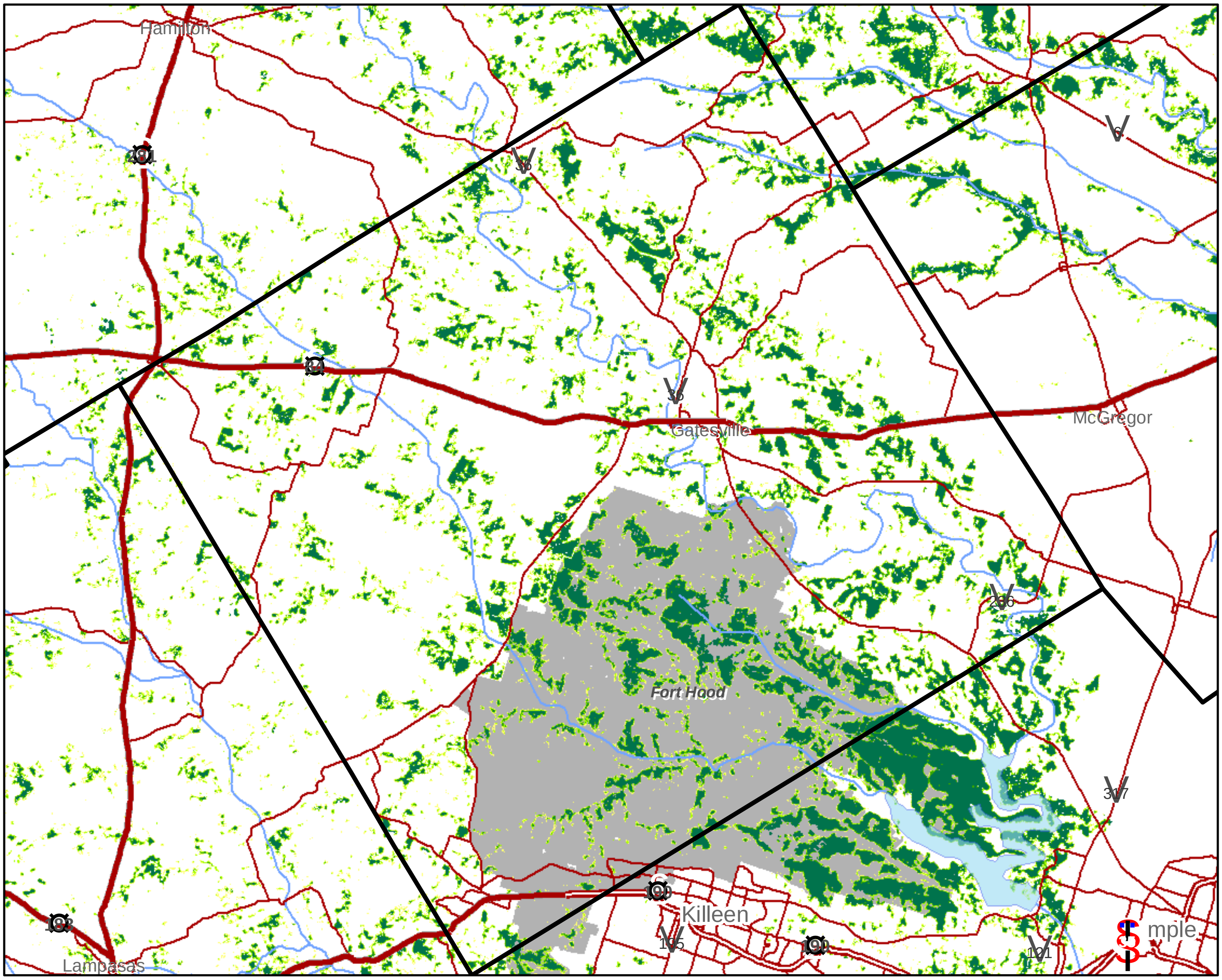
Figure 3. GCW Model C

CORYELL COUNTY

Habitat Quality

- Not Habitat
- 1 Low Quality
- 2
- 3
- 4 High Quality





Legend

- County
- Limited Access Highway
- Highway
- Major Road
- Stream
- Lake
- Military Installation

1:469,397

0 4 8 16 Miles

0 5 10 20 Kilometers

Figure 4. GCW Model D

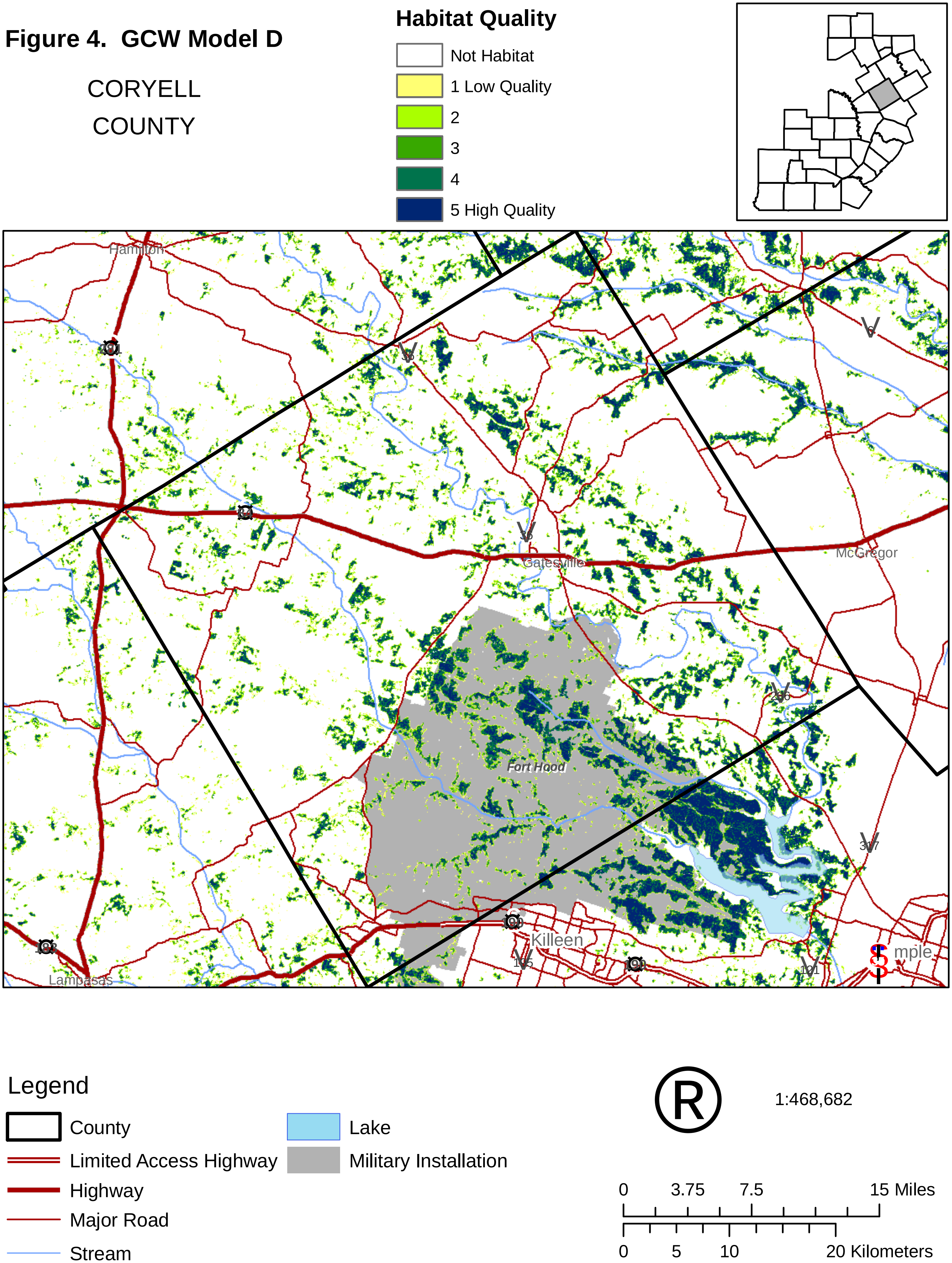
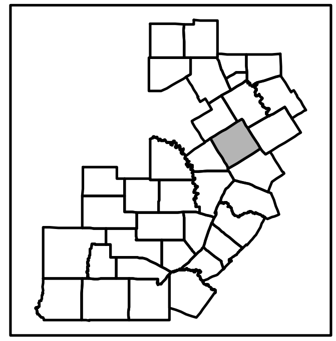


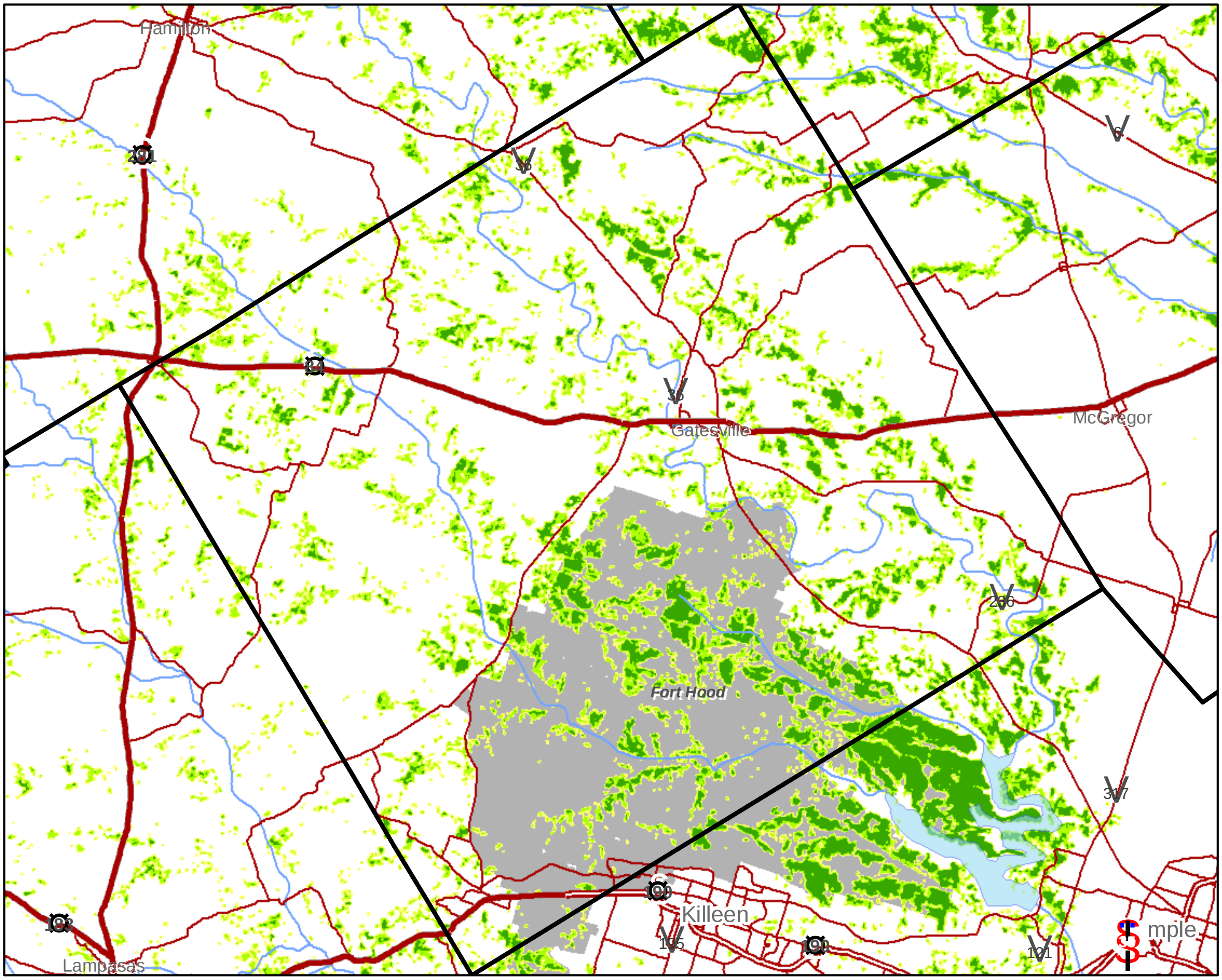
Figure 5. GCW Model L

CORYELL
COUNTY

Habitat Quality

- Not Habitat
- 1 Low Quality
- 2
- 3 High Quality





Legend

- County
- Limited Access Highway
- Highway
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- Lake
- Military Installation

1:469,397

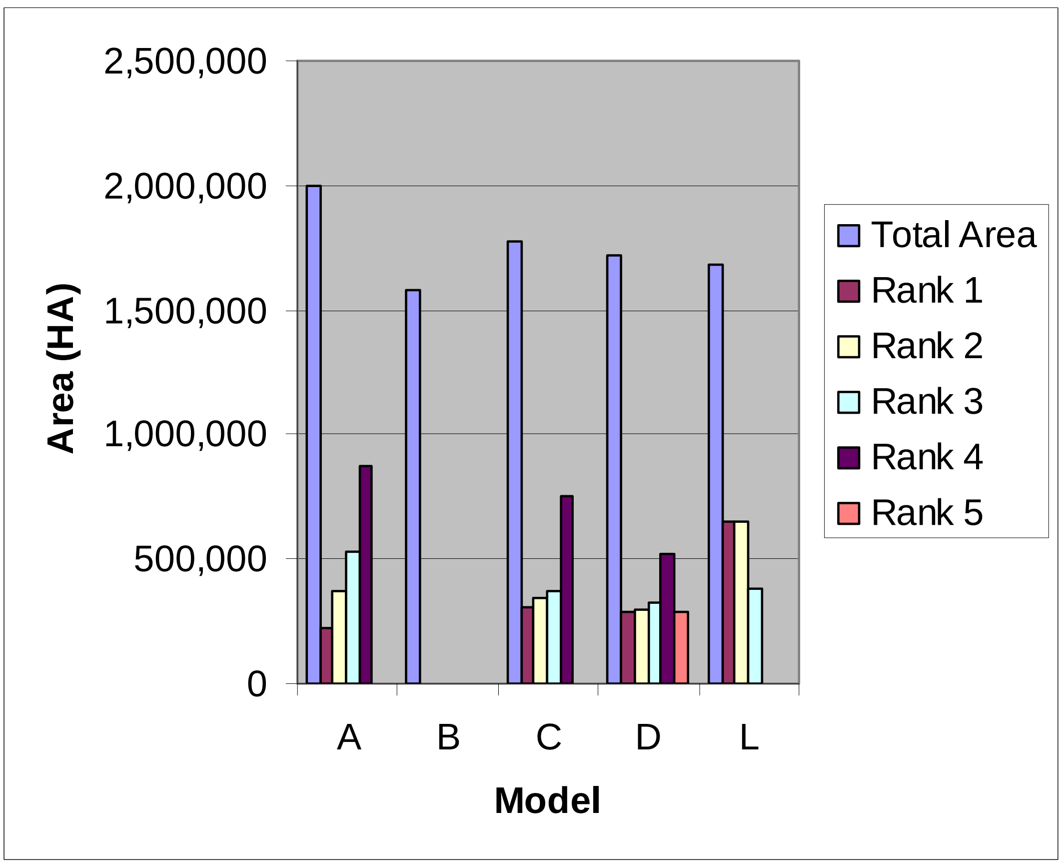
0 4 8 16 Miles

0 5 10 20 Kilometers

Distinguishing Among Models

The difference between Model B, which was the most conservative approach (e.g. only forest within 250 hectare patches of 'partially forested landscapes' or within 200 m of a 250 hectare patch), and Model A, the most liberal 'landscape context' approach, was 419,141 hectares, or 20.9% (Figure 6). Model A only considers landscape context, and even though this integrates patch size and edge density to some extent, it does not consider edge directly. Careful studies have shown that edge does influence reproductive success (hence habitat quality) for GCWs (see Peak 2007, Reidy 2007). Model B does not provide habitat quality rankings at all, and is quite conservative in that only large patches and forest near large patches are considered GCW habitat. We believe that the former is too liberal and the latter is too conservative.

Figure 6. Differences of Total Area among Models



The difference between the most conservative and the most liberal of the three remaining models (C, D, and L) was 92,370 hectares, or 5.2%. Model C considers landscape context and thus patch size and edge density indirectly and also considers edge directly, whereas Model D considers those variables and adjusts quality for canopy density. Model L considers landscape context and canopy density, and reduces quality rank for areas with low cover that are not close to areas of higher cover, but it does not consider edge directly (contact Loomis Austin for detailed methodology).

We believe that these three models all provide a reasonable representation of the total amount of breeding habitat for GCWs. However, important spatial variation in the distribution of habitat exists between Models A – D versus Model L, partly because different base input data and different versions of the range of GCWs were used. The input for Model L came from canopy closure data provided by the USGS, whereas Models A – D used data on forest land cover we developed ourselves. Model L tends to identify less area on the west, northwest, and far northern part of the range as habitat, and the eastern and northeastern boundary of the range of the GCW were different versus the ones we used. Therefore, the FWS should consult Loomis Austin for questions regarding details of Model L. Model C places more habitat within the highest quality rank, whereas Model D places the most habitat within the second highest rank, and Model L places about equal amounts in the first and second rank, and less within the highest rank. Model L identifies only three levels of habitat quality whereas Model C identified four, and Model D, five.

Habitat quality ranks can be interpreted as follows.

Model C

-1 to 0 – not habitat

1 – potential low quality habitat when bordering higher ranked habitat; not habitat when not bordering higher ranked habitat

2 – potential low quality habitat when bordering higher ranked habitat; probably not habitat when not bordering higher ranked habitat

3 – potential moderate quality habitat when bordering habitat ranked 4; potential low quality habitat when not bordering habitat ranked 4

4 – potential moderate to high quality habitat

Model D
Ranks range from -2 to 5. Same interpretation as Model C, except habitat ranked as 5 is dense forest and may have a higher likelihood of being high quality habitat, although not for certain (see discussion below).

Model L (contact Loomis Austin for details)

1 - potential low quality habitat
2 – potential medium quality habitat
3 – potential high quality habitat

Note that average canopy cover within a neighborhood is used to score habitat quality for Model L, whereas canopy cover is overlain directly with neighborhood analyses for

Model D. Since Model L is a 'spatial average,' it accounts for variation in canopy cover within the neighborhood, whereas Model D does not. In other words, the highest scoring areas for Model D have the highest canopy cover, whereas the highest scoring areas for Model L have the highest **average** canopy cover within the neighborhood. Since GCWs have nesting territories that spread across a given area that may include both higher and lower percent canopy cover, Model L has some appeal. Basically, Model L attempts to account for both landscape context and canopy cover at the same time, whereas Model D (and C) account for landscape context first, then edge, then (for Model D) canopy cover.

Defining Habitat Quality - Habitat quality can only be defined based on differences in nest productivity or reproductive success. However, no range-wide studies of reproductive success exist, and indeed local studies are spotty (Keddy-Hector 1993, 1995, Fink 1996, Coldren 1998, Maas-Burleigh 1998, Peak 2007, Reidy 2007). In our view, the most convincing, quantitative evidence from these studies link measures of edge to reproductive success (e.g. nests close to habitat edges experience reduced reproductive success). Other emergent variables such as fragmentation (less is better) and patch size (larger is better) have been suggested as important. Local stand variables such as canopy cover, species-specific canopy cover, canopy height, the variance of canopy height, species composition, slope aspect and percent, stand age, and the overall variability within a breeding territory have also all been suggested as important factors in defining habitat quality.

Evaluation of Models - Lacking data on reproductive success, we evaluated presence/absence data from DeBoer and Diamond (2007) in an attempt to select the best habitat quality model (Table 5). We overlaid the location of GCW sampling points with model results. The percent of GCWs present in Model L's highest class rose to 48%, the highest for any model, whereas the percent absent in the middle class rose to 86%, about the same as for the second highest ranked class for other models. Likewise, no GCWs were found outside of what was considered habitat by Model L, whereas GCWs were found outside of what was considered habitat (1 to 3 samples) for all other models. These samples were not forested but were very near forest (<30 m). Because the presence/absence data involved listening from a point location, the GCWs detected at these spots might well have been within nearby forest. This demonstrates a problem with the presence/absence data gathering as much as a problem with any of the models. Model L did not 'miss' these sample points because the average canopy within the neighborhood was at least 30%, even though the actual spot might not have been forested. This may or may not be good in terms of the model's overall accuracy. Unfortunately, very few samples (6 for the bottom two classes in Models C and D, 6 in the bottom class for Model L, and 0 from the bottom two classes of Model A) from DeBoer and Diamond (2007) actually fall within the lower ranked habitat classes for any of the models.

Table 5. Presence/Absence Data for 5 Models

Model A

Rank	Presence	% Presence	Absence	% Absence	Total
0	2	33.33%	4	66.67%	6
1	0		0		0
2	0		0		0
3	3	15.00%	17	85.00%	20
4	60	40.82%	87	59.18%	147
Total	65		108		173

Model B

Rank	Presence	% Presence	Absence	% Absence	Total
0	3	17.65%	14	82.35%	17
1	62	39.74%	94	60.26%	156
Total	65		108		173

Model C

Rank	Presence	% Presence	Absence	% Absence	Total
< 1	2	33.33%	4	66.67%	6
1	0		0		0
2	1	14.29%	6	85.71%	7
3	2	13.33%	13	86.67%	15
4	60	41.38%	85	58.62%	145
Total	65		108		173

Model D

Rank	Presence	% Presence	Absence	% Absence	Total
<1	1	16.67%	5	83.33%	6
1	0		2	100.00%	2
2	2	33.33%	4	66.67%	6
3	1	12.50%	7	87.50%	8
4	22	34.38%	42	65.63%	64
5	39	44.83%	48	55.17%	87
Total	65		108		173

Loomis

Rank	Presence	% Presence	Absence	% Absence	Total
0	0	0.00%	8	100.00%	8
1	2	25.00%	6	75.00%	8
2	5	13.89%	31	86.11%	36
3	58	47.93%	63	52.07%	121
Total	65		108		173

The data summarized above are too few to allow definitive conclusions even in terms of presence/absence, even though the study used a spatially stratified random design to the extent practical (the only known range wide study to do so, which is why it was used here). The apparent differences among models might not be real, and again, at any rate, presence/absence data are not sufficient to define habitat quality in terms of differences in reproductive success.

Lacking sufficient data, the selection of a preferred model from among Models C, D, and L must be left to best professional judgment. We feel that Model C should be selected if the desire is to (1) identify slightly more habitat area, and therefore miss less actual GCW habitat, and (2) identify more habitat as top quality and relatively less as low quality. Model L should be selected if the desire is to (1) be more conservative in terms of defining habitat (e.g. fewer hectares) and (2) be more conservative in defining top quality habitat (fewer of the hectares of habitat are identified as top quality). Model D is intermediate between Models C and L in terms of total habitat area identified, but identifies the least amount of habitat as top quality.

Habitat quality in terms of nest success is influenced by proximity to edge, at least at Ft. Hood and near Austin (Peak 2007, Reidy 2007). Model L and Model D indirectly assume that the variables evaluated and methods employed effectively integrate factors that influence habitat quality well enough that a relatively small area can be identified as top quality (382,268 hectares and 285,707 hectares, respectively). Model C indirectly assumes that not enough is known to effectively discern habitat quality beyond what can be modeled using landscape context and edge directly, so much of the habitat (755,168 hectares, or almost twice as much versus Model L and more than twice as much as Model D) is ranked at highest quality.

Selection of a Preferred Model - We prefer Model C. First, the basic land cover input data on which the analyses for Models A – D were based used tried and true remote sensing image classification techniques. The input data for Model L used a sub-pixel percent canopy algorithm that has yet to be widely vetted.

Model C also identifies more total area and might therefore be less likely to exclude GCW habitat, incorporates edge directly as a factor in habitat quality, and assumes that the largest faction of habitat is within the highest ranked quality class. This tends to recognize that most of the habitat is indeed in large patches away from patch edges, and that habitat quality may vary within the forest interior for reasons (e.g stand canopy closure, stand height, stand age, stand species composition, slope percent, slope exposure, variability within the stand, interactions among these variables) and in ways we do not understand. The primary argument in favor of Model L and Model D is that they do indeed incorporate canopy closure directly in the model, and habitat quality is thought to influence reproductive success, although we do not feel that the influence of canopy closure, independent of other variables, has been shown as convincingly as the influence of edge. FWS staff must make the final judgment in terms of which model to use, possibly via re-constitution of the original project Steering Committee (see Appendix A) or the GCW Recovery Team. All models are close in terms of the overall result. Additional spatially explicit presence/absence data may exist, and if so these data could be plotted against model results to provide additional information to distinguish among the habitat quality models. One caution, though: presence/absence data, regardless of the quantity, can never substitute for data on reproductive success in terms of defining habitat quality.

Delivery products

1. This report in hard copy and electronic copy
2. GIS files of model results for Models A, B, C, D, and L

We will also be available for further consultation, clarification, and limited analyses as needed for a minimum of 12 months.

Selected Relevant Literature

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Appendix A – Steering Committee Meeting Notes

Initial GCW Steering Committee Invitees:

Clay Bales, Texas Forest Service
Clayton Blodgett, MoRAP, University of Missouri
John Cornelius, Ft. Hood
Timery DeBoer, Graduate Student
Lee Elliott, TNC
Craig Farquhar, TPWD
Jeff Hatfield, UGSS
Clif Ladd, Loomis Austin
Charlotte Reemts, TNC, Ft. Hood
Chuck Sexton, USFWS
Rebecca Peak, TNC
Paul Sunby, SWCA
Diane True, MoRAP, University of Missouri
Matt Wagner, TPWD
Butch Weckerly, Texas State University
Christina Williams, USFWS
David Wolfe, Environmental Defense

Added for the second meeting (October 13, 2006):

Amanda Aurora, Loomis Austin
Paul Sunby, SWCA

Added for the third meeting (July 26, 2007):

Tevon Fuller, University of Texas
Sahotra Sarkar, University of Texas

Feb 8, 2006 Meeting Attendees (Becky Peak also provided significant input for this meeting, and Timery DeBoer and Jeff Hatfield attended via phone)

Name	**Affiliation**
Butch Weckey	Texas State University
Charlotte Reemts	TNC, Ft. Hood
Christina Williams	USFWS
Chuck Sexton	USFWS
Clay Bales	Texas Forest Service
Clif Ladd	Loomis Austin
Craig Farquhar	TPWD
David Diamond	MoRAP, Univ. Missouri
David Wolfe	Environment Defense
Lee Elliott	The Nature Conservancy
Matt Wagner	TPWD

October 13, 2006 Meeting Attendees

Name	**Affiliation**
Becky Peak	TNC, Ft. Hood
Butch Weckey	Texas State University
Charlotte Reemts	TNC, Ft. Hood
Christina Williams	FWS
Chuck Sexton	Balcones Canyonlands NWR
Clay Bales	Texas Forest Service
Clayton Blodgett	MoRAP, Univ of Missouri
Clif Ladd	Loomis Austin
Craig Farquhar	TX Parks and Wildlife Dept
David Diamond	MoRAP, Univ of Missouri
David Wolfe	Environmental Defense
Diane True	MoRAP, Univ of Missouri
Jeff Hatfield	USGS
John Cornelius	Ft. Hood
Lee Elliott	TNC, San Antonio
Paul Sunby	SWCA, Inc.
Timery DeBoer	Currently Ph.D. Student

June 26, 2007 Meeting Attendees: list not available

February 8, 2006 meeting at TPWD and June 26, 2007 meeting at USFWS: Agendas Presented via PowerPoint

Golden-cheeked Warbler Habitat Modeling Meeting

GOAL:	Review Draft Habitat Quality Model(s) and Define Future Directions
DATE:	**October 13, 2006**
TIME:	9:00 A.M. – 1:00 P.M.
PLACE:	Texas Parks & Wildlife Dept, Fountain Park Plaza, 3000 IH-35 S, Suite 100, Austin – we will meet in the building across the parking lot, as we did before

9:00 Introductions (Diamond)

9:15 Progress to date: summary of last meeting, land cover mapping, development of habitat quality model, recent ground verification - PowerPoint (Diamond and Blodgett)

10:00 Discussion: How adequate is the approach? The draft model(s)? How can the models be improved? Be verified? (Group)

10:30 Break

11:00 Continue discussion

11:30 Summarize: What needs to be done, what can be done, and by whom? Utility of the model: What are the caveats? What are the appropriate uses the group would recommend for this habitat quality model? Plans for future input from the group (WebEx meetings? Further review?).

12:00 Group lunch – location to be decided at the meeting; we may order in or eat out

GCW WebEx meeting
May 25

Diane and I met with Lee Elliott and Bill Carr for about 1.5 hours today via WebEx. The goals were:

1. Test the effectiveness of WebEx as a way to show data and gain input
2. Show the landform models and see if those look reasonable
3. View some GCW locations against the landcover, landforms, and geology
4. Look at geology as an influence in terms of GCW habitat quality – specifically, look at the Glen Rose as possibly being lower quality GCW habitat in general

Results

1. We had initial trouble with WebEx but fixed it in about 20 minutes
2. Landform models look good, except we cannot separate low flats from higher flats. We talked about soil depth, parent material, or elevation differences (e.g. just setting a cut-off elevation for low versus high flats). The latter isn't going to work for many landscapes, because we have tried it. The former might work if the SSURGO soils data contain the right information. In this regard, we decided that it really doesn't matter that much for GCW habitat quality mapping anyway. I am thinking that it is not worth the time to try to correct this problem, because there is no reasonably easy way to do it … all are time-consuming.
3. Landform appears to be the main factor in terms of the location of habitat and habitat quality. We cannot use the geology layer for modeling GCW habitat.

Other Notes and Action Items:

1. Precipitation might be important but we don't see how it can be used in any reasonable way given the data available.
2. We need to identify the patches where Timery did NOT find GCWs and try to determine why they were not found in those patches – this will provide clues to habitat quality mapping.
3. We still need to determine how we will treat slope and distance to urban, etc. in terms of habitat quality. It appears that in the landscapes we viewed the slope exposure will not be a factor that can be used. The percent slope might be important but that is highly questionable.
4. The distance to edge was also discussed – we were not sure if that is really a factor in determining habitat quality after viewing the data. Patch size seems an overwhelmingly important and integrating variable.
5. We did not look at the SSURGO soils – specifically, we should look at the utility of using the Redlands type soils as a modifier of habitat quality.

The next task is to complete 2-3 habitat quality models for viewing by a larger group via a WebEx meeting. To do this, we would like to complete our new landcover data layer – that is critically important – that is a minimum of two weeks and possibly as much as two months away.

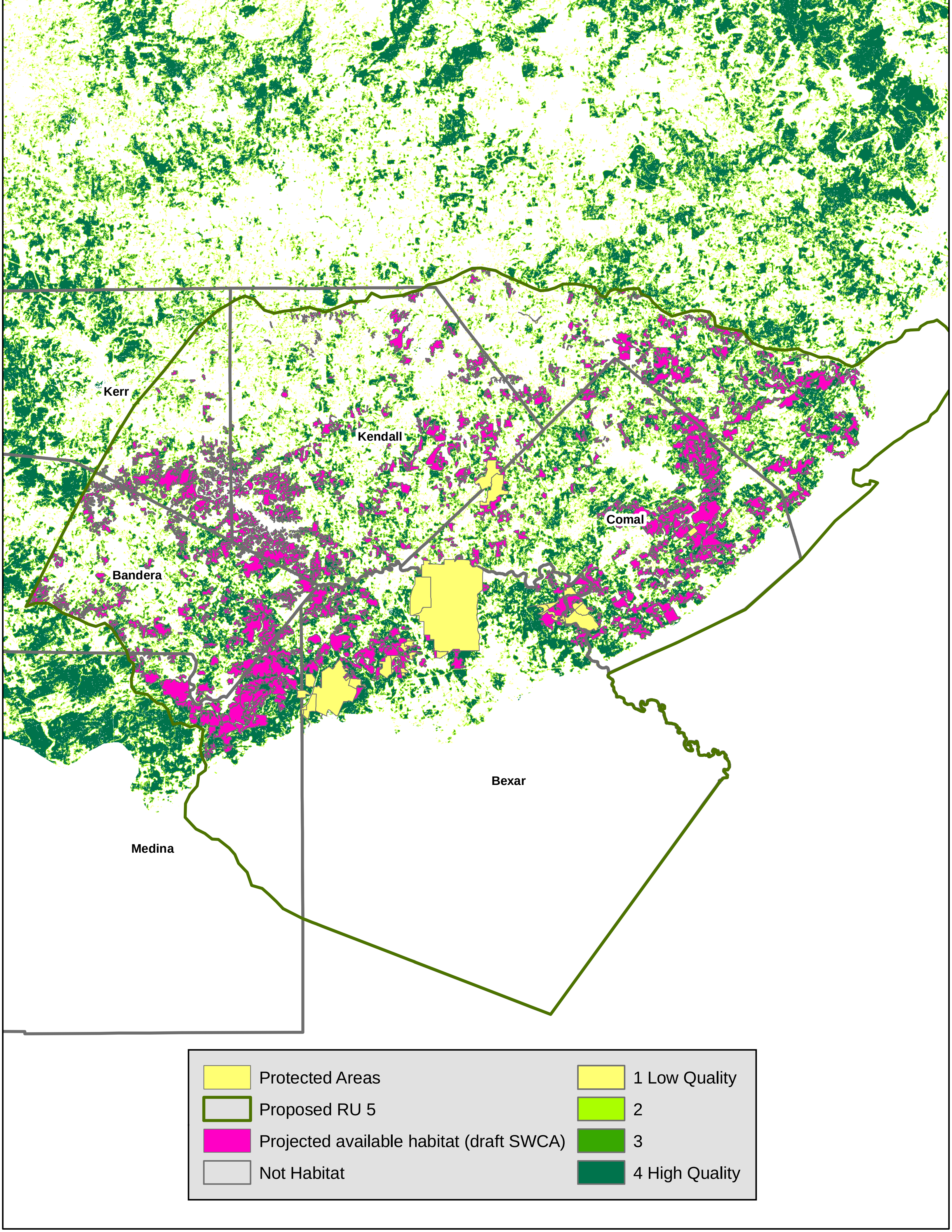
Most Important Variables Selected during the Feb. 8 Meeting, with notes from subsequent meetings

Variable	Comment
suitable vegetation	must have certain canopy cover, height, and percent juniper/deciduous; we need to get better vegetation data as a priority; Lee suggests to identify suitable habitat by modeling (forest and solar insolation, precipitation, and ecological site type) forest first, then overlaying other variables related to patch size and context .... Craig suggests that we look at Timery's data in the NW (the patches that were not occupied) and see if the composition or other variables were different in that region
patch size	this was considered most important earlier; shape might also be important but Chuck suggested that linear was not bad sometimes; MARCH 8 Up-date - Becky suggests that distance from edge is more important that other factors in determining nest success; she does not hazard a guess on thresholds regarding patch size
distance to large patch	Becky makes point that we don't know dispersal distance so hard to determine from metapopulation standpoint
solar insolation	slope and aspect are important according to some but need to check with Becky who did not find this important on Ft. Hood; further input from Becky notes she found no differences in nest success based on slope and thinks the "slopes are better" idea appears to be an unfounded myth, related possibly to the fact that flats are mainly cleared and slopes are mainly forested on private lands; MARCH 8 NOTE FROM DIAMOND: Ft Hood has a lot of the 'wetter' massive, cracking limestone habitat on uplands, so the idea that slope is important could be a false impression based on a limited sample; Dean Keddy-Hector felt the same way as Becky, and he did also band and closely observe birds in a population farther to the South; this is an issue we need to deal with ... Should we include slope as a factor in habitat quality at all? Timery also noted later that she agrees with Chuck ... the idea that slope is not important at Ft. Hood does not mean that it is not important at all, and in fact I get the feeling that most people think it is important insofar as it influences forest type
landscape context	especially regarding urban land cover; may not be needed if we consider distance to urban; might substitute land cover context for all the distance to the edge values; 100m too small or a neighborhood…maybe 250m … Chuck is looking at Tom's dissertation; Charlotte and Lee made a point here and need to please elaborate ... I believe that they were saying that land cover context may serve as a surrogate for patch size, distance to a large patch, edge, urban, and many other variables

distance to edge	need more input from Becky here - type of edge may be important as well (e.g. urban, crop, grassland); Becky has just now (March 8) been looking at hard data on nest success related to distance form edge, and indicated that distance from edge seems to be a good predictor of nest success - probably the best she has measured
Precipitation	if evapotranspiration is available digitally then that would be a much better variable; Lee might have these data…temperature might also help modify this; MARCH 8 update: Diamond has found that there are no easily accessible data on evapotranspiration; he is looking at the original weather station data to see what can be gleaned ... probably the best that can be done is to look at creating a new interpolated precipitation data layer from the original data
ecological site type	especially when modeling vegetation for new classification and currently for modeling differences on flats; Clay will help with the soils here; March 8 up-date - Diamond now has all of the SSURGO soils data and there seems to be some promise in using these to help identify 'appropriate' vegetation
ADDITIONAL MARCH 8 UP-DATES	we have not been able to get the new, 10m DEMs for the study are yet, but are told that they are 'on the way' .. The soils are in-house and do look promising; we have extracted floodplains using the soils and will work on the 'redlands' … I might call Clay soon to talk about other EcoClass Types we can pull out as supporting different vegetation; we do also have all of the weather data that are available and we are going to try to interpolate a precipitation surface that is better that the one available from PRISM; algorithms are available for calculation of evapotranspiration, but we do not have enough data to support those algorithms from enough reporting weather stations to be able to create a surface across the study area; the new National Land Cover Dataset is not yet out ... our current plan from here now is to await DEMs and NLCD, and work on the weather data and the soils data ... we also need to draft a habitat quality algorithm
ADDITIONAL SEPTEMBER 12 UP-DATES	we had to draft new land cover for the range of the GCW - the circa 1992 coverage from NLCD was too old to live with; this 'coarse and quick' version for the 36 counties will work, and is better than what we had; we used the DEMs to calculate solar insolation and land position; we used SSURGO soils to identify floodplains; we developed a new precipitation model but it was not useful - not enough data points; the geology data proved not useful; we have not gotten with Clay on the use of the soils yet; we are just now ready to develop the habitat quality model and hope to have those done within 3 weeks; we have a field trip to do some ground verification planned for Oct 8 - 12 and will meet with the committee on Oct 13; we had a WebEx meeting with Bill Carr and Lee Elliott to check methods and look at some things we have done

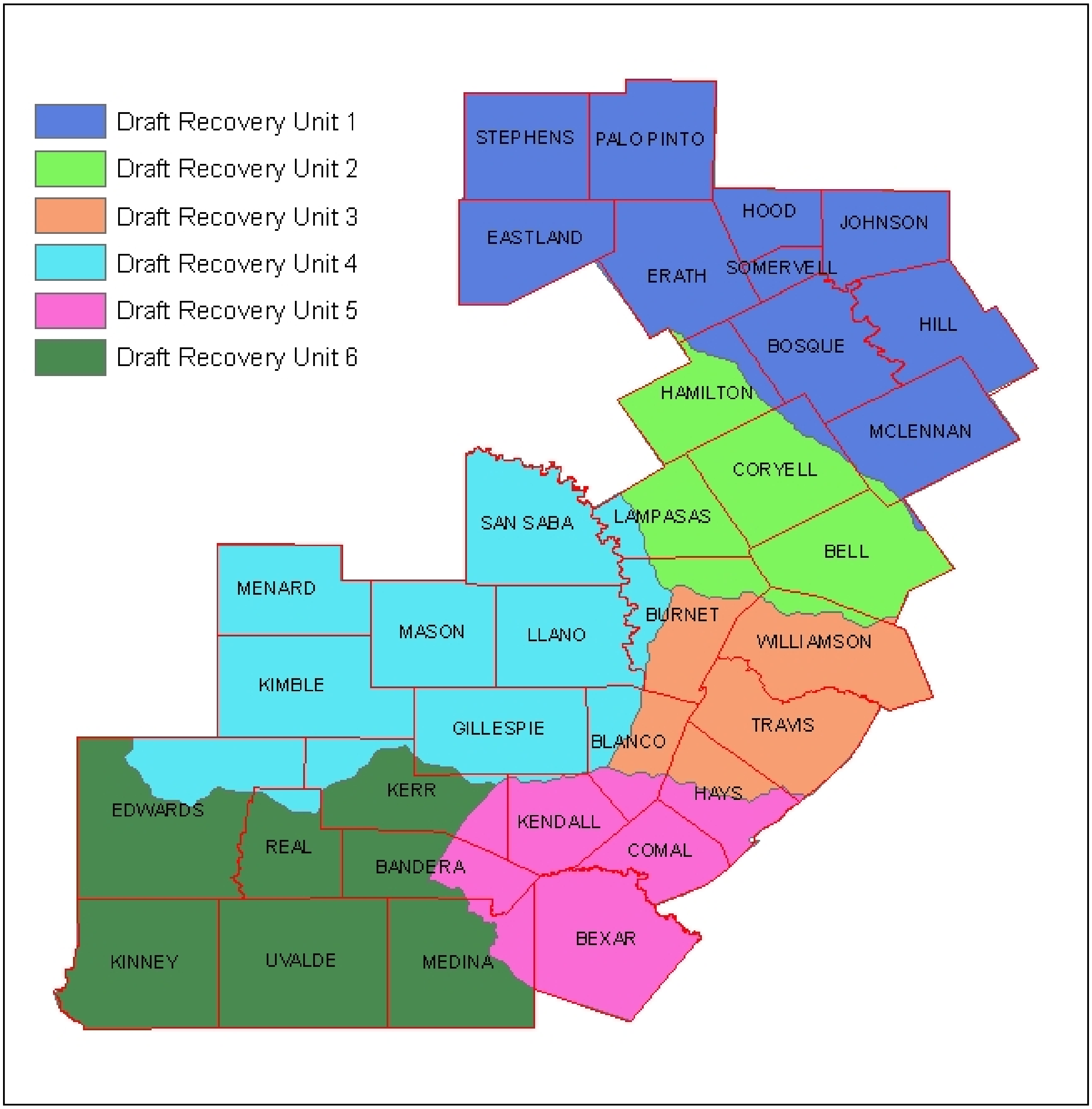
Appendix B

Maps of Models A, B, C, D, and L

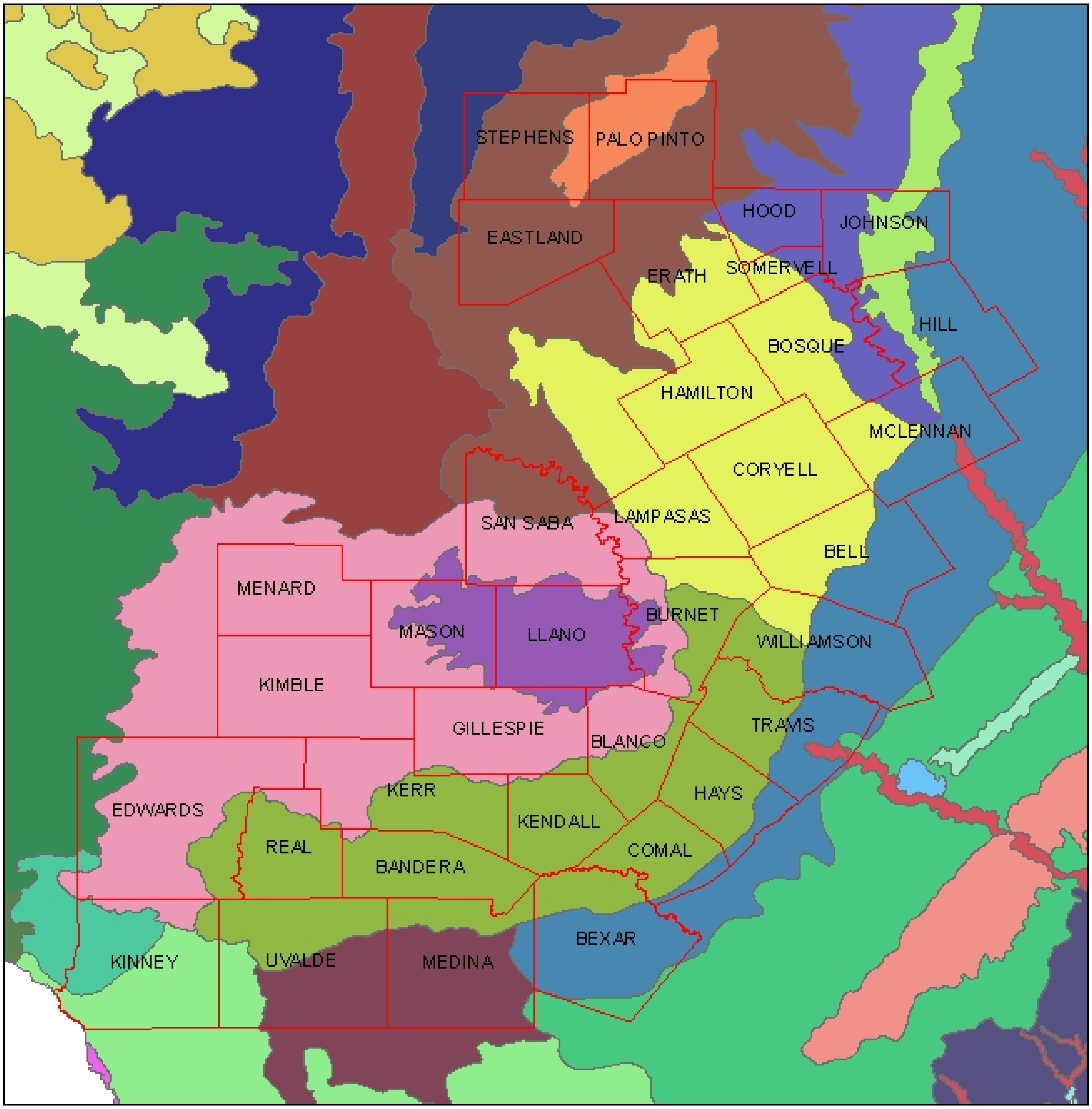


Kerr
Kendall
Comal
Bandera
Bexar
Medina
Protected Areas
Proposed RU 5
Projected available habitat (draft SWCA)
Not Habitat
1 Low Quality
2
3
4 High Quality

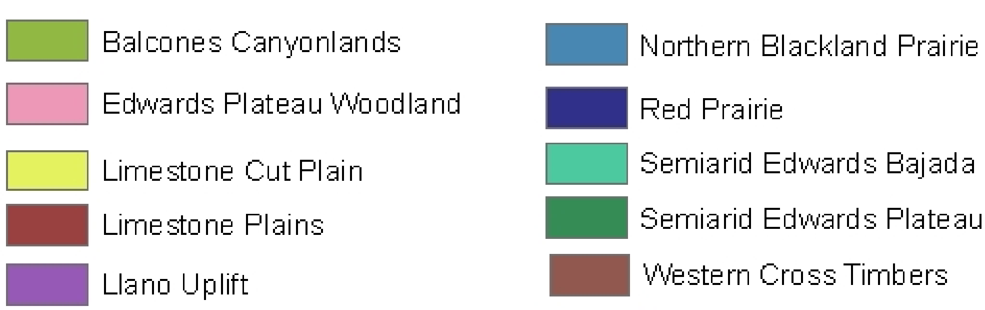
Proposed GCWA Recovery Units



Ecotypes within GCWA Breeding Range



Selected Ecotypes



Species for consideration to be included in Southern Edwards Plateau HCP (SEP-HCP)
Biological Advisory Team Nov 2009

Birds

- Black-capped vireo (*Vireo atricapilla*)
- Golden-cheeked warbler (*Dendroica chrysoparia*)
- Whooping Crane (*Grus americana*)
- Interior Least Tern (*Sterna antillarum athalassos*)

Karst Creatures

- ~~Braken Bat Cave Meshweaver (*Cicurina venii*)~~
- ~~Cokendolpher Cave Harvestman (*Texella cokendolpheri*)~~Government Canyon Bat Cave Spider (*Neoleptoneta microps*)
- ~~Helotes Mold Beetle (*Batrisodes venyivi*)~~
- Madla Cave Meshweaver (*Cicurina madla*)
- *Rhadine exilis* (*no common name*)
- *Rhadine infernalis* (*no common name*)
- ~~Robber Baron Cave Meshweaver (*Cicurina baronia*)~~

Plants

- ~~Elmendorf Onion (*Allium elmendorfii*)~~ – Although collected in southern & eastern Bexar County, it hasn't been seen for over 50 fifty. Also these locations would not be within the proposed GCWA recovery zone.
- Hill Country Wild Mercury (*Argythamnia aphoroides*) – Recent collections from Bandera, Comal, Kerr, and Kendall counties. All locations except the Kerr County location are also within the GCWA RZ. There's an ancient (<1900) collection from San Marcos in Hays County.
- Basin Bellflower (*Campanula reverchonii*) – There is a 1935 collection from N of Waring in Kendall County. This seems outside the habitat and range of this species, but I haven't seen the specimen. It would be within the GCWA RZ. I would tentatively include this until someone has checked the specimen.
- ~~Texabama Croton~~ (*Croton alabamensis var texensis*) – Not none from any of the counties.
- Sabinal Prairie Clover (*Dalea sabinalis*) – Last collected in 1885 at the "entrance to Sabinal Canyon" which may or may not be in Bandera County. Not in the GCWA RZ.
- Warnock's Coral-Root (*Hexalectris warnockii*) – Collected almost 30 years ago in Hays County along the Devil's Backbone; also in GCWA RZ.
- Carrizo Sands Wollywhite (*Hymenopappus carrizoanus*) – Collected recently in far southern Bexar County, and somewhat older collections from far southern Medina County, neither of which would be in the GCWA RZ.
- Longstalk Heimia (*Nesaea longipes*) – Very recently seen in Kerr County and a 60+ year old locations from far southern Bandera County slightly east of the Medina/Uvalde County line. Is the Kerr County site between Kerrville and Center Point in the GCWZ RZ?
- ~~Canyon Mock-Orange (*Philadelphus ernestii*)~~ – The latest taxonomic treatment combines this species with *P. texensis*, thus making neither species as rare.

Comment [RH1]: ZARA: C venii occurs in less than 5 locations; no take permit can be issued

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Comment [RH2]: ZARA: T cokendolpheri occurs in less than 5 locations; no take permit can be issued

Comment [RH3]: ZARA: C vespera occurs in less than 5 locations; no take permit can be issued

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~~<#>Government Canyon Bat Cave Meshweaver (*Cicurina vespera*)~~¶

Comment [RH4]: ZARA: N microps occurs in less than 5 locations; no take permit can be issued

Comment [RH5]: ZARA: B. venyivi occurs in less than 5 locations; no take permit can be issued

Comment [RH6]: ZARA: C baronia occurs in less than 5 locations; no take permit can be issued.

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- ~~Texas Mock-Orange (*Philadelphus texensis var. coryanus*)~~ – This variety is no longer recognized. It is part of *P. texensis* (no varieties recognized), which is not extremely rare.
- Correll's False Dragonhead (*Physostegia correllii*) – An 1897 collection from Bexar County in "San Antonio", might or might not be in the GCWA RZ. Jayne Neal: documented in NW Bexar County in 2007
- Parks' Jointweed (*Polygonella parksii*) – Collected 30 years ago 0.8 miles north of Bexar-Atascosa county line. Not in the GCWA RZ.
- Canyon Rattlesnake-Root (*Prenanthes carrii*) – A recently described species known from Lost Maples SNA in Bandera County and somewhere in Kerr County; Kerr County location might be in GCWA RZ.
- Big Red Sage (*Salvia pentstemonoides*) – Recent locations in Bandera and Kendall counties (none of Bandera County locations with GCWA RZ) and several historical locations in Kerr County (most recent from 1946, some might be within the GCWA RZ); one 1849 collection attributed to Bexar County but collected at Cibolo (current Kendall County sites are along Cibolo Creek; what were the boundaries of Bexar County in 1849). This species might be petitioned for listing in the near future.
- Tobusch Fishhook Cactus (*Sclerocactus brevihamatus subsp. Tobuschii*) – Recent locations in Bandera and Kerr counties (probably both with GCWA RZ). State and federally listed as endangered.
- Bracted Twistflower (*Streptanthus bracteatus*) – Recent locations in Bexar and Medina counties, both within GCWA RZ. Also an 1846 New Braunfels location from Comal County. This species may be petitioned for listing in the near future.
- ~~Granite Spiderwort (*Tradescantia pedicellata*)~~ – In Blanco County but north of GCWA RZ.
- Texas Wild Rice (*Zizania texana*) – Upper 2 km of San Marcos River basically within San Marcos in Hays County (is this in the GCWA RZ?). State and federally listed as endangered.

Additional Species under consideration

Mussels:

- Texas fatmucket (*Lampsilis bracteata*)
- Texas heelsplitter (*Potamilus amphichaenus*)
- Salina mucket (*Potamilus metnecktayi*)
- Golden orb (*Quadrula aurea*)
- Smooth pimpleback (*Quadrula houstonensis*)
- Texas pimpleback (*Quadrula petrina*)
- False spike (*Quincuncina mitchelli*)
- Mexican fawnsfoot (*Truncilla cognata*)
- Texas fawnsfoot (*Truncillamacrodon*)

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- A cave obligate crustaean (*Monodella texana*)
- American Peregrine Falcon (*Falco peregrinus tundrius*)
- Cascade Caverns Salamander (*Eurycea latitans*)
  AGG: Found in caves and a few springs in Kendall and Comal Counties. Its range may extend into Bexar County but at this point, the only populations

that have been analyzed genetically are hybrids between E. neotenes and E. latitans.

- Comal Blind Salamander (*Eurycea tridentifera*)
  AGG: This species is actually a troglobitic morph of E. latitans and should be considered as such.
- Peregrine Falcon (*Falco pergrinus*)
- Texas Salamander (*Eurycea neotenes*)
  AGG: Restricted to springs in NW Bexar County and S. Kendall Co with the exception of one troglobitic population in N. Bexar Co., three hybrid pops in Bexar Co, and the large spring-dwelling pop at Comal Springs 9Hueco Springs too).
- Western Burrowing Owl (*Athene cunicularia hypugaea*)
- White-faced Ibis (*Plegadis chihi*)
- Wood Stork (*Mycteria americana*)
- Zone-tailed Hawk (*Buteo albonotatus*

Additional Listed and Rare Species in Proposed Recovery Unit 5 (as identified by TPWD)

- A mayfly (*Baetodes alleni*)
- A mayfly (*Plauditus futilis*)
- American Peregrine Falcon (*Falco peregrinus anatum*)
- Arctic Peregrine Falcon (*Falco peregrinus tundrius*)
- Baird's Sparrow (*Ammodramus bairdii*)
- Bald Eagle (*Haliaeetus leucocephalus*)
- Black Bear (*Ursus americanus*)
- Blanco River Springs Salamander (*Eurycea pterophila*)
- Cascade Cave Amphipod (*Stygobromus dejectus*)
  AGG: Known only from cascade Caverns and one locality on Camp Bullis.
- Cave Myotis Bat (*Myotis velifer*)
- Edwards Plateau Shiner (*Cyprinella lepida*)
- Ezell's Cave Amphipod (*Stygobromus flagellatus*)
- Frio Pocket Gopher (*Geomys texensis bakeri*)
- Ghost-faced Bat (*Mormoops megalophylla*)
- Guadalupe Bass (*Micropterus treculii*)
- Guadalupe Darter (*Percina sciera apristis*)
- Headwater Catfish (*Ictalurus lupus*)
- Leonora's Dancer Damselfly (*Argia leonorae*)
- Long-legged Cave Amphipod (*Stygobromus longipes*)
- Mountain Plover (*Charadrius montanus*)
- Nueces Roundnose Minnow (*Dionda serena*)
- Rawson's Metalmark (*Calephelis rawsoni*)
- Sage Sphinx (*Sphinx eremitoides*)
- Texas Austrotinodes caddisfly (*Austrotinodes texensis*)
- Texas Salamander (*Eurycea neotenes*)
- Valdina Farms Sinkhole Salamander (*Eurycea troglodytes complex*)
  AGG: Type locality is considered extirpated but no recent surveys have been conducted. Otherwise, this complex is found in caves and springs in Edwards, Uvalde, Kerr, Bandera, Medina counties.

Listed species that occur in springs down-gradient from Bexar County (e.g. San Marcos Springs, Comal Springs) that would benefit from the protection and management of upstream recharge areas (e.g. San Marcos Springs, Comal Springs)

- Comal Springs Dryopid Beetle (*Stygoparnus comalensis*)
- Comal Springs Riffle Beetle (*Heterelmis comalensis*)
- Fountain Darter (*Etheostoma fonticola*)
- Peck's Cave Amphipod (*Stygobromus pecki*)
- San Marcos Gambusia (*Gambusia georgei*)
- San Marcos Salamander (*Eurycea nana*)
- Texas Blind Salamander (*Eurycea rathbuni*)
- Texas Wild Rice (*Zizania texana*)
- Blanco Blind Salamander (*Eurycea robusta*)

The County proposes that the SEP-HCP cover the federally listed species occurring in the proposed SEP-HCP Plan Area (including Bexar, Medina, Bandera, Kerr, and Kendall counties) for which incidental take authorization is both possible and warranted.

The proposed list of covered species for the SEP-HCP includes the following 6 species:

- Golden-cheeked Warbler (*Dendroica chrysoparia*)
- Black-capped Vireo (*Vireo atricapilla*)
- Madla Cave meshweaver (*Cicurina madla*)
- A ground beetle (*Rhadine exilis*)
- A ground beetle (*Rhadine infernalis*)
- Tobusch fishhook cactus (*Sclerocactus brevihamatus* ssp *tobuschii*)

The County would also consider the addition of non-listed species, provided that such species would be reasonably likely to become listed within the next 5 to 10 years and that obtaining incidental take coverage for such species would be both possible and warranted. The County seeks guidance from the USFWS and the BAT to determine if the list of species covered by the SEP-HCP should be expanded.

Rationale and Discussion:
The proposed SEP-HCP Plan Area for incidental take authorization would include Bexar, Medina, Bandera, Kerr, and Kendall counties. The TPWD county lists of rare species for these counties (accessed December 30, 2009) identify 16 species as federally endangered (15 animals and 1 plant).

To be covered for incidental take under the SEP-HCP and the associated permit, sufficient information about the species must exist to quantify the amount of take anticipated and assess the impacts of the take and proposed mitigation on the species. The USFWS must also determine that the proposed take authorization would not cause jeopardy of the species.

Zara Environmental reviewed the list of federally endangered karst invertebrates in Bexar County (see attached report dated January 6, 2010), and found that six of these species are known from less than five different localities, including:

- Helotes mold beetle (*Batrisodes venyivi*)
- Cokendolpher cave harvestman (*Texella cokendolpheri*)
- Government Canyon Bat Cave spider (*Neoleptoneta microps*)
- Robber Baron Cave meshweaver (*Cicurina baronia*)
- Bracken Bat Cave meshweaver (*Cicurina venii*)
- Government Canyon Bat Cave meshweaver (*Cicurina vespera*)

Obtaining incidental take coverage for these species would likely not be possible, since (based on currently available information) any take of these species would likely result in a jeopardy determination by the USFWS. (*Note: A possible synonymy between* Cicurina madla *and* Cicurina vespera *has been suggested by Paquin and Hedin (2004), which if confirmed could allow the SEP-HCP to also cover* C. vespera). Therefore, these species are not proposed for coverage under the SEP-HCP.

Two of the federally listed species in the proposed Plan Area are thought to be extirpated from Texas, including the gray wolf (*Canis lupis*) and the red wolf (*Canis rufus*). Since these species are no longer expected to occur in Texas, seeking incidental take authorization for these species is not warranted.

Incidental take coverage for the whooping crane (*Grus americana*) and the interior least tern (*Sterna antillarum athalassos*) in the proposed Plan Area is also not likely to be warranted. The whooping crane is a seasonal migrant in the proposed Plan Area and is not known to habitually make stop-overs in this area, making the need for incidental take authorization unlikely. According to the TPWD, breeding sites for the interior least tern are currently known to occur at only a handful of locations in Texas along the Rio Grande River, the Canadian River, the Red River, and the Prairie Dog Town Fork of the Red River, and the species winters along the Texas Gulf Coast (Campbell 2003). Therefore, incidental take authorization for this species is also not likely to be needed for activities in the Plan Area.

The TPWD county lists of rare species for Bexar, Medina, Bandera, Kerr, and Kendall counties include 70 other species that are not federally listed (see attached list). Some of these species are state-listed as threatened or endangered, but most are not listed by either the federal or state governments. While none of these species are currently identified as candidates for federal listing, some species could have the potential to become listed in the future. The County seeks guidance from the USFWS and the SEP-HCP BAT to determine if any of the non-listed species are likely to become federally listed in the next 5 to 10 years and if any of these likely candidates warrant incidental take coverage under the SEP-HCP (i.e., Is incidental take likely to occur from activities in the Plan Area? Is there sufficient information to conduct a take and impacts analysis? Would incidental take result in jeopardy?)

Campbell, L. 2003. Endangered and threatened animals of Texas: their life history and management. Texas Parks and Wildlife Department, Austin, Texas.

Paquin, P., and M. Hedin. 2004. The power and perils of ‘molecular taxonomy’: a case study of eyeless and endangered *Cicurina* (Araneae: Dictynidae) from Texas caves. Molecular Ecology 13 (10): 3239–3255.

TPWD Rare Species Lists; downloaded Dec 30, 2009

Taxon	Common Name	Scientific Name	Federal Status	State Status	SEP-HCP IT Plan Area (Bexar, Medina, Bandera, Kerr, & Kendall counties)	Bexar	Medina	Bandera	Kerr	Kendall	Blanco	Gillespie	Comal	Hays	Description
AMPHIBIANS	Cascade Caverns salamander	Eurycea latitans complex		T	x	x		x	x	x			x		endemic; subaquatic; springs and caves in Medina River, Guadalupe River, and Cibolo Creek watersheds within Edwards Aquifer area
AMPHIBIANS	San Marcos salamander	Eurycea nana	LT	T										x	headwaters of the San Marcos River downstream to ca. ½ mile past IH-35; water over gravelly substrate characterized by dense mats of algae (Lyng bya) and aquatic moss (Leptodictym riparium), and water temperatures of 21-22 O C; diet includes amphipods, midge larve, and aquatic snails
AMPHIBIANS	Texas salamander	Eurycea neotenes			x	x				x					endemic; troglobitic; springs, seeps, cave streams, and creek headwaters; often hides under rocks and leaves in water; restricted to Helotes and Leon Creek drainages
AMPHIBIANS	Blanco River springs salamander	Eurycea pterophila			x					x	x			x	subaquatic; springs and caves in the Blanco River drainage
AMPHIBIANS	Texas blind salamander	Eurycea rathbuni	LE	E										x	troglobitic; water-filled subterranean caverns along a six mile stretch of the San Marcos Spring Fault, in the vicinity of San Marcos; eats small invertebrates, including snails, copepods, amphipods, and shrimp
AMPHIBIANS	Blanco blind salamander	Eurycea robusta		T										x	troglobitic; water-filled subterranean caverns; may inhabit deep levels of the Balcones aquifer to the north and east of the Blanco River
AMPHIBIANS	Edwards Plateau spring salamanders	Eurycea sp 7											x		endemic; springs and waters of some caves of this region
AMPHIBIANS	Comal Springs salamander	Eurycea sp 8													endemic; Comal Springs
AMPHIBIANS	Comal blind salamander	Eurycea tridentifera		T	x	x				x			x		endemic; semi-troglobitic; found in springs and waters of caves
AMPHIBIANS	Valdina Farms sinkhole salamander	Eurycea troglodytes complex			x		x	x	x			x			isolated, intermittent pools of a subterranean streams and sinkhole in Nueces, Frio, Guadalupe, and Pedernales watersheds within Edwards Aquifer area
ARACHNIDS	Bandit Cave spider	Cicurina bandida												x	very small, subterrestrial, subterranean obligate
ARACHNIDS	Robber Baron Cave meshweaver	Cicurina baronia	LE		x	x									small, eyeless, or essentially eyeless spider; karst features in north and northwest Bexar County
ARACHNIDS	Madla Cave meshweaver	Cicurina madla	LE		x	x									small, eyeless, or essentially eyeless spider; karst features in north and northwest Bexar County
ARACHNIDS	Bracken Bat Cave meshweaver	Cicurina venii	LE		x	x									small, eyeless, or essentially eyeless spider; karst features in north and northwest Bexar County
ARACHNIDS	Government Canyon Bat Cave meshweaver	Cicurina vespera	LE		x	x									small, eyeless, or essentially eyeless spider; karst features in north and northwest Bexar County
ARACHNIDS	Government Canyon Bat Cave spider	Neoleptoneta microps	LE		x	x									small, eyeless, or essentially eyeless spider; karst features in north and northwest Bexar County
ARACHNIDS	Cokendolpher cave harvestman	Texella cokendolpheri	LE		x	x									small, eyeless harvestman; karst features in north and northwest Bexar County
BIRDS	Baird's Sparrow	Ammodramus bairdii			x		x	x	x			x			shortgrass prairie with scattered low bushes and matted vegetation; mostly migratory in western half of State, though winters in Mexico and just across Rio Grande into Texas from Brewster through Hudspeth counties
BIRDS	Western Burrowing Owl	Athene cunicularia hypugaea			x	x	x	x	x	x	x	x	x	x	open grasslands, especially prairie, plains, and savanna, sometimes in open areas such as vacant lots near human habitation or airports; nests and roosts in abandoned burrows
BIRDS	Zone-tailed Hawk	Buteo albonotatus		T	x	x	x	x	x	x	x	x	x	x	arid open country, including open deciduous or pine-oak woodland, mesa or mountain county, often near watercourses, and wooded canyons and tree-lined rivers along middle-slopes of desert mountains; nests in various habitats and sites, ranging from small trees in lower desert, giant cottonwoods in riparian areas, to mature conifers in high mountain regions
BIRDS	Mountain Plover	Charadrius montanus			x	x	x		x	x	x	x	x	x	breeding: nests on high plains or shortgrass prairie, on ground in shallow depression; nonbreeding: shortgrass plains and bare, dirt (plowed) fields; primarily insectivorous
BIRDS	Golden-cheeked Warbler	Dendroica chrysoparia	LE	E	x	x	x	x	x	x	x	x	x	x	juniper-oak woodlands; dependent on Ashe juniper (also known as cedar) for long fine bark strips, only available from mature trees, used in nest construction; nests are placed in various trees other than Ashe juniper; only a few mature junipers or nearby cedar brakes can provide the necessary nest material; forage for insects in broad-leaved trees and shrubs; nesting late March-early summer
BIRDS	Peregrine Falcon	Falco peregrinus	DL	T	x	x	x	x	x	x	x	x	x	x	both subspecies migrate across the state from more northern breeding areas in US and Canada to winter along coast and farther south; subspecies (F. p. anatum) is also a resident breeder in west Texas; the two subspecies' listing statuses differ, F.p. tundrius is no longer listed in Texas; but because the subspecies are not easily distinguishable at a distance, reference is generally made only to the species level; see subspecies for habitat.
BIRDS	American Peregrine Falcon	Falco peregrinus anatum	DL	T	x	x	x	x	x	x	x	x	x	x	year-round resident and local breeder in west Texas, nests in tall cliff eyries; also, migrant across state from more northern breeding areas in US and Canada, winters along coast and farther south; occupies wide range of habitats during migration, including urban, concentrations along coast and barrier islands; low-altitude migrant, stopovers at leading landscape edges such as lake shores, coastlines, and barrier islands.

BIRDS	Arctic Peregrine Falcon	Falco peregrinus tundrius	DL		x	x	x	x	x	x	x	x	x	x	migrant throughout state from subspecies' far northern breeding range, winters along coast and farther south; occupies wide range of habitats during migration, including urban, concentrations along coast and barrier islands; low-altitude migrant, stopovers at leading landscape edges such as lake shores, coastlines, and barrier islands.
BIRDS	Whooping Crane	Grus americana	LE	E	x	x	x	x	x	x	x	x	x	x	potential migrant via plains throughout most of state to coast; winters in coastal marshes of Aransas, Calhoun, and Refugio counties
BIRDS	Bald Eagle	Haliaeetus leucocephalus	DL	T	x				x	x	x	x	x	x	found primarily near rivers and large lakes; nests in tall trees or on cliffs near water; communally roosts, especially in winter; hunts live prey, scavenges, and pirates food from other birds
BIRDS	Wood Stork	Mycteria americana		T	x	x									forages in prairie ponds, flooded pastures or fields, ditches, and other shallow standing water, including salt-water; usually roosts communally in tall snags, sometimes in association with other wading birds (i.e. active heronries); breeds in Mexico and birds move into Gulf States in search of mud flats and other wetlands, even those associated with forested areas; formerly nested in Texas, but no breeding records since 1960
BIRDS	White-faced Ibis	Plegadis chihi		T	x	x									prefers freshwater marshes, sloughs, and irrigated rice fields, but will attend brackish and saltwater habitats; nests in marshes, in low trees, on the ground in bulrushes or reeds, or on floating mats
BIRDS	Interior Least Tern	Sterna antillarum athalassos	LE	E	x	x	x	x	x	x					subspecies is listed only when inland (more than 50 miles from a coastline); nests along sand and gravel bars within braided streams, rivers; also know to nest on man-made structures (inland beaches, wastewater treatment plants, gravel mines, etc); eats small fish and crustaceans, when breeding forages within a few hundred feet of colony
BIRDS	Black-capped Vireo	Vireo atricapilla	LE	E	x	x	x	x	x	x	x	x	x	x	oak-juniper woodlands with distinctive patchy, two-layered aspect; shrub and tree layer with open, grassy spaces; requires foliage reaching to ground level for nesting cover; return to same territory, or one nearby, year after year; deciduous and broad-leaved shrubs and trees provide insects for feeding; species composition less important than presence of adequate broad-leaved shrubs, foliage to ground level, and required structure; nesting season March-late summer
CRUSTACEANS	Texas troglobitic water slater	Lirceolus smithii												x	subaquatic, subterranean obligate, aquifer
CRUSTACEANS	A cave obligate crustaean	Monodella texana			x	x								x	subaquatic, subterranean obligate; underground freshwater aquifers
CRUSTACEANS	Texas cave shrimp	Palaemonetes antrorum												x	subterranean sluggish streams and pools
CRUSTACEANS	Balcones Cave amphipod	Stygobromus balconis												x	subaquatic, subterranean obligate amphipod
CRUSTACEANS	Cascade Cave amphipod	Stygobromus dejectus			x				x	x					subaquatic crustacean; subterranean obligate; in pools
CRUSTACEANS	Ezell's cave amphipod	Stygobromus flagellatus			x		x						x	x	known only from artesian wells
CRUSTACEANS	Long-legged cave amphipod	Stygobromus longipes			x					x			x		subaquatic crustacean; subterranean obligate; found in subterranean streams
CRUSTACEANS	Peck's cave amphipod	Stygobromus pecki	LE	E									x		small, aquatic crustacean; lives underground in the Edwards Aquifer; collected at Comal Springs and Hueco Springs
FISHES	Edwards Plateau shiner	Cyprinella lepida			x		x	x							Edwards Plateau portion of Nueces basin, mainstem and tributaries of Nueces, Frio, and Sabinal rivers; clear, cool, spring-fed headwater creeks; usually over gravel
FISHES	Nueces roundnose minnow	Dionda serena			x		x	x							Edwards Plateau portion of Nueces basin: mainstream and tributaries of Nueces, Frio and Sabinal rivers
FISHES	Fountain darter	Etheostoma fonticola	LE	E									x	x	known only from the San Marcos and Comal rivers; springs and spring-fed streams in dense beds of aquatic plants growing close to bottom, which is normally mucky; feeding mostly diurnal; spawns year-round with August and late winter to early spring peaks
FISHES	San Marcos gambusia	Gambusia georgei	LE	E										x	extinct; endemic; formerly known from upper San Marcos River; restricted to shallow, quiet, mud-bottomed shoreline areas without dense vegetation in thermally constant main channel
FISHES	Headwater catfish	Ictalurus lupus			x		x	x		x	x	x			originally throughout streams of the Edwards Plateau and the Rio Grande basin, currently limited to Rio Grande drainage, including Pecos River basin; springs, and sandy and rocky riffles, runs, and pools of clear creeks and small rivers
FISHES	Guadalupe bass	Micropterus treculii			x	x		x	x	x	x	x	x	x	endemic to perennial streams of the Edward's Plateau region; introduced in Nueces River system
FISHES	Ironcolor shiner	Notropis chalybaeus												x	Big Cypress Bayou and Sabine River basins; spawns April-September, eggs sink to bottom of pool; pools and slow runs of low gradient small acidic streams with sandy substrate and clear well vegetated water; feeds mainly on small insects, ingested plant material not digested
FISHES	Guadalupe darter	Percina sciera apristis			x				x	x			x	x	Guadalupe River basin; most common over gravel or gravel and sand raceways of large streams and rivers
FISHES	Widemouth blindcat	Satan eurystomus		T	x	x									troglobitic, blind catfish endemic to the San Antonio Pool of the Edward's Aquifer
FISHES	Toothless blindcat	Trogloglanis pattersoni		T	x	x									troglobitic, blind catfish endemic to the San Antonio Pool of the Edward's Aquifer
INSECTS	A mayfly	Allenhyphes michaeli			x			x		x	x				TX Hill Country; mayflies distinguished by aquatic larval stage; adult stage generally found in shoreline vegetation
INSECTS	Leonora's dancer damselfly	Argia leonorae			x		x	x	x					x	south central and western Texas; small streams and seepages
INSECTS	Texas austrotinodes caddisfly	Austrotinodes texensis			x			x						x	appears endemic to the karst springs and spring runs of the Edwards Plateau region; flow in type locality swift but may drop significantly during periods of little drought; substrate coarse and ranges from cobble and gravel to limestone bedrock; many limestone outcroppings also found along the streams

INSECTS	A mayfly	Baetodes alleni			x					x					mayflies distinguished by aquatic larval stage; adult stage generally found in shoreline vegetation
INSECTS	Helotes mold beetle	Batrisodes venyivi	LE		x	x									small, eyeless mold beetle; karst features in northwestern Bexar County and northeastern Medina County
INSECTS	Rawson's metalmark	Calephelis rawsoni			x	x		x	x	x			x	x	moist areas in shaded limestone outcrops in central Texas, desert scrub or oak woodland in foothills, or along rivers elsehwere; larval hosts are Eupatorium havanense, E. greggii.
INSECTS	Flint's net-spinning caddisfly	Cheumatopsyche flinti												x	very poorly known species with habitat description limited to 'a spring'
INSECTS	Comal Springs diving beetle	Comaldessus stygius											x		known only from the outflows at Comal Springs; aquatic; diving beetles generally inhabit the water column
INSECTS	Edwards Aquifer diving beetle	Haideoporus texanus											x	x	habitat poorly known; known from an artesian well in Hays County
INSECTS	Disjunct crawling water beetle	Haliplus nitens									x				unknown, maybe shallow water
INSECTS	Comal Springs riffle beetle	Heterelmis comalensis	LE										x	x	Comal and San Marcos Springs
INSECTS	A mayfly	Plauditus futilis			x			x							OK, TX, and Canada; mayflies distinguished by aquatic larval stage; adult stage generally found in bankside vegetation
INSECTS	A mayfly	Procloeon distinctum												x	mayflies distinguished by aquatic larval stage; adult stage generally found in shoreline vegetation
INSECTS	San Marcos saddle-case caddisfly	Protoptila arca												x	known from an artesian well in Hays County; locally very abundant; swift, well-oxygenated warm water about 1-2 m deep; larvae and pupal cases abundant on rocks
INSECTS	A mayfly	Pseudocentroptiloides morihari											x		mayflies distinguished by aquatic larval stage; adult stage generally found in shoreline vegetation
INSECTS	A ground beetle	Rhadine exilis	LE		x	x									small, essentially eyeless ground beetle; karst features in north and northwest Bexar County
INSECTS	A ground beetle	Rhadine infernalis	LE		x	x									small, essentially eyeless ground beetle; karst features in north and northwest Bexar County
INSECTS	Sage sphinx	Sphinx eremitoides			x				x						desert, grassland; sandy prairie or desert with sage; caterpillars feed on leaves of sage; adults emerge late spring or summer, but little information available; immatures develop directly to the pupal stage probably in 5-7 weeks, and pupae overwinter underground
INSECTS	Manfreda giant-skipper	Stallingsia maculosus			x	x									most skippers are small and stout-bodied; name derives from fast, erratic flight; at rest most skippers hold front and hind wings at different angles; skipper larvae are smooth, with the head and neck constricted; skipper larvae usually feed inside a leaf shelter and pupate in a cocoon made of leaves fastened together with silk
INSECTS	Comal Springs dryopid beetle	Stygoparnus comalensis	LE										x	x	dryopids usually cling to objects in a stream; dryopids are sometimes found crawling on stream bottoms or along shores; adults may leave the stream and fly about, especially at night; most dryopid larvae are vermiform and live in soil or decaying wood
MAMMALS	Gray wolf	Canis lupus	LE	E	x	x	x	x	x	x	x	x			extirpated; formerly known throughout the western two-thirds of the state in forests, brushlands, or grasslands
MAMMALS	Red wolf	Canis rufus	LE	E	x	x	x	x	x	x	x	x	x	x	extirpated; formerly known throughout eastern half of Texas in brushy and forested areas, as well as coastal prairies
MAMMALS	Pale Townsend's big-eared bat	Corynorhinus townsendii pallescens			x				x						roosts in caves, abandoned mine tunnels, and occasionally old buildings; hibernates in groups during winter; in summer months, males and females separate into solitary roosts and maternity colonies, respectively; single offspring born May-June; opportunistic insectivore
MAMMALS	Frio pocket gopher	Geomys texensis bakeri			x		x								associated with nearly level Atco soil, which is well-drained and consists of sandy surface layers with loam extending to as deep as two meters
MAMMALS	Llano pocket gopher	Geomys texensis texensis			x				x		x	x			found in deep, brown loamy sands or gravelly sandy loams and is isolated from other species of pocket gophers by intervening shallow stony to gravelly clayey soils
MAMMALS	Jaguarundi	Herpailurus yaguarondi	LE	E									x		thick brushlands, near water favored; 60 to 75 day gestation, young born sometimes twice per year in March and August, elsewhere the beginning of the rainy season and end of the dry season
MAMMALS	Ghost-faced bat	Mormoops megalophylla			x	x	x	x							colonially roosts in caves, crevices, abandoned mines, and buildings; insectivorous; breeds late winter-early spring; single offspring born per year
MAMMALS	Cave myotis bat	Myotis velifer			x	x	x	x	x	x	x	x	x	x	colonial and cave-dwelling; also roosts in rock crevices, old buildings, carports, under bridges, and even in abandoned Cliff Swallow (Hirundo pyrrhonota) nests; roosts in clusters of up to thousands of individuals; hibernates in limestone caves of Edwards Plateau and gypsum cave of Panhandle during winter; opportunistic insectivore
MAMMALS	White-nosed coati	Nasua narica		T	x				x						woodlands, riparian corridors and canyons; most individuals in Texas probably transients from Mexico; diurnal and crepuscular; very sociable; forages on ground and in trees; omnivorous; may be susceptible to hunting, trapping, and pet trade
MAMMALS	Plains spotted skunk	Spilogale putorius interrupta			x	x	x	x	x	x	x	x	x	x	catholic; open fields, prairies, croplands, fence rows, farmyards, forest edges, and woodlands; prefers wooded, brushy areas and tallgrass prairie
MAMMALS	Black bear	Ursus americanus	T/SA;NL	T	x	x	x	x	x	x	x	x	x		bottomland hardwoods and large tracts of inaccessible forested areas; due to field characteristics similar to Louisiana Black Bear (LT, T), treat all east Texas black bears as federal and state listed Threatened
MOLLUSKS	Rock pocketbook	Arcidens confragosus			x	x					x		x	x	mud, sand, and gravel substrates of medium to large rivers in standing or slow flowing water, may tolerate moderate currents and some reservoirs, east Texas, Red through Guadalupe River basins

MOLLUSKS	Horseshoe liptooth snail	Daedalochila hippocrepis											x		terrestrial snail known only from the steep, wooded hillsides of Landa Park in New Braunfels
MOLLUSKS	Texas fatmucket	Lampsilis bracteata			x	x			x	x	x	x	x	x	streams and rivers on sand, mud, and gravel substrates; intolerant of impoundment; broken bedrock and course gravel or sand in moderately flowing water; Colorado and Guadalupe River basins
MOLLUSKS	Mimic cavesnail	Phreatodrobia imitata			x	x									subaquatic; only known from two wells penetrating the Edwards Aquifer
MOLLUSKS	Golden orb	Quadrula aurea			x	x	x	x	x	x	x	x	x	x	sand and gravel in some locations and mud at others; intolerant of impoundment in most instances; Guadalupe, San Antonio, and Nueces River basins
MOLLUSKS	Smooth pimpleback	Quadrula houstonensis									x				small to moderate streams and rivers as well as moderate size reservoirs; mixed mud, sand, and fine gravel, tolerates very slow to moderate flow rates, appears not to tolerate dramatic water level fluctuations, scoured bedrock substrates, or shifting sand bottoms, lower Trinity (questionable), Brazos, and Colorado River basins
MOLLUSKS	Texas pimpleback	Quadrula petrina			x	x	x	x	x	x	x	x		x	mud, gravel and sand substrates, generally in areas with slow flow rates; Colorado and Guadalupe river basins
MOLLUSKS	False spike mussel	Quincuncina mitchelli			x	x			x	x	x	x	x	x	substrates of cobble and mud, with water lilies present; Rio Grande, Brazos, Colorado, and Guadalupe (historic) river basins
MOLLUSKS	Creeper (squawfoot)	Strophitus undulatus			x	x		x	x	x	x	x	x	x	small to large streams, prefers gravel or gravel and mud in flowing water; Colorado, Guadalupe, San Antonio, Neches (historic), and Trinity (historic) River basins
MOLLUSKS	Pistolgrip	Tritogonia verrucosa			x	x			x	x	x	x	x	x	stable substrate, rock, hard mud, silt, and soft bottoms, often buried deeply; east and central Texas, Red through San Antonio River basins
MOLLUSKS	Texas fawnsfoot	Truncilla macrodon									x	x			little known; possibly rivers and larger streams, and intolerant of impoundment; flowing rice irrigation canals, possibly sand, gravel, and perhaps sandy-mud bottoms in moderate flows; Brazos and Colorado River basins
PLANTS	Elmendorf's onion	Allium elmendorfii			x	x									Texas endemic; grassland openings in oak woodlands on deep, loose, well-drained sands; in Coastal Bend, on Pleistocene barrier island ridges and Holocene Sand Sheet that support live oak woodlands; to the north it occurs in post oak-black hickory-live oak woodlands over Queen City and similar Eocene formations; one anomalous specimen found on Llano Uplift in wet pockets of granitic loam; flowering March-April, May
PLANTS	Hill Country wild-mercury	Argythamnia aphoroides			x	x		x	x	x	x	x	x	x	Texas endemic; mostly in bluestem-grama grasslands associated with plateau live oak woodlands on shallow to moderately deep clays and clay loams over limestone on rolling uplands, also in partial shade of oak-juniper woodlands in gravelly soils on rocky limestone slopes; flowering April-May with fruit persisting until midsummer
PLANTS	Basin bellflower	Campanula reverchonii			x					x		x			Texas endemic; among scattered vegetation on loose gravel, gravelly sand, and rock outcrops on open slopes with exposures of igneous and metamorphic rocks; may also occur on sandbars and other alluvial deposits along major rivers; flowering May-July
PLANTS	Comal snakewood	Colubrina stricta											x		in El Paso County, found in a patch of thorny shrubs in colluvial deposits and sandy soils at the base of an igneous rock outcrop; the historic Comal County record does not describe the habitat; in Mexico ,found in shrublands on calcareous, gravelly, clay soils with woody associates; flowering late spring or early summer
PLANTS	Sabinal prairie-clover	Dalea sabinalis			x			x							Texas endemic: information sketchy, but probably in rocky soils or on limestone outcrops in sparse grassland openings in juniper-oak woodlands; flowering April-May or May -June
PLANTS	Small-headed pipewort	Eriocaulon koernickianum										x			in East Texas, post-oak woodlands and xeric sandhill openings on permanently wet acid sands of upland seeps and hillside seepage bogs, usually in patches of bare sand rather than among dense vegetation or on muck; in Gillespie County, on permanently wet or moist hillside seep on decomposing granite gravel and sand among granite outcrops; flowering/fruiting late May-late June
PLANTS	Warnock's coral-root	Hexalectris warnockii										x		x	in leaf litter and humus in oak-juniper woodlands on shaded slopes and intermittent, rocky creekbeds in canyons; in the Trans Pecos in oak-pinyon-juniper woodlands in higher mesic canyons (to 2000 m [6550 ft]), primarily on igneous substrates; in Terrell County under Quercus fusiformis mottes on terrraces of spring-fed perennial streams, draining an otherwise rather xeric limestone landscape; on the Callahan Divide (Taylor County), the White Rock Escarpment (Dallas County), and the Edwards Plateau in oak-juniper woodlands on limestone slopes; in Gillespie County on igneous substrates of the Llano Uplift; flowering June-September; individual plants do not usually bloom in successive years
PLANTS	Sandhill woollywhite	Hymenopappus carrizoanus			x	x	x								Texas endemic; disturbed or open areas in grasslands and post oak woodlands on deep sands derived from the Carrizo Sand and similar Eocene formations; flowering April-June
PLANTS	Rock quillwort	Isoetes lithophila										x			Texas endemic; rooted in sand and gravel under shallow water of seasonal pools (vernal pools) that develop during rainy seasons in small, shallow, unshaded basins on barren outcrops of granite and gneiss; sporulating in late winter and spring, and opportunistically in other seasons following heavy rainfall

PLANTS	Longstalk heimia	Nesaea longipes			x			x	x						moist or subirrigated alkaline or gypsiferous clayey soils along unshaded margins of cienegas and other wetlands; occurs sparingly on an alkaline, somewhat saline silt loam on terraces of spring-fed streams in grassland; also occurs common in moderately alkaline clay along perennial stream and in subirrigated wetlands atop poorly-defined spring system; also occurs in low, wetland area along highway right-of-way; flowering May-September
PLANTS	Canyon mock-orange	Philadelphus ernestii			x					x	x		x	x	Texas endemic; usually found growing from honeycomb pits on outcrops of Cretaceous limestone exposed as rimrock along mesic canyons, usually in the shade of mixed evergreen-deciduous canyon woodland; flowering April-June, fruit dehiscing September-October
PLANTS	Texas mock-orange	Philadelphus texensis			x			x		x			x		limestone outcrops on cliffs and rocky slopes, on boulders in mesic canyon bottoms, usually in shade of mixed evergreen-deciduous slope woodland forest; flowering April-May, but readily recognizable throughout the growing season
PLANTS	Correll's false dragon-head	Physostegia correllii			x	x									wet, silty clay loams on streamsides, in creek beds, irrigation channels and roadside drainage ditches; or seepy, mucky, sometimes gravelly soils along riverbanks or small islands in the Rio Grande; or underlain by Austin Chalk limestone along gently flowing spring-fed creek in central Texas; flowering May-September
PLANTS	Parks' jointweed	Polygonella parksii			x	x									Texas endemic; mostly found on deep, loose, whitish sand blowouts (unstable, deep, xeric, sandhill barrens) in Post Oak Savanna landscapes over the Carrizo and Sparta formations; also occurs in early successional grasslands, along right-of-ways, and on mechanically disturbed areas; flowering June-late October or September-November
PLANTS	Canyon rattlesnake-root	Prenanthes carrii			x			x	x			x			Texas endemic; rich humus soils over limestone in upper woodland canyon drainages, upper small spring fed drainages, typically near springs in deep soils around the springs and on limestone shelves, honeycomb rock (porous rock); flowering and fruiting late August-November
PLANTS	Big red sage	Salvia pentstemonoides			x	x		x	x	x		x			Texas endemic; moist to seasonally wet, steep limestone outcrops on seeps within canyons or along creek banks; occasionally on clayey to silty soils of creek banks and terraces, in partial shade to full sun; basal leaves conspicuous for much of the year; flowering June-October
PLANTS	Tobusch fishhook cactus	Sclerocactus brevihamatus ssp tc	LE	E	x			x	x						Texas endemic; shallow, moderately alkaline, stony clay and clay loams over massive fractured limestone; usually on level to slightly sloping hilltops; occasionally on relatively level areas on steeper slopes, and in rocky floodplains; usually open areas within a mosaic of oak-juniper woodlands, occasionally in pine-oak woodlands, rarely in cenizo shrublands or little bluestem grasslands; sites are usually open with only herbaceous cover, although the cactus may be somewhat protected by rocks, grasses, or spikemosses; flowering (late January-) February-March (rarely early April)
PLANTS	Bracted twistflower	Streptanthus bracteatus			x	x	x	x					x		Texas endemic; shallow, well-drained gravelly clays and clay loams over limestone in oak juniper woodlands and associated openings, on steep to moderate slopes and in canyon bottoms; several known soils include Tarrant, Brackett, or Speck over Edwards, Glen Rose, and Walnut geologic formations; populations fluctuate widely from year to year, depending on winter rainfall; flowering mid April-late May, fruit matures and foliage withers by early summer
PLANTS	Granite spiderwort	Tradescantia pedicellata									x				Texas endemic; mostly in fractures on outcrops of granite, gneiss, and similar igneous and metamorphic rocks, or in early successional grasslands or forb-dominated assemblages on well-drained, sandy to gravelly soils dervied from same; flowering at least April-May
PLANTS	Edwards Plateau cornsalad	Valerianella texana										x			very shallow, well-drained, but seasonally moist gravelly-sandy soils derived from igneous or metamorphic rocks, often along the downslope margin of rock outcrops, in full sun or in partial shade of oak-juniper woodlands; more likely encountered in early successional areas; population numbers fluctuate considerably from year to year, with higher numbers following winters with higher rains and/or moderate temperatures; peak flowering/fruiting mid-March–late April, stems wither and disappear by the beginning of May
PLANTS	Texas wild-rice	Zizania texana	LE	E										x	Texas endemic; spring-fed river, in clear, cool, swift water mostly less than 1 m deep, with coarse sandy soils rather than finer clays; flowering year-round, peaking March-June
REPTILES	Timber/Canebrake rattlesnake	Crotalus horridus		T	x	x									swamps, floodplains, upland pine and deciduous woodlands, riparian zones, abandoned farmland; limestone bluffs, sandy soil or black clay; prefers dense ground cover, i.e. grapevines or palmetto
REPTILES	Indigo snake	Drymarchon corais		T	x	x	x								Texas south of the Guadalupe River and Balcones Escarpment; thornbush-chaparral woodlands of south Texas, in particular dense riparian corridors; can do well in suburban and irrigated croplands if not molested or indirectly poisoned; requires moist microhabitats, such as rodent burrows, for shelter
REPTILES	Texas tortoise	Gopherus berlandieri		T	x	x	x								open brush with a grass understory is preferred; open grass and bare ground are avoided; when inactive occupies shallow depressions at base of bush or cactus, sometimes in underground burrows or under objects; longevity greater than 50 years; active March-November; breeds April-November

REPTILES	Cagle's map turtle	Graptemys caglei		T	x				x	x			x	x	endemic; Guadalupe River System; short stretches of shallow water with swift to moderate flow and gravel or cobble bottom, connected by deeper pools with a slower flow rate and a silt or mud bottom; gravel bar riffles and transition areas between riffles and pools especially important in providing insect prey items; nest on gently sloping sand banks within ca. 30 feet of water's edge
REPTILES	Spot-tailed earless lizard	Holbrookia lacerata			x	x	x	x	x	x	x	x	x	x	central and southern Texas and adjacent Mexico; moderately open prairie-brushland; fairly flat areas free of vegetation or other obstructions, including disturbed areas; eats small invertebrates; eggs laid underground
REPTILES	Texas horned lizard	Phrynosoma cornutum		T	x	x	x	x	x	x	x	x	x	x	open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rock when inactive; breeds March-September
REPTILES	Texas garter snake	Thamnophis sirtalis annectens			x	x				x	x		x	x	wet or moist microhabitats are conducive to the species occurrence, but is not necessarily restricted to them; hibernates underground or in or under surface cover; breeds March-August

SOUTHERN EDWARDS PLATEAU HABITAT CONSERVATION PLAN

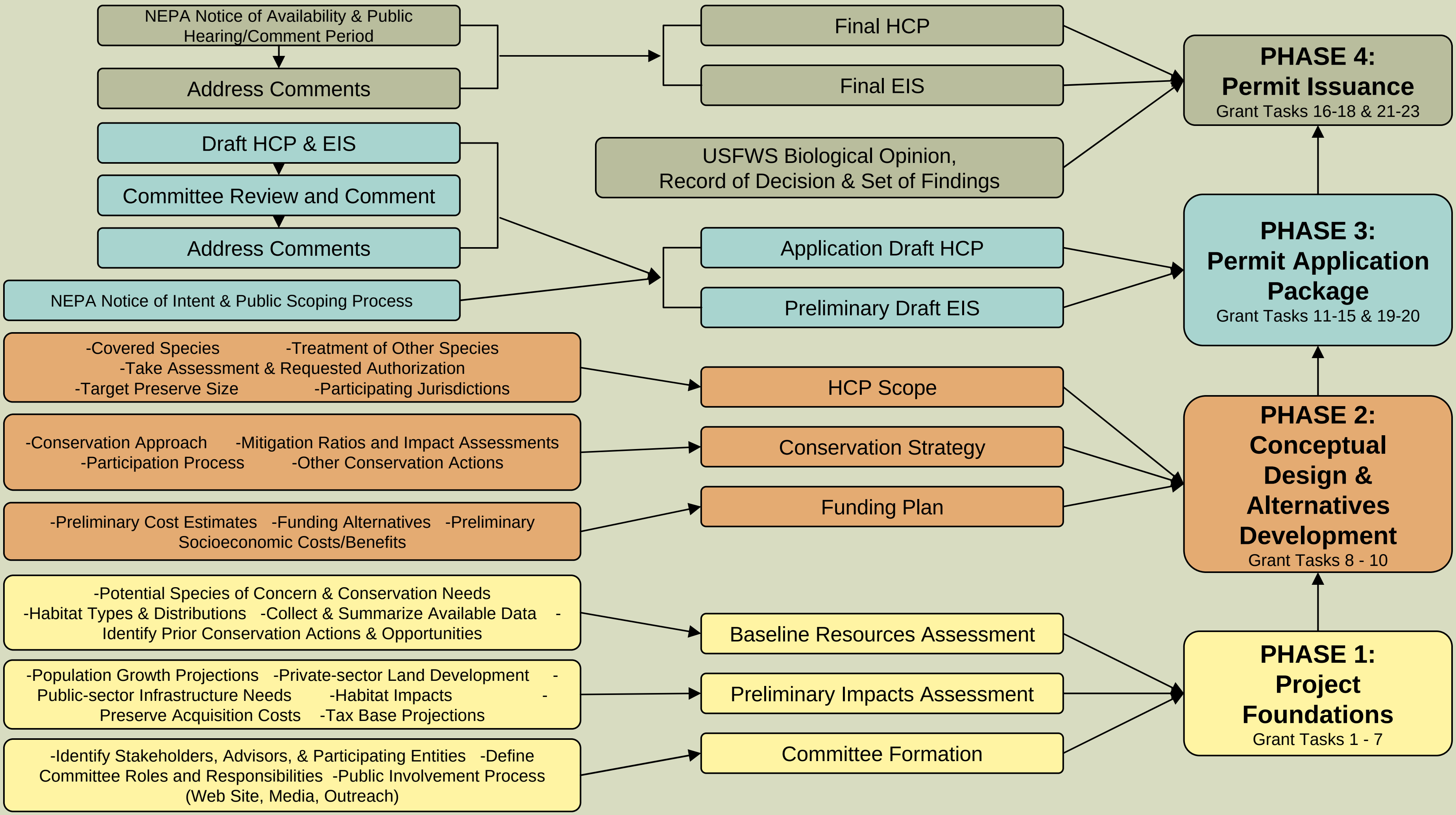
PRESENTATION TO THE

BIOLOGICAL ADVISORY TEAM

JANUARY 29, 2010

LOOMIS PARTNERS

SEP-HCP Work Plan



Major Milestones

PERMIT ISSUANCE: SEPT 2012

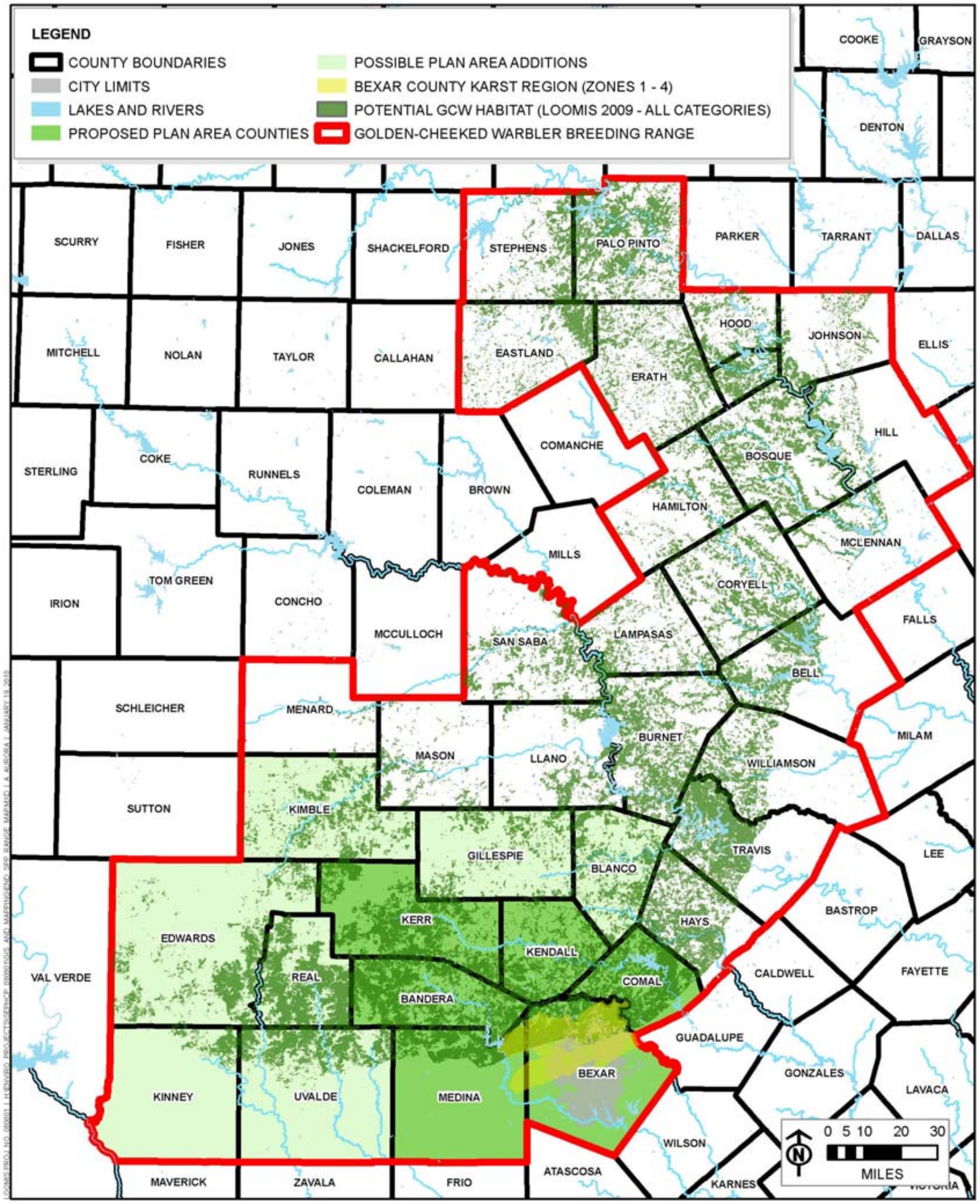
Major Milestone	Tasks	Duration	Date
MAJOR MILESTONE: **Complete Phase 4 Permit Issuance**	Address public comments on draft HCP and draft EIS. Finalize HCP and assist USFWS with finalization of EIS and other permitting documents, as appropriate. Permit issued.	*5 mos.*	APR 2012
	Local USFWS office review and comment. NEPA Notice of Availability, public hearing, and 60 to 90-day comment period on draft HCP and draft EIS.	*7 mos.*	**SEPT 2011**
MAJOR MILESTONE: **Complete Phase 3 Permit Application Package**	Prepare Final Application Draft of HCP (incorporating comments from the first draft) and a complete draft of the PDEIS for approval by committees and Client. Submit draft HCP and PDEIS to USFWS as part of application for ESA Section 10(a) permit.	*5 mos.*	APR 2011
	Prepare First Draft of HCP and Alternatives Considered/Affected Resources sections of the PDEIS. Present to committees for review and comment. Collect and address comments. Conduct NEPA scoping process, including Notice of Intent, public scoping meeting, and 30-day comment period.	*7 mos.*	**SEPT 2010**
MAJOR MILESTONE: **Complete Phase 2 Conceptual Design and Alternatives**	Present conceptual alternatives to committees and identify consensus opinion regarding the preferred alternative for HCP. Preferred alternative scope, strategy, and funding mechanism form the framework of a Preliminary Draft HCP.	*2 mos.*	JULY 2010
	Develop conceptual alternatives for HCP scope, conservation strategy, and funding plan.	*2 mos.*	**MAY 2010**
MAJOR MILESTONE: **Complete Phase I Project Foundations**	Complete interim deliverables for Baseline Resources Assessment and Preliminary Impacts Assessment. Present assessments to committees and discuss early ideas and concerns.	*2 mos.*	MAR 2010
	Initial briefings of committee members on overall ESA process and HCPs. Begin technical documents for species, habitats, population, and land development. Identify major framing issues and preferred alternatives for critical path decisions.	*2 mos.*	JAN 2009
	Complete contracting arrangements. Preliminary project planning and scoping. Establish processes for communications and work flow. Early coordination with potential stakeholders and agencies. Establish process for committee involvement. Identify, contact, and appoint committee members.	*2 mos.*	**NOV 2009**

Covered Species Considerations

- The list of species for which incidental take coverage will be sought.
  - Incidental take authorization under the ESA is only needed for federally listed species.
  - HCPs can cover non-listed species as long as they are treated as if they were listed.
- Grant application anticipated coverage of all listed species in Bexar County (13 terrestrial species).
- Number of species covered is the factor that will most affect the complexity of the conservation plan.
  - Degree of complexity has implications for the project scope and schedule.

Covered Species Considerations

- To obtain incidental take coverage for a species:
  - Must have sufficient information to
    - perform a quantitative take and impacts analysis
    - design effective conservation actions with measurable benefits (avoid, minimize, mitigate)
  - Conservation actions for the covered species must be practicable to implement.
  - Requested take must not jeopardize the survival and recovery of the species in the wild.



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GCW AND BEXAR COUNTY KARST RANGES

DRAFT JANUARY 19, 2010
INFORMATION SUBJECT TO CHANGE

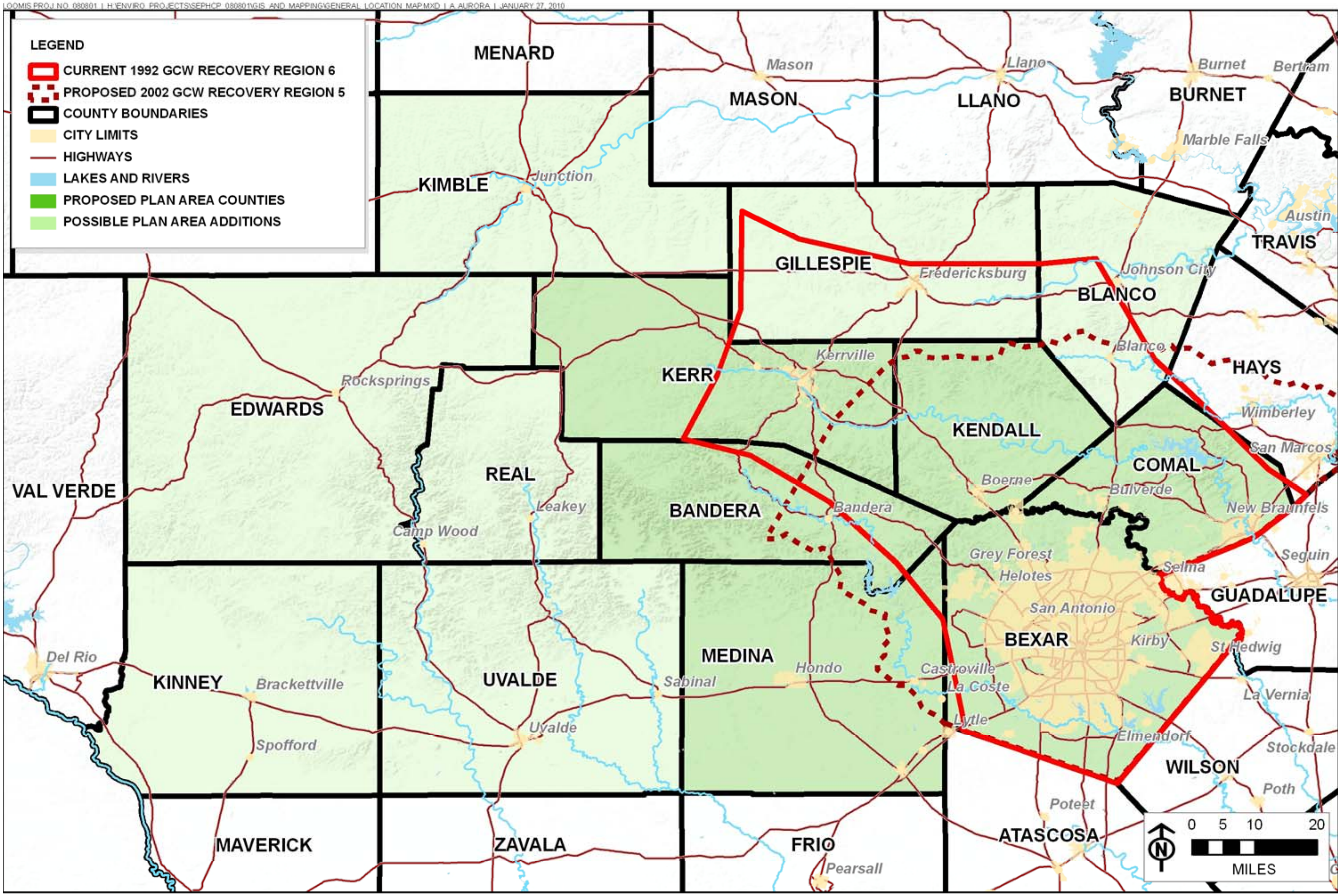
Plan Area Considerations

- The most critical path decision for beginning substantive work on assessing baseline conditions.
- Grant award anticipated a multi-county, regional plan.
  - Mentions Bexar, Medina, Bandera, Kerr, Kendall, and Comal counties for possible inclusion in the regional HCP
  - Generally consistent with the extent of the proposed GCW Recovery Region 5.
- Needs to encompass the area within which take will be authorized and mitigation will be accomplished.

Plan Area Considerations

- Take Considerations
  - Should be relevant to the entities who will hold, fund, and administer the permit.
    - Accommodate economic growth and development within and influenced by the greater San Antonio area over the next 30 years.
- Biological Considerations
  - Should include sufficient opportunities for appropriate mitigation to balance authorized take for each of the covered species.
  - Mitigation should generally be close to the area of impact and within the same recovery region as the impact.
- Administrative & Practical Considerations
  - Should be clearly defined and stable so all parties understand what is included.
  - Should not conflict with the operation of other regional HCPs.
  - Size of the plan area affects the complexity of the plan, which has implications for the project scope and schedule.

LOOMIS PROJ NO. 080801 | H:\ENVIRO_PROJECTS\SEPHCP_080801\GIS_AND_MAPPING\GENERAL_LOCATION_MAP.MXD | A. AURORA | JANUARY 27, 2010



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GENERAL LOCATION MAP FOR THE SEP-HCP

DRAFT JANUARY 29, 2010
INFORMATION SUBJECT TO CHANGE