Final Report: Provision and Inventory of Diverse Aquatic Ecosystem-related Resources for the Great Plains Landscape Conservation Cooperative (GPLCC)

Grant Agreement Number 20181AG915 between U.S. Fish and Wildlife Service and University of Texas at Austin

by

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Provided November 15, 2010

to

James Broska, GPLCC Science Director (James_Broska@fws.gov) via email, download, and on mailed digital media

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Executive Summary

The newly established Great Plains Landscape Conservation Cooperative (GPLCC) is faced with the immense task of having to quickly compile and manage extensive databases or inventories of the biodiversity that it has been charged to manage and sustain, and then with the task of analyzing those huge data sets and capitalizing on them to develop sound, science-based management plans. As if that weren't difficult enough, we now know that the playing field for that planning will be shifting continually as climates change. How do those faced with such difficult tasks proceed? We bring our considerable and diverse expertise to bear on these issues.

The basic task of inventorying biodiversity has actually been under way for many years. Existing natural history museum collections, like those in which we work, can provide major contributions to such inventories in the form of valuable historic organismal occurrence records, and their specimens can be used in many ways for basic research and applied conservation planning. Unfortunately, much of the wealth of information stored in natural history collections requires substantial investment to be made accessible and useful to natural resource managers and researchers.

We were charged by the GPLCC with providing some of the inventory data that will be required, and to assess what other data may be available and what will be required to make it useful. From databases that we and our collaborators (see Acknowledgments) manage, we compiled extensive, high quality data sets on occurrences of fishes, aquatic reptiles and amphibians ("herps"), freshwater mussels, and cave invertebrates from the Texas, New Mexico, Colorado and Oklahoma portions of the GPLCC. We here deliver these >76,000 complete, standardized and normalized records (Appendix 3, summarized in Table 1), over 55% of them georeferenced and in a format that should make them immediately useful to the GPLCC.

We also surveyed our colleagues and otherwise explored availability of other data sets for aquatic organisms in the GPLCC, providing 19 metadata records describing these additional resources. These metadata have been accepted by the National Biological Information Infrastructure (NBII) and will be published by that major metadata aggregating service to assure future availability to interested parties.

We also mined the Global Biodiversity Information Facility (GBIF) for organismal occurrence records within the GPLCC and here provide those nearly 2 million records of over 27,000 species ranging from bacteria through fungi, plants and animals. Unfortunately only about 2% are georeferenced with precision estimates and much work would be required to standardize and georeference these records and make them useful to the GPLCC via applications such as those used in this project.

Once the GPLCC obtains the extensive biodiversity inventories it requires, it is by no means easy to integrate such massive data sets into management planning. However, we demonstrate how raw occurrences for diverse sets of organisms can be effectively combined in computer models with diverse environmental data (including past, present and future) in ways that greatly facilitate planning at the landscape level. Our methods also allow incorporation of complex information on socioeconomic factors that in practice always complicate on-the-ground management into such planning. We do this by first developing powerful predictive computer models of each species' distribution. These models provide a continuous coverage of probabilities of occurrence of each species for all cells of a fine-scale grid extending across the landscape of interest (the entire state of Texas in our demonstration), thus "filling

in the blanks" between the actual occurrences that are limited by many factors such as historic factors, accessibility, and landowner permission. Our models were developed with recent occurrence records and recent climate data, and were thoroughly tested and demonstrated to be powerful predictors of actual occurrences under current conditions. While our demonstration was done statewide for Texas, it uses species that occur in, and are of particular interest to, the GPLCC, and our methods could be used by the GPLCC for its geographic area once appropriate occurrence data are obtained.

However, we know the current conditions on which our models are based are not going to persist; climates are changing globally but, at least for the GPLCC reliable fine-scale predictions of exactly how they will change have not been available. We here provide a solution to the previous lack of high resolution regional climate change predictions by taking the most widely accepted and authoritative, and most recent, global predictions of the International Panel on Climate Change (IPCC) and regionalizing them, at high spatial resolution, for the GPLCC and for all of Texas. We were then able to replace the current climate data that went into our species distribution models with predicted future climate data, and thus compute how species' distributions would shift if those climate predictions were realized.

But, simply knowing how the climate-based habitat suitability for a handful of species might shift under predicted scenarios of climate change does not go a long way toward planning conservation of those and many more species indefinitely into an uncertain future, especially in complex socioeconomic settings that invariably limit management options. To illustrate how substantive progress can be made toward solving such exceedingly complex conundrums, we demonstrate how our species distribution models can be used together with current and predicted future environment and socioeconomic factors as input to a protocol for the selection of priority areas for biodiversity conservation. We use the powerful ConsNet conservation planning program to implement this protocol and produce a portfolio of priority area sets for conservation network planning. Initial results from ConsNet integrate a great diversity of biological knowledge and serve as a baseline starting point from which managers and policy makers can proceed by adding additional levels of multi-criteria analyses of other factors, such as habitat impaction and/or socioeconomic/ecosystem service cost-benefit parameters. With our sample data we demonstrate how, with ConsNet, planners can easily and interactively produce large numbers of variations of such results for diverse criteria of interest, thus providing a large variety of alternatives to consider for potential implementation.

In summary, GPLCC support for this project enabled us to utilize fish occurrence data for Texas that we had been compiling, normalizing and improving for many years and apply it in the rigorous modeling, climate change and conservation network planning exercises reported here. These proof-of-concept demonstrations focused on Texas only because that is the area for which our previous projects provided the required high quality data. However, this project has now begun to compile the basic historic, current and future species occurrence and environmental data sets the GPLCC will need to perform such analyses for its own geographic scope, perhaps applying the same methodologies, data sets and tools we developed and provided in this project. We look forward to continuing to work with GPLCC to build and improve its data resources and tool set to help it address the complex issues it will face as it strives to attain its long-term conservation and sustainability objectives.

0.1 -Introduction

The Executive Summary provides a basic overview and introduction for this project and here we explain simply how this report is structured and how the largely digital products are provided.

The proposal for this grant was structured in two major sections and this report follows the same basic outline. The first major section in the proposal, "List 1 deliverables," included a number of products that the PIs were confident they could provide by the end of the contracted project and all of those are provided and discussed in this report. "List 2 deliverables" of the proposal included many additional products that could potentially be delivered and it was the understanding of both parties that this section would be modified shortly after contracting via discussions between the PI and Program Coordinator, James Broska. PI Hendrickson and Broska met and an agreement on the content of "List 2 deliverables" was finalized in a memo from PI Hendrickson to James Broska on July 9, 2010. The structure of the "List 2 deliverables" section of this report thus follows the outline of that memo.

All deliverables are discussed in this written report and its appendices, and text versions of all data sets are included in this report when feasible. All deliverable data sets will be delivered in electronic format on a physical hard drive delivered to the GPLCC Science Coordinator, James Broska and may also be downloaded via the Internet at https://goodnight.corral.tacc.utexas.edu/tacc/home/gplcc with the user login "gplcc" and password "Fishy".

As noted in the Executive Summary, our report demonstrates how the GPLCC might obtain and manage the large basic biodiversity data sets that it will require to achieve its complex objectives over its large and complex landscape. We do this by focusing, for purposes of this demonstration, on Texas, where we already had the high quality and large biological (on fishes in our case) data set and landscape scale environmental data sets appropriate for such analyses. Though the GPLCC currently lacks such data sets, we compiled and provide occurrence data sets for diverse organisms that help initiate an inventory of data, and we provide copious metadata that will help it compile more. For the modeling analysis, we selected species that we believed to be of particular interest to the GPLCC and for which we had sufficient data to produce high quality distribution models. At the same time, as part of this project, we created new, high resolution, downscaled global climate change predictions (based on the most recent standard IPCC projections), and projected our fish models onto them to see how each species' climate-based habitat suitability might shift if those climate projections are realized.

Finally, we integrated the many species models and multiple biological factors known to affect maintenance of biodiversity into demonstrations of conservation planning protocols. These were constructed using models for the current time period and for different representation targets (proportion of each species' distribution included) to demonstrate how conservation planning for all species might be affected over different levels of conservation priority. While what we provide through model construction and the conservation planning analyses is primarily a demonstration, we hope that we effectively demonstrate to the GPLCC that our methods are sound and productive and that they could be applied to other and larger data sets. The development of such data sets would facilitate progress toward the GPLCC's ultimate goal of managing the landscape and biodiversity it is charged to sustain into the future.

1.0-List 1 deliverables

1.01-Fish occurrence data

We acquired fish occurrence data from the GPLCC from four sources: (1)Texas Natural Science Center's, Texas Natural History Collection, Fishes of Texas database (FoTXdb), which is a compilation of data from 34 museums (as of November 3, 2010); (2)The Sam Noble Oklahoma Museum of Natural History (as of June 28, 2010); (3) The Museum of Southwestern Biology's Division of Fishes (as of June 3 - Sept 15, 2010); and (4) The Larval Fish Lab at Colorado State University (as of September 1, 2010). Those data include 41,080 records covering an approximate date range of 1853-2010. We here provide those data in Appendix 3 with other museum occurrence data provided as part of this report in a single Excel file called "GPLCC Occurrence Data Compilation". Sorting or filtering on the first column (*Collection descriptor*) will aid in finding these data specifically. All data provided on this spreadsheet are provisional and should not be used in publication without the consent of the specific data donors. Donors must be cited in any products derived from this dataset. Table 1 summarizes all donor occurrence data provided as part of this report. To aid in visualizing these data, and all occurrence data received directly from our donors provided as part of this report, we include a map of fish occurrences in the GPLCC area (Figure 1). The map includes only those records for which we were able to obtain coordinates directly from our providers; more records are available in Appendix 3, but could not be mapped without georeferencing.

We have formatted these data so that they fit within our Fishes of Texas Database fields and additional relevant data provided by these institutions has been concatenated and placed in our *Notes(record level)* and *Notes(event level)* fields. In some instances donor's original notes or remarks fields were parsed to retrieve data for our accepted fields, however there may be rare instances where important data that should be included among our accepted fields remains in notes fields.

Here we provide what we received from contributors based on our request for data occurring in the GPLCC area. It is possible that records are missing or that extra records beyond the GPLCC area are included depending on how specific queries were executed by our data donors. Typically a record represents a collection of individuals of a unique species, collected at a specific location on a specific date, however record definitions vary across institutions and collections and may be cataloged such that individuals are unique records. This is important for interpreting summary data, but we have not assessed this for the data provided here.

We have not verified or edited these data in anyway and our formatting only allows us to put them in our accepted fields. In some instances fields for an entire institution or fields for specific records may be missing and in such cases those data may or may not exist with the donor (we simply did not receive them). All questions regarding data specifically should be directed to the relevant donor institution. While we have not evaluated these data for errors, and here accept them as we received them from the donor institutions, we are confident that they would be improved greatly by editing as we have done for our Fishes of Texas Project data.

1.02-Aquatic reptile and amphibian occurrence data

We acquired herpetological occurrence data from the Museum of Southwestern Biology (as of Sept 27, 2010) and the Texas Natural History Collections (as of August 17, 2010). These data include 32,567 records covering an approximate date range of 1905-2009 are provided in Appendix 3 with other museum occurrence data provided as part of this report in a single Excel file called GPLCC Occurrence Data Compilation. Sorting or filtering on the first column (*Collection descriptor*) will aid in finding these data specifically. All data provided on this spreadsheet are provisional and should not be used in publication without the consent of the specific data donors. Donors must be cited in any products derived from this dataset. Table 1 summarizes all donor occurrence data provided as part of this report. To aid in visualizing these data, and all occurrence data received directly from our donors provided as part of this report, we include a map of reptile and amphibian occurrences in the GPLCC area (Figure 2). The map only includes those records for which we were able to obtain coordinates directly from our providers; more records are available in Appendix 3, but could not be mapped without georeferencing.

We have formatted these data so that they fit within our Fishes of Texas Database fields and additional relevant data provided by these institutions has been concatenated and placed in our *Notes(record level)* and *Notes(event level)* fields. In some instances donor's original notes or remarks fields were parsed to retrieve data for our accepted fields, however there may be rare instances where important data that should be included among our accepted fields remains in notes fields.

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We have not verified or edited these data in anyway and our formatting only allows us to put them in our accepted fields. In some instances fields for an entire institution or fields for specific records may be missing and in such cases those data may or may not exist with the donor (we simply did not receive them). All questions regarding data specifically should be directed to the relevant donor institution. It should be noted that MSB did not provide specific locality information (only county) and requests that users contact them specifically for such data. While we have not evaluated these data for errors, and here accept them as we received them from the donor institutions, we are confident that they would be improved greatly by editing as we have done for our Fishes of Texas Project data.

1.03-Mussel occurrence data

We have acquired mussel occurrence data from the Texas Natural Science Center's Non-vertebrate Paleontology Laboratory's Mussel Collection (as of October 13, 2010). Those data include 2,345 records covering an approximate date range of 1991-2004 and are here provided in Appendix 3 with other museum occurrence data provided as part of this report in a single Excel file called GPLCC Occurrence Data Compilation. Sorting or filtering on the first column (*Collection descriptor*) will aid in finding these data specifically. All data provided on this spreadsheet are provisional and should not be used in

publication without the consent of the specific data donors. Donors must be cited in any products derived from this dataset. Table 1 summarizes all donor occurrence data provided as part of this report. To aid in visualizing these data, and all occurrence data received directly from our donors provided as part of this report, we include a map of mussel occurrences in the GPLCC area (Figure 3). The map only includes those records for which we were able to obtain coordinates directly from our providers and much more data is available in Appendix 3, but can only be mapped after georeferencing.

We have formatted these data so that they fit within our Fishes of Texas Database fields and additional relevant data provided by these institutions has been concatenated and placed in our *Notes(record level)* and *Notes(event level)* fields. In some instances donor's original notes or remarks fields were parsed to retrieve data for our accepted fields, however there may be rare instances where important data that should be included among our accepted fields remains in notes fields.

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1.04-Species distribution modeling analyses of Fishes of Texas Database occurrence data. Predictions of climate-based habitat suitability shifts of selected fishes under varied climate change scenarios.

Climate layer construction

Past monthly average, maximum, and minimum temperature and precipitation layers from the Climate Research Unit (CRU) high resolution climate data, version 2.1, were downloaded from the Intergovernmental Panel on Climate Change (IPCC, http://www.ipcc.ch/) Data Distribution Centre (http://www.ipcc-data.org/obs/cru_ts2_1.html). Future climate global circulation models (GCM) from the IPCC 4thAssessment were downloaded from the World Climate Research Programme's (WCRP's) Coupled Model Intercomparison Project (CMIP3) Multi-Model Dataset Archive at the Program for Climate Model Diagnosis and Intercomparison (PCMDI) (http://www-pcmdi.llnl.gov/ipcc/about_ipcc.php). Specifically, the (Australian) Commonwealth Scientific and Industrial Research Organization's (CSIRO)'s A2 and B1 models were selected for future projections.

These future scenarios and models encompass the conservative (B1) and extreme (A2) projected temperature increases expected this century. Using both the most conservative (B1) and the most extreme (A2) among likely scenarios enhances the robustness of the results of the analysis. Climate layers were averaged for each decade, 1901-2000 for past data and 2001-2100 for future data. Using the Computational Information Systems Laboratory's (CISL's) National Center for Atmospheric Research (NCAR) Command Language, each decadal layer (i.e. average, minimum, and maximum temperature and precipitation) was linearly interpolated and corrected for elevation (6.5 °C per 1000 meters), using the Global 30 Arc-Second Elevation Data Set (GTOPO30), to .25 and .05 degree resolutions. Nineteen bioclimatic layers, corresponding to the standard WorldClim (http://www.worldclim.org/) layers most commonly used in species distribution modeling, were created from the interpolated data (Table 2). They differ slightly from the originally proposed climate layers because, in the interest of controlling uncertainty as much as possible, we decided to utilize the fourth IPCC assessment climate data instead of the third. A consequence of this is that the resolution of the layers was only interpolated to 0.05 degree, or approximately 6 km^2. Downscaling the fourth assessment projections to a finer resolution (e.g., 30-arc seconds) would lead to errors because of the uncertainty of model projections (which were only partly quantified in the case of the fourth IPCC assessment). It would also require significantly more time and resources, and we accepted this data quality—resolution tradeoff as necessary in order to begin working with the most up-to-date climate data available. Additionally, this process enabled the construction of 10-year interval climate layers instead of the 30-year intervals we originally proposed. Metadata on the new climate layer sets are included in the metadata compilation in Appendix 2 of this report.

Topographic layer construction

A new set of topographical layers (altitude, slope, aspect, and compound topographical index [CTI]) were constructed in order to ensure consistency in resolution to the climate layers. This task required a large amount of GIS time in order for calculations of these variables to be processed with a minimal loss in precision and for these independently derived data to align properly with the climatic data layers. Altitude was derived from a 2.5 arc-minute worldwide data layer obtained from the WorldClim website (http://www.worldclim.org/) and resampled to a 3 arc-minute resolution (0.05 degree) by registering it to a layer at the desired spatial extent. Aspect was created from this using Spatial Analyst tool in ArcMap 9.3. Slope in degrees was calculated using an altitude layer that was reprojected and resampled to a Mercator-projected coordinate system at a 6 km^2 resolution. CTI was created using the following formula: ln(((flowAccumulation+1)*pixel area)/tan(slope in radians)). Flow Accumulation was calculated using Spatial Analyst tool in Arcmap 9.3. Slope and CTI were then resampled and reprojected back to a geographic coordinate system at 0.05 degrees. Metadata on the new topographical layer sets are included in the metadata compilation in Appendix 2 of this report.

Species distribution models

Current species distribution models (SDMs) were created for a trial group of species (Table 3) using occurrence records obtained from the Track 1 data of Fishes of Texas database (FoTXdb) and various climatic and topographic variables created as described above (Table 2). Models were constructed only for fish species with a minimum of 10 occurrences, with a georeferencing error no larger than the grid

cell diameter, corresponding to a minimum of 10 unique cells on the environmental layer grids. The maximum entropy algorithm encoded in the Maxent software package version 3.3.4 (Phillips et al. 2006; Phillips & Dudík 2008) was used for model construction. Maxent has been shown to be robust for species distribution modeling with presence-only records (Elith et al. 2006). Maxent was parameterized following published recommendations (Phillips et al. 2006, Phillips and Dudik 2008), wherein species models were replicated 100 times with 40% of 'test' localities randomly withheld for testing each replicate model, while the remaining 60% served as model 'training' records. The 100 replicates were then averaged for the final current model. Model performance was evaluated using a (threshold-independent) receiver operating characteristic (ROC) analysis and 11 internal 'training' and 'test' binomial analyses of occurrence omission. The ROC analysis characterizes model performance at all possible thresholds using the area under the curve (AUC). The AUC provides a measure of model performance independent of the choice of any particular threshold (Phillips et al. 2006). Predictions of probability of occurrence are considered random when they do not differ from 0.5, poor when they are in the range 0.5–0.7, and useful in the range 0.7–0.9. Predictions > 0.9 are considered good to excellent (1 = perfect).

The modeling step described above served as a primary filter (Step 1 in species selection for modeling onto future climate layers), during which species' models developed as described above were considered reliable and retained for further analysis if they satisfied three tests: (i) a conservative threshold of 0.9 for the average AUC over 100 replicates (ii) an average *p*-value of 0.05 for all internal training and test binomial occurrence omission analyses among all replicates performed by Maxent, and (iii) a less than five percent difference between average test and training AUC, indicating lack of over-fitting.

Species distribution model past-projection validation

Step 2 was to take the species meeting the above criteria and project these models into the past (average climatic data from 1900-1950), using corresponding historic records from the FoTXdb to validate model performance. Species whose historic occurrence records extracted an average occurrence probability > 0.5 on the past projection model were retained for future projection analysis. Two species (*Notropis potteri, Hybognathus placitus*) with past records resulting in less than an average of 0.5 extracted occurrence probability were retained for future projection analysis on the basis that past projection-validation tests failed due to these species experiencing reduced ranges in the southern extent of their distribution due to suspected human-induced extirpations (Runyan 2007). Future projections are constructed with these two species without a past-projection validation step.

Future projections: climate-based habitat suitability shifts under 2 IPPC climate scenarios

For seven species selected as described above, models were projected onto CSIRO's future (averages over 2021-30, 2051-60, and 2091-00) climatic model under the A2 (extreme) and B1 (conservative) emission scenarios to determine shifts in climate-based habitat suitability (Table 3). (Originally proposed future time intervals (2030, 2050, and 2080) were altered due to the nature of the climatic data created and the ability to construct decadal averages instead of 30 year intervals.). For each of these species we display the current model and each time-interval/climate-scenario combination model for visual comparison (Figures 4-10); the top five explanatory variables are reported for each species as

determined by a Maxent generated AUC variable-jackknife test that determines an AUC for each variable independently (Phillips et al. 2006). Figures of each bioclimatic variable are displayed for each time-interval/scenario combination as well as for the current time period for which the current species distributions were trained on (Figures 11-29), thus permitting visual comparative analysis of habitat suitability shifts due to variables that are most influential in determining a species' distribution. The extents of both the species models and climate models are displayed at a Texas political extent in order to correspond to species occurrence data spatial availability and the species distribution model construction extent.

2.0-List 2 deliverables (as per memo of agreement dated July 9, 2010)

2.01-Assessment of availability of other aquatic insect data [as for fishes above]

We are aware of several potential sources for museum-vouchered aquatic insect data all likely to have data for the GPLCC area. This list is by no means comprehensive and future work would surely yield many more.

1. The University of North Texas' Elm Fork Natural Heritage Museum (http://efnhmuseum.unt.edu/collections/vertebrate.htm) has an aquatic insect collection with approximately 100,000 specimens.
2. Texas A&M University has an insect collection (http://insects.tamu.edu/research/systematics/collection.html) with 1.86 million specimens.
3. The University of Texas (http://www.utexas.edu/tmm/tnhc/entomology/index.html) has a collection with 250,000 specimens, most of which are not databased.
4. The New Mexico Museum of Natural History and Science (http://www.nmnaturalhistory.org/bioscience-collections.html) has a small collection.
5. The University of Kansas (http://www.nhm.ku.edu/ksem/collect/gendscrp.html) has a collection with 4.5 million specimens.
6. Colorado State University (http://www.ecology.colostate.edu/resources/insectcollection.php) has an insect collection with 3 million specimens.

2.02-Merge herp data provided as part of this project into FoTX data schema

See section 1.2.

2.03-Exploration of other collections data via HerpNET, GBIF and other services

A total of 1.9 million georeferenced occurrence records were retrieved for the GPLCC area from the Global Biodiversity Information Facility (GBIF) dataportal on October 10, 2010. GBIF is continually being updated with more and improved data thus future downloads are recommended. We retrieved approximately 1.7 million animal occurrence records from the GBIF dataportal, representing 298 orders, 1,200 families and approximately 41,000 species as listed by the source institutions (Table 4). 1.4 million of these records are observational records with an additional 209,000 representing specimens housed in

museums. Nearly 13,000 are fossil records, of which animal fossils were the large majority. We retrieved 216,000 plant occurrence records representing 99 orders, 672 families and approximately 12,500 species. This dataset is provided as digital media in Appendix 3 as separate text files that correspond to our section downloads. All data provided here are governed by GBIF's data use policies (http://www.gbif.org/) and donors must be cited in any products derived from this dataset.

The GBIF dataportal system allows users to query data via several parameters, including species name, species common name, latitude range, longitude range, collection date, and/or donating institution. The most direct method for retrieving occurrence records for a large area such as the GPLCC, was the use of a large polygon that encompasses the entire GPLCC area. However, due to a GBIF's maximum allowable download capacity of 250,000 records per query, the polygon that encompassed the entire GPLCC area was further broken into 18 separate polygons, with each section representing a latitudinal slice of the GPLCC area. This allowed for complete retrieval of all biological occurrence records within the GPLCC area, which were then combined into a single large dataset. All section downloads were bounded by the same east and west longitudinal values, and had an approximately 1 degree of latitudinal difference. Latitudinal sections with especially dense occurrence records were further divided into 0.5 or 0.25 degree subsections. Table 5 provides a breakdown of each section download, including bounding geographic coordinates of each section and a taxonomic breakdown of the data retrieved. Using these methods we were only able to retrieve records that contain geographic coordinates, however we know that GBIF many records lacking coordinates. Retrieving non-georeferenced records for the GPLCC would be an exceedingly time-consuming and difficult, if not simply impossible, task, whether done taxonomically or geographically (using political boundaries) especially given the record number ceiling limitation of GBIF and the incomplete nature of political geographic and taxonomic fields for many records.

We performed only minimal verification and correction of the data we obtained, but did find significant issues that one might expect for a large dataset retrieved from essentially many institutions each with unique original formats and data fields. Many records had null or conflicting terms for higher taxonomy, lack of date format consistency, few unit values for coordinate precision, lack of datum for any coordinates. Furthermore, based on our own recent work with GBIF data and other museum data that we are now correcting as part of our Fishes of Texas Project, we expect there to be errors in data accuracy as well. In particular, species identifications, dates, and georeferences may be in error, but we make no attempt to assess or correct those here.

Such a large (greater than standard Microsoft Office programs' capacities) and taxonomically broad dataset made attempts to analyze these data time consuming. Verification and errors were addressed with this dataset as best as possible, given our limited time and manpower constraints. Most corrections/additions were focused on completing higher taxonomy fields and correcting obvious instances where taxonomic names were entered in the wrong fields (ex. Coleoptera, an order, listed as species). Such errors would obviously skew summary statistics. We were not able to correct some taxonomy problems and left many of these listed as 'unclassified'. There were approximately 4,000 unclassified records, representing 0.2 % of the total records retrieved. While this alone is not a large

percentage of the total number of records, there are potentially valuable data records among these, some of which may be rare or endangered species.

We selected 15 species of mammals, birds and fish of conservation interest in the Great Plains region to map GBIF record holdings. Of these, 12 are species listed by the US Fish and Wildlife Service as GPLCC "Priority Species", and 3 are from the national endangered species list (Table 6, Figures 33-35). These datasets can be used to assess occurrences throughout the GPLCC.

2.04-Provide occurrence records from the Texas Speleological Society's database of cave invertebrates

We have acquired 327 records from the Texas Natural Science Center's, Texas Natural History Collection cave invertebrate database (as of September 26, 2010). Those data lack dates and specific locality names, but both are retrievable via paper records. These records are here provided in Appendix 3 with other museum occurrence data provided as part of this report in a single Excel file called GPLCC Occurrence Data Compilation. Sorting or filtering on the first column (*Collection descriptor*) will aid in finding these data specifically. All data provided on this spreadsheet are provisional and should not be used in publication without the consent of the specific data donors. Donors must be cited in any products derived from this dataset. Table 1 summarizes these data and all donor occurrence data provided as part of this report.

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We have not verified or edited these data in anyway and our formatting only allows us to put them in our accepted fields. In some instances fields for an entire institution or fields for specific records may be missing and in such cases those data may or may not exist with the donor (we simply did not receive them). All questions regarding data specifically should be directed to the relevant donor institution. While we have not evaluated these data for errors, and here accept them as we received them from the donor institutions, we are confident that they would be improved greatly by editing as we have done for our Fishes of Texas Project data.

2.05-Provide details for possible use of Texas Advanced Computing Center (TACC) as long term data depository for GPLCC data

All of our research data storage and computations are now done on TACC infrastructure. Much of the analysis done for this project would have been far more labor and time intensive to accomplish without access to TACC resources.

We intend to store and provide access to the final report for this project and all associated data sets from TACC infrastructure. As an extension of our research program, TACC is happy to provide that as long as we are actively using their facilities for GPLCC-sponsored research. Should the GPLCC wish, however, to explore longer-term data storage or storage of other data sets with TACC we will facilitate discussions. TACC staff provided the following response when we asked for them about long-term storage of GPLCC data:

> *The management and preservation of digital data is of great importance to the Texas Advanced Computing Center (TACC), and TACC has demonstrated commitment to digital research data through provision of the petabyte-scale data applications facility, Corral, and the 10-petabyte tape archive, Ranch; both of these resources successfully serve the needs of hundreds of researchers at UT Austin and around the country, through the NSF's TeraGrid national cyberinfrastructure program. Our goal is to be able to provide long-term support for storage and access to important digital data products through careful sustainability planning and a diverse portfolio of support. TACC operates a Preservation Network including the resources at TACC and additional resources at geographically distant partner organizations, to ensure the highest possible data integrity across, space, time, natural disasters, and institutional failures. No file stored in the preservation environment has ever been lost.*
>
> *If for any reason TACC is unable to continue hosting GPLCC data, TACC would undertake a formal procedure to inform GPLCC at least six months prior to the time when data may need to be removed, and would work with GPLCC and other partners to provide additional support to maintain the data at TACC, or to identify appropriate transitional resources and to ensure a smooth transition of access services as well as preservation-quality digital objects held in the archive. TACC operates under the conviction that careful contingency and succession planning, while ideally never needed, is nevertheless an essential component of responsible stewardship of digital data in support of scientific research.*

2.06-Provide metadata for all environmental datasets developed by the Fishes of Texas Project

See Appendix 2.

2.07-Preliminary conservation reserve planning

To demonstrate the area prioritization methodology, we used a tabu search algorithm implemented in the ConsNet 2.0 software package (Ciarleglio et al. 2009; Ciarleglio et al. 2010) for systematic conservation planning (Margules and Sarkar 2007). Areas were prioritized for conservation and management in Texas using 128 species for which accurate species distribution models were produced.

We used all 128 species rather than those that only occur in the GPLCC region to ensure that the identified priority areas were biologically meaningful, given that a large portion of the species of concern within the GPLCC could not be modeled due to insufficient data, specifically *Notropis girardi*, *Fundulus kansae*, *Platygobio gracilis*, and *Macrhybopsis tetranema*. In addition, we feel the broader extent of Texas offers a more ecologically meaningful demonstration of ConsNet.

The basic prioritization problem was to identify a minimal set of areas that satisfy adequate representation targets for the species of interest. We present two sets of results. First we present the map of priority areas required for the protection of 10 to 90 percent of the modeled habitat of the species (Figure 30). This is a zonation of the waterscapes of Texas with respect to their conservation value for fish species. This was done to achieve targeted representation of the species in minimal area. Second we present nominal management areas when the targets of representation were 20 and 30 percent (Figures 31, 32). The second set of plans is produced by adding compactness of shape and connectivity as additional criteria optimized for ease of planning and management. We can produce a large number of variations of these results, depending on the criteria of interest, including socioeconomic or ecosystem service criteria. Such a portfolio would give decision makers a large variety of alternatives for consideration for potential implementation.

2.08-Provide metadata for sources of un-vouchered data available to GPLCC

We know of several other sources (or potential sources) of unvouchered fish occurrence data that may have records in the GPLCC area. Most of these have been added to our metadata compilation (Appendix 2).

1. The Oklahoma Department of Wildlife and Conservation (ODWC) has a database created from their fisheries surveys which may be worth exploring, but likely contains mostly game fish.
2. ODWC has a database of environmental data collected by the late Jimmie Pigg during his extensive fish collections.
3. The Texas Parks and Wildlife Department (TPWD) has a database derived from their fish survey data and contains records of game and non-game fish. We have requested this data, but as of yet have not received it.
4. TPWD has scientific collecting permit reports (paper forms and more recently digital) that have not been databased and thus are not easily queried. We have initiated contact but as of yet do not have data.
5. TPWD has a fish kill database that is digitally databased. These data should be accessible, but as of yet we have not been able to acquire them.
6. We (at TNHC) are developing a database of literature-based occurrences as part of our Fishes of Texas Project. The database is quickly growing, and currently contains over 10,300 records from approximately 60 publications. Most of the publications are journal articles, but many are government reports and dissertations.

2.09-Assess availability of other fish data

We know of several other sources (or potential sources) of museum vouchered fish occurrence data that may have records in the GPLCC area. Items 1-4 have been added to our metadata compilation (Appendix 2).

1. James Kennedy at the University of North Texas' Elm Fork Natural Heritage Museum (http://efnhmuseum.unt.edu/collections/vertebrate.htm) has a small databased fish collection that is primarily used for teaching purposes and potentially contains useful occurrence records. We have initiated contact but as of yet do not have data.
2. The New Mexico Biodiversity Collections Consortium (http://nmbiodiversity.org/) offers an online database that can be used to query records in New Mexico, and this data is available through GBIF. However, institutions contributing to this database may also have records for areas of the GPLCC outside of New Mexico and not available via the Consortium's website or GBIF. The following institutions may have relevant data: Eastern New Mexico University (ENMU), Gila Center for Natural History, New Mexico Museum of Natural History, New Mexico State University's Center for Natural History Collections, and the University of New Mexico's Museum of Southwestern Biology (MSB).
3. We recently visited ENMU's fish collection and noted that they have an estimated 5,000 lots of fish specimens, including many from the Texas and Oklahoma portions of the GPLCC. Those records, however are not databased and thus cannot be properly assessed or utilized until they are. They also have insect, mammal, herp and plant collections with probably a similar geographic scope.
4. We recently visited MSB's fish collection and provide their data as part of this report. However they also have a considerable number of fish collections from the GPLCC area that are accessioned but not yet cataloged, and so are not included in the data we provide here.
5. Oklahoma State University (OSU) has a fish collection that has records covering areas of the GPLCC that can easily be obtained from Dr. Anthony Echelle (or see item 6 below).
6. The Atlas of the Fishes of Oklahoma Project maintained by Oklahoma Department of Wildlife and Conservation (ODWC) contains data for vouchered museum specimens at both the University of Oklahoma Sam Noble Fish Collection (OMNH) and Oklahoma State (OSU). These records should be accessible as well directly from those two institutions (and we have already acquired OMNH's data for this report and provide it here), but will in future also be available for download from an Atlas of Fishes of Oklahoma website.
7. The Oklahoma Department of Environmental Quality (http://www.deq.state.ok.us/) may have fish specimens that are not yet included in any museum records.
8. Baylor University's Mayborn Museum Complex (http://www.baylor.edu/mayborn/, previously the Strecker Museum) has a large number of unsorted and uncataloged fish specimens from Texas, mostly collected by Dennis R. Rose. Some are likely from the GPLCC area, but this cannot be determined until those backlogged jars are more carefully examined.
9. Lamar University (http://www.lamar.edu/) has a small collection of Texas specimens some of which may fall in the GPLCC area. Arrangements are being made to accession those into the TNHC.

10. The Texas Commission of Environmental Quality (http://www.tceq.state.tx.us/) and TPWD (http://www.tpwd.state.tx.us/) both have undatabased specimens that have been promised to be deposited and cataloged into the TNHC's fish collections.
11. The Arizona State University Fish Collection has a large number of fish specimens collected in Kansas in the 1950's and 1960's. Data from this collection are not generally accessible via the Internet, only via direct inquiries with the curator Dr. Thomas Dowling (thomas.dowling@asu.edu).

2.10-Research availability of other mussel occurrence data sets

Given the intimate host/parasite relationships between many fishes and mussels, the obviously highly endangered status of most freshwater mussels throughout North American and their apparent susceptibility to changes in environmental conditions, we are keenly interested in obtaining mussel occurrence data for modeling and analysis in conjunction with our new extensive and well developed fish models. While mussel collections exist in natural history museums, as we are well aware from our many years of work developing our Fishes of Texas database that made our current work for the GPLCC possible, extensive effort is required to discover and obtain data from all potential data owners. Furthermore the effort spent in discovering and obtaining data then pales in comparison to the subsequent effort required for digitalization, normalization, georeferencing and generally improving the quality of the data before the required high quality, high resolution models can be produced.

Our search for mussel data generally revealed that collections of mussels exist in Oklahoma, Texas and New Mexico, but our attempts to obtain actual data or even metadata for those were relatively unsuccessful. We will continue to work with our contacts in those states to try to obtain more information about those. Searches of the metadata we compiled for this project will provide information for several collections for which we did obtain at least basic information, but that do not yet have metadata or occurrence records in GBIF. The data we downloaded from GBIF capture what is available from that major data aggregator at this point in time and we point out that little of the mussel data in GBIF is currently georeferenced and mussels are notoriously difficult to identify, so we caution that any application of mussel data in projects like we have done here for fishes should not be attempted without first verifying identifications.

Very shortly before finalizing this report, we obtained mussel data for Texas from 5-years of statewide surveys in Texas funded by Texas Parks and Wildlife Department (TPWD) and carried out by Dr. Luyobov Burlakova. We are in the process of compiling and normalizing these data and it appears all records are georeferenced by field GPS and identifications were well verified. Voucher specimens are widely scattered among many collections, but do exist. TPWD also supplied data from many years of reports to them by Dr. Robert Howells on his mussel survey work, however, we expect that this data set will largely duplicate (and possibly complement to some extent) the data set based on specimens deposited by Dr. Howells at University of Texas Austin that was compiled, normalized and georeferenced for this project by Dr. Ann Molineux. Finally, we have been promised, but have yet to obtain, data from the volunteer-based TPWD Mussel Watch program. We are happy to keep the GPLCC apprised of any mussel data we might obtain in future and to work with the data donors to make them available to the GPLCC.

2.11-Explore taxonomic and geographic expansion of the FoTX website to include GPLCC

A beta test version of our Fishes of Texas Project database web interface is currently accessible (querying by default only our own collection's data, though the database contains data from 41 other collections) at http://www.fishesoftexas.org. We feel it is a useful way to serve diverse compiled biodiversity data like that produced for this project for a specific geographic area. It also attempts to facilitate further data contributions and comments about data that have great potential to improve the database at low cost by exploiting Citizen Science and Crowdsourcing across the web. We have discussed geographic expansion of the scope of the project with our programmer, who sees no major obstacles and who would be willing to work with us to implement a GPLCC-focused data exploration/provision service.

2.12-Explore expansion of existing Citizen Science/Crowdsourcing features of FoTX website and expansion of that system to GPLCC

As noted for taxonomic and geographic expansion of the Fishes of Texas website, implementing citizen science and crowdsourcing features for a GPLCC-focused website is clearly a possibility that we would be interested in exploring with the GPLCC.

3.0-Conclusions and Discussion

3.01-Data Compilation

We provide to the GPLCC biodiversity inventory data and an assessment of other datasets that may be available and what will be required to make them useful. From databases that we and our collaborators (see Acknowledgments) manage, we have compiled extensive, high quality data sets on occurrences of fishes, aquatic reptiles and amphibians ("herps"), freshwater mussels, and cave invertebrates from the Texas, New Mexico, Colorado and Oklahoma portions of the GPLCC. While support for this project enabled us to utilize such high quality data for Texas in the rigorous modeling analyses here reported, these additional primary data could eventually be used by the GPLCC to perform such analyses for its own geographic scope.

From the online database clearing house, Global Biodiversity Information Facility (GBIF), we have compiled and provided approximately 2 million biological occurrence records from the geographic area of the GPLCC for various major taxonomic groups. This substantial dataset is potentially very useful, but unfortunately as currently provided by GBIF, contains relatively little quantification or qualification, substantially limiting its usefulness. As previously mentioned, only about 2% of these records are georeferenced with error estimates that we feel are critical for modeling comparable to what we have done for fishes. Additionally, many records have incomplete taxonomic, date, or locality information, or lack datum information when coordinates are provided. Our work on the Fishes of Texas project (http://www.fishesoftexas.org/) exemplifies the extensive expertise and effort required to to improve, maintain, and analyze such datasets.

We also explored availability of other data sets for aquatic organisms found in the GPLCC, and provided useful metadata records describing the availability and status of these additional resources. These metadata have been accepted by the National Biological Information Infrastructure (NBII) and should soon be published by that major metadata aggregating service to assure future availability to any interested party.

The data provided as described above partially satisfies the GPLCC Action Plan's first objective of obtaining comprehensive, accurate and fully verifiable historic and recent occurrence records. However, subsequent storage and accessibility of these datasets can be a daunting task. For our data storage and analyses, we have come to rely on the Texas Advanced Computing Center (TACC), a research, archival, and computational center for advanced computational science and engineering. TACC is funded through the National Science Foundation, and collaborators include researchers at many U.S. universities as well as government laboratories. As an example of how these services were and are still utilized, this project relied heavily on the TACC supercomputer Ranger, on which we've logged approximately 65,000 CPU hours to produce the models used in the analysis provided here. Additionally, approximately two terabytes of raw data were produced through these analyses, and is stored in TACC's secure archival facility Ranch (http://www.tacc.utexas.edu/resources/data-storage/). Modeling and analyses such as presented in this report are not possible on standard personal computers, or would consume immense time if attempted on such hardware.

3.02-Species Distribution Modeling

In the short time frame allowed by this grant, we explored the consequences of climate change for seven selected freshwater fishes and generated techniques for quantitative and robust estimates of climatic-based shifts in habitat suitability. Generally, species model projections showed substantial southerly shifts in suitability. This is especially apparent in species with distributions centered in Texas and the southern extent of the GPLCC area (e.g., in the Edwards Plateau and southern Rolling Plains ecoregions), with two species (*M. treculii* and *P. carbonaria*) losing nearly all suitability within the study region by 2100 in the A2 climate scenario. Species with distributions centered in the northern areas of the extent (e.g., *N. oxyrhynchus* and *H. placitus*) generally showed model projections with expanded suitability into the study area under both conservative and aggressive climate scenarios. This raises questions of possible pressures due to climate on the northern portions of their range outside of the extent considered in this analysis. One exception to the southerly shifting suitability pattern observed was the result of *Cyprinodon variegatus* models, the range of which increased under both climate change scenarios, expanding up-drainage and eastward.

Limitations to this analysis should be emphasized:

- There is considerable uncertainty about future climate scenarios and results rely on the A2 (extreme) and B1 (conservative) available IPCC emission scenarios. We emphasize that the interpretation of habitat suitability shifts be interpreted with limitations of both scenarios in mind (Beaumont et al. 2008). However, the choice of climate scenarios has a great influence on species distribution modeling, and as demonstrated here the magnitude and direction of a species projection differs with alternative scenarios, underscoring the need to assess the

reliability of the climate data, models, and downscaling techniques used to generate the scenarios. The use of extreme and conservative emission scenarios should shed light on intermediate scenarios. Furthermore, the AR4 (IPCC 4th assessment report) climate predictions for the southern U.S., including Texas, indicate a furthering of the negative century-long temperature trends already seen in the twentieth century, with temperatures rising again later in the second half of the next century. This anomaly is discussed in John Nielsen-Gammon's contribution to "The Impact of Global Warming on Texas", a UT press book currently in press, but viewable at http://www.texasclimate.org/. Nielson suggests that temperature in the south-central US will increase markedly over the next 50 years, countering patterns seen in the AR4 climate data.

- Our models do not explicitly incorporate biotic interactions or land and water development influences (e.g., human interactions), leaving much room for improvement (see below) in modeling applications. This means that there is no estimate of how much of a species' potential habitat it will occupy in future scenarios due to uncertainty about biogeographic and dispersal constraints. These models should be viewed primarily as climate-based shifts in habitat suitability and not predicted shifts in actual species distributions. Interpretations should therefore be limited to direction and magnitude of a potential shift, and the identification of potential future climatic pressures on portions, or the entirety in some circumstances, of a species' current distribution.
- Conclusions drawn from this analysis are limited to the spatial extent utilized. The extents of both the species models and climate models are displayed at a Texas political extent in order to correspond to species occurrence data spatial availability and the species distribution model construction extent. Other objectives reached in this report, such as species occurrence data compilation of neighboring states, will allow the integration of occurrence records on expanded species ranges and extents, permitting the expansion of extent on subsequent analyses. For example, GPLCC priority species such as *Notropis girardi* could not be modeled due to insufficient data within Texas; our data compilation from other museums and the Global Biodiversity Information Facility (GBIF) has added 377 localities (all outside of Texas, georeferencing quality not assessed, see Figure 33). When properly georeferenced and verified, these additional records should enable model construction for this federally threatened species.

It is our aim to continue using our recently developed (and still under development) modeling techniques in order to address important issues in aquatic conservation. One great benefit of these techniques is that they produce snap shots of species' distributions, comparable in nature, that allow insights into species' responses to differing climatic pressures that otherwise are not understood well enough to directly analyze as a mechanistic process (Elith & Leathwick 2009, Guisan & Zimmermann 2000). That said, methodological improvements such as incorporation of additional hydrologically relevant variable layers and improvements in resolution and scale of the bioclimatic data could greatly improve results and allow more precise insights into causal relationships of such phenomena as shifting distributions (e.g., Syphard et al. 2007), assemblage homogenization (e.g., Algar et al. 2009), metacommunity dynamics (e.g., Keith et al. 2008), dispersal patterns and capabilities (e.g., J. T. Anderson et al. 2009, Engler et al. 2009), and instream flow requirements (e.g., Leathwick et al. 2008).

One potential improvement we are exploring is incorporation of the National Hydrography Dataset Plus (NHD+ - http://www.horizon-systems.com/nhdplus/) platform into model analyses and assessments, as well as into a revised version of the conservation planning software platform (ConsNet) that will make it hydrologically based and focused on freshwater conservation networks. Systematic association of modeled probabilities of occurrence to stream segments within this dataset would facilitate a direct stream-segment-based link to land use/land cover variables within the National Land Use/Land Cover database and hydrologic variables within the NHD+. Preliminary analysis incorporating selected NHD+ variables (e.g., cumulative drainage, mean annual flow, stream segment slope) has proven very informative and led to generally improved models, encouraging us to continue research and development. These hydrologic variables and subsequent models could be used to assess, for example, differential flow conditions that taxa experience over a spectrum of potential to realized distributions.

3.03-Conservation Area Prioritization Demonstration

As a demonstration of systematic conservation planning, we constructed a zonation of the waterscapes based on their conservation value for fish species, as well as produced a second set of priority areas (that is, nominal conservation area networks) for the representation of 20% and 30% of fish species' predicted expected occurrences (from the species distribution models) taking into account compactness of shape and connectivity as spatial criteria relevant to management and conservation. The optimization was carried out using tabu search as implemented in the ConsNet software package (Ciarleglio et al. 2009, 2010). The zonation results identify a hierarchy of priority areas, beginning with a solution that identified the highest priority areas, which are those that are required to represent fish species' expected occurrences a 10% target. The initial 10% target of representation identifies priority areas in a combination of large mainstem rivers (e.g., Brazos and Pecos), as well as large tributaries and smaller feeders (e.g., Devils River, Limipa Creek in the Davis Mountains, headwaters of Edwards Plateau drainages, and many, small drainages in the Piney Woods area of southeast Texas). These areas are known to be important for many Texas endemics and species of concern, including the federally listed taxa *Dionda diaboli* in the Devils River, *Cyprinodon bovinus* and *Cyprinodon elegans* in the Limpia Creek Drainage, and *Etheostoma fonticola* in the San Marcos drainage. The next level of priority area identification at 20% shows an expansion of areas previously selected and selection of areas up-drainage from large mainstem rivers. Subsequent higher representation targets increasing identify large mainstem rivers, and generally expand on areas previously selected by incorporating at first large tributary feeders, then smaller tributaries and headwaters.

Within the Great Plains LCC, the initial 10% prioritization identifies areas of the upper Brazos River, Wichita River, Pease River, and upper Red Rivers. At higher targets, the mainstem of these drainages increasingly are selected. At targets of 20% and 30%, the upper Brazos is increasingly selected, which is important habitat for two candidates for federal listing, *Notropis oxyrhynchus* and *Notropis buccula*. At a 50% representation target, most of the Concho and Colorado mainstem and large tributary drainages are incorporated; these areas provide habitat for many Texas endemics such as *Moxostoma congestum*, *Notropis amabilis*, and *Dionda nigrotaeniata*. At a 70% representation target, medium and small tributaries are incorporated into the priority area selected throughout the panhandle. Notably, the Canadian river, which contains a GPLCC priority and federally threatened species, *Notropis girardi*, is not

substantially selected until 40%. This area prioritization could not incorporate this imperiled species, among others such as *Machybopsis tetranema, Fundulus kansae,* and *Platygobio gracilis*, due to insufficient data for species distribution model construction. We would need to compile more records for these species, most likely from outside of Texas, in order to produce models of sufficient quality to include them in such conservation planning work.

The second set of results was produced by adding compactness of shape and connectivity as additional criteria optimized for ease of planning and management. These two maps fit within the patterns of priority area selection seen at similar targets in the zonation analysis. At a 20% representation target, there is a similar selection of priority areas in the Piney Woods ecoregion of southeast Texas, Guadalupe and central Colorado River mainstems, headwaters of southern Edwards Plateau streams, as well as the Devils and Pecos Rivers. The difference from the zonation map is that large compact areas are identified as units to be potentially put under a conservation plan. At a 30% representation target, most priority areas expand, incorporating larger areas of the Brazos River, Northeast Texas drainages. The most notable increase in area between the two targets is the incorporation of a large area of the Conchos River watershed, a large tributary of the Colorado River that is the southernmost drainage within the GPLCC, and critical for many central Texas endemic taxa as noted above.

These initial results should be regarded only as a preliminary area prioritization. The zonation analysis will require future modification through the incorporation of additional species. In the case of the prioritized areas at the 20% and 30% targets of representation, a variety of additional criteria must be incorporated before areas for conservation and management are identified for implementation in the field. These should presumably include socio-economic criteria. ConsNet permits the incorporation of an indefinite number of criteria through multi-criteria analysis but the performance of such an analysis remains a task for the future. Finally, the 20% and 30% targets are arbitrary in the sense that they were based on educated intuitions about what may potentially be implemented in the field but have no further biological basis. These results should be regarded as the first step in initiating a discussion about what targets are appropriate, including the question whether targets should be varied between species depending on their conservation and endemicity status.

Acknowledgements

We gratefully acknowledge the considerable support provided by our primary collaborators in this project. At University of New Mexico's Museum of Southwestern Biology, Ms. Alexandra Snyder, Fish Collection Manager, worked diligently to provide fully georeferenced and high quality fish occurrence data for the GPLCC, as did Mr. David Giermakowski to provide occurrences for reptiles and amphibians. Both also put us in contact with other collections in New Mexico that provided either data and/or metadata. Similarly, Dr. Edie Marsh Matthews and assistants at University of Oklahoma provided fish occurrence records for theGPLCC focused on Oklahoma, and contacts with diverse other collections at University of Oklahoma and elsewhere in that state. At the Larval Fish Lab at Colorado State University, Dr. Kevin Bestgen supplied fish occurrence records. Many staff at University of Texas at Austin worked diligently on this project: James Reddell and Travis LaDuc each provided data from their collections. Adam E. Cohen managed all of the incoming data, formatting, normalizing and summarizing it for

applications in modeling and report production. Dr. Muhammad J. Shaikh and Matthew Moskwik were critical for construction and provision of the climate layers necessary for future projection modeling. The GIS skills and computer modeling and data management expertise of both Ben Labay and Blake Sissel were critical for production of the models and other products presented here. Adam Cohen, Ben Labay and Dr. Floyd Douglas Martin all participated with the PI in various phases of the project that required their considerable knowledge of biology, ecology and distributions of regional fishes. Jeremy Harrison also assisted in data management, metadata compilation and production of GIS products. Chris Jordan and staff at the Texas Advanced Computing Center provided much support and expertise in the facilitation of running the species distribution models as well as archival of datasets and databases. Alexandra Myers managed the mussel database that is provided here. At many other institutions, others too numerous to mention here by name contributed metadata for diverse collections, and often their names can be found as contacts in the metadata provided here.

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4.0-Appendices

4.1-Appendix 1: Tables and Figures

Donor Data tables and figures

Table 1. Donor data summaries for major taxonomic groups.

Donor Collection	No. Record	No. of Georeferenced Records	Approximate Date Range	No. Genera	No. Species
Cave Invertebrates					
Texas Natural Science Center, Texas Natural History Collection, Cave Invertebrates Collection	327	none	unknown	86	105
Fishes					
Colorado State University Fish	6,605	2,552	1905-2010	39	61
Museum of Southwestern Biology Fish Collection	18,888	14,573	1939-1977	56	83
Oklahoma Museum of Natural History Fish collection	9,982	9,794	1921-2009	44	92
Texas Natural Science Center, Texas Natural History Collection, Fishes of Texas Project	5,605	5,605	1853-2004	48	104
Total Unique Records	41,080	32,524		71	148
Herps					
Museum of Southwestern Biology Herpetology Collection	18,254	8,768	1905	87	178
Texas Natural Science Center, Texas Natural History Collection, Herpetology Collection	14,313	40	1947-2009	59	121
Total Unique Records	32,567	8,808		87	178
Mussels					
Texas Natural Science Center, Non-vertebrate Paleontology Mussel Collection	2,345	1,218	1991-2004	29	46

Donor Data figures of georeferenced data per institution and major taxonomic group

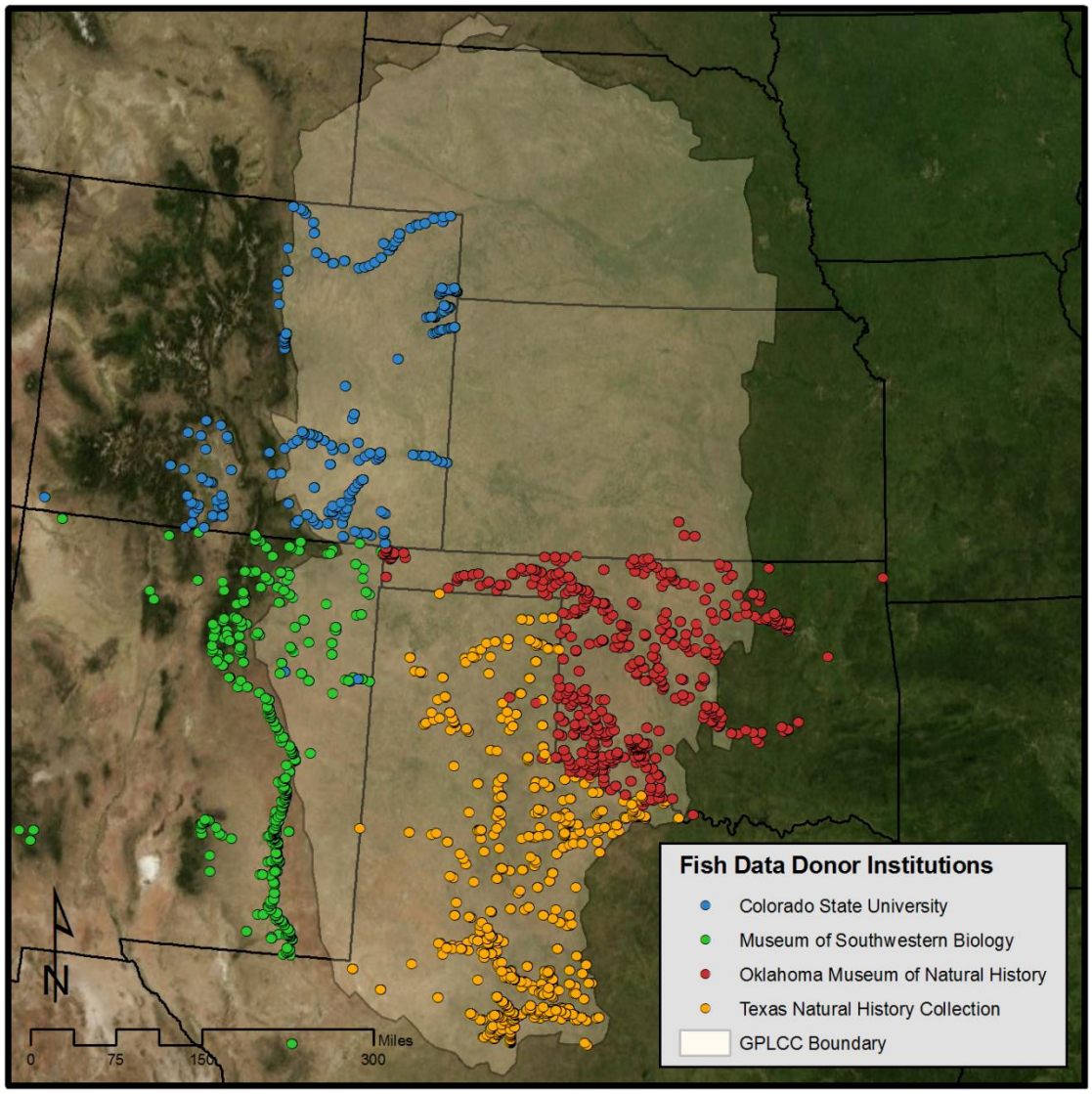

Figure 1. Map of georeferenced fish occurrence records received from primary data contributors for this project. Many additional data points were obtained and are delivered in products provided together with this report, but are not yet georeferenced and thus not mapped.

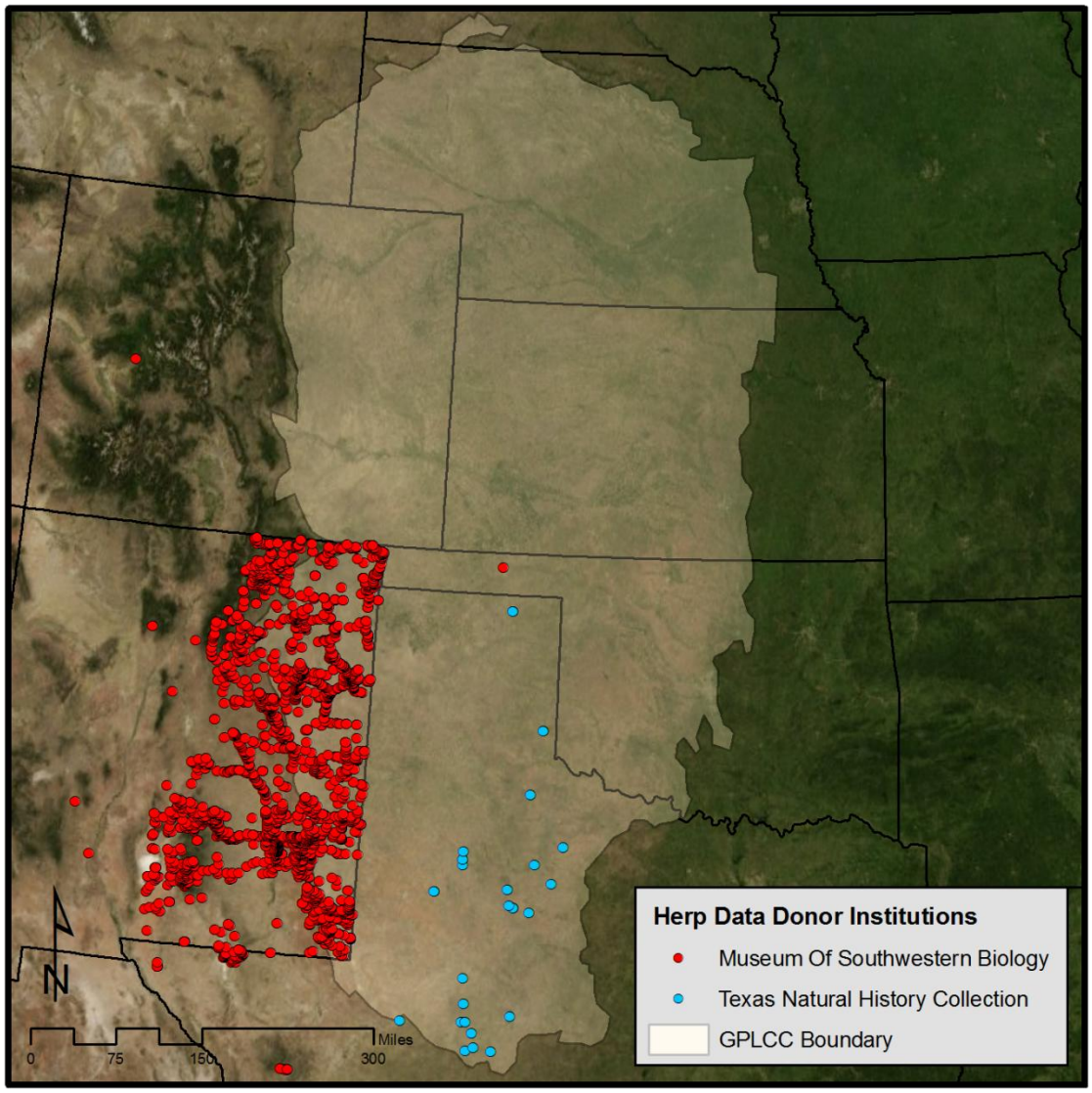

Figure 2. Map of georeferenced herp (reptile and amphibian) occurrence records received from primary data contributors for this project. Many additional data points were obtained and are delivered in products provided together with this report, but are not yet georeferenced and thus not mapped.

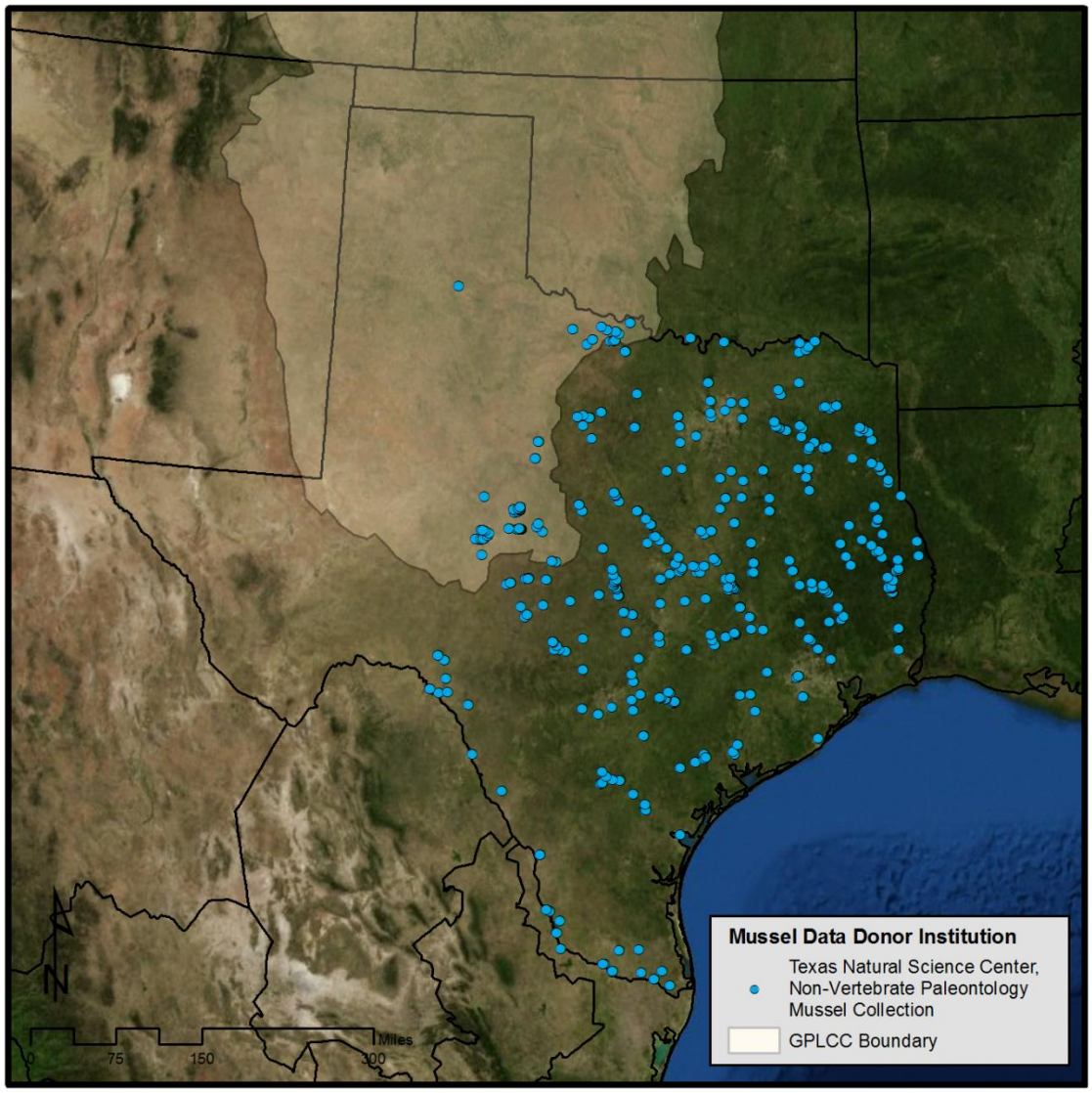

Figure 3. Map of georeferenced mussel occurrence records received from primary data contributors for this project. Many additional data points were obtained and are delivered in products provided together with this report, but are not yet georeferenced and thus not mapped.

Species Distribution Modeling tables and figures

Table 2. Variables created for SDM climate modeling. Climatic variables were created for each decade from 1900 to 2100 with future decades (2000-2100) calculated under both the A2(extreme) and B1(conservative) IPCC climate change scenarios.

Layer category	Layer
Topological Layers	aspect
	slope
	compound topological index (ln(acc.flow/tan[slope]))
	altitude
Climate Layers	P1. annual mean temperature
	P2. mean diurnal range (mean of monthly (max temp - min temp))
	P3. isothermality (P2/P7)(*100)
	P4. temperature seasonality (sd *100)
	P5. max temperature of warmest period (~month)
	P6. min temperature of coldest period (~month)
	P7. temperature annual range (P5-P6)
	P8. mean temperature of wettest quarter
	P9. mean temperature of driest quarter
	P10. mean temperature of warmest quarter
	P11. mean temperature of coldest quarter
	P12. annual precipitation
	P13. precipitation of wettest period (~month)
	P14. precipitation of driest period (~month)
	P15. precipitation seasonality (coefficient of variation)
	P16. precipitation of wettest quarter
	P17. precipitation of driest quarter
	P18. precipitation of warmest quarter
	P19. precipitation of coldest quarter

Table 3. Full list of trial species modeled; species modeled onto future climate scenarios in bold.

Genus species	Common Name	1951-present records	1900-1950 records (past-projection validation set)
Campostoma anomalum	Central Stone Roller	825	94
Cyprinella venusta	Blacktail Shiner	2027	83
Cyprinodon variegatus	**Sheepshead Minnow**	**321**	**43**
Etheostoma lepidum	Greenthroat Darter	253	15
Fundulus grandis	Gulf Killifish	369	24
Fundulus zebrinus	Plains Killifish	313	13
Hybognathus placitus	**Plains Minnow**	**114**	**10**
Micropterus treculii	**Guadalupe Bass**	**230**	**23**
Moxostoma congestum	**Grey Red Horse**	**210**	**21**
Notropis oxyrhynchus	**Sharpnose Shiner**	**61**	**10**
Notropis potteri	**Chub Shiner**	**90**	**14**
Notropis shumardi	Silverband Shiner	95	11
Percina carbonaria	**Texas Logperch**	**178**	**17**
Pimephales vigilax	Bullhead Minnow	1613	143

Species figures: models constructed on Texas political extent to correspond to species occurrence data spatial availability

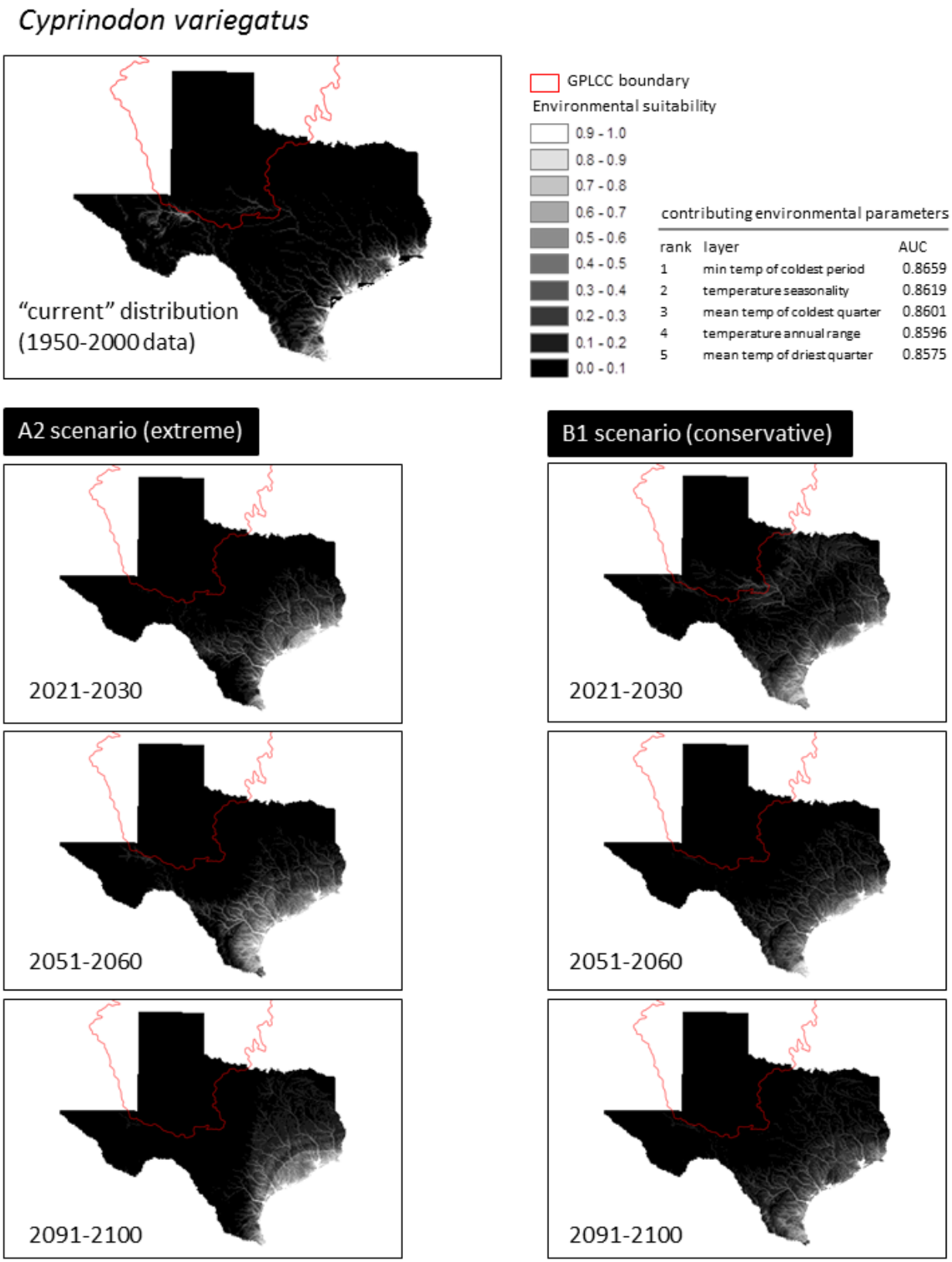

Figure 4. *Cyprinodon variegatus*: Future climatic-based habitat suitability shifts under 2 IPCC climate scenarios. The top 5 species-specific contributing environmental parameters are reported.

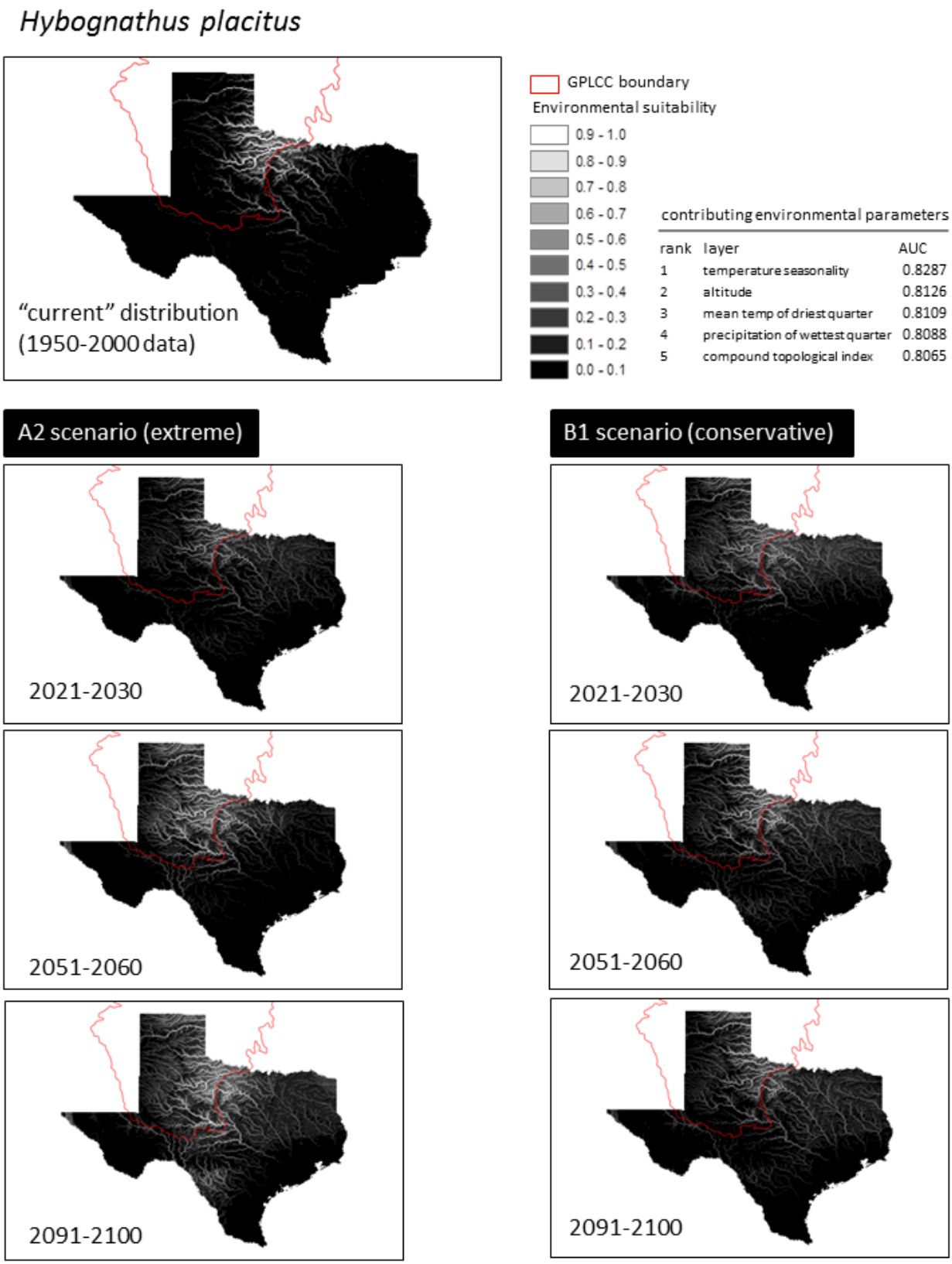

Figure 5. *Hybognathus placitus*: Future climatic-based habitat suitability shifts under 2 IPCC climate scenarios. The top 5 species-specific contributing environmental parameters are reported.

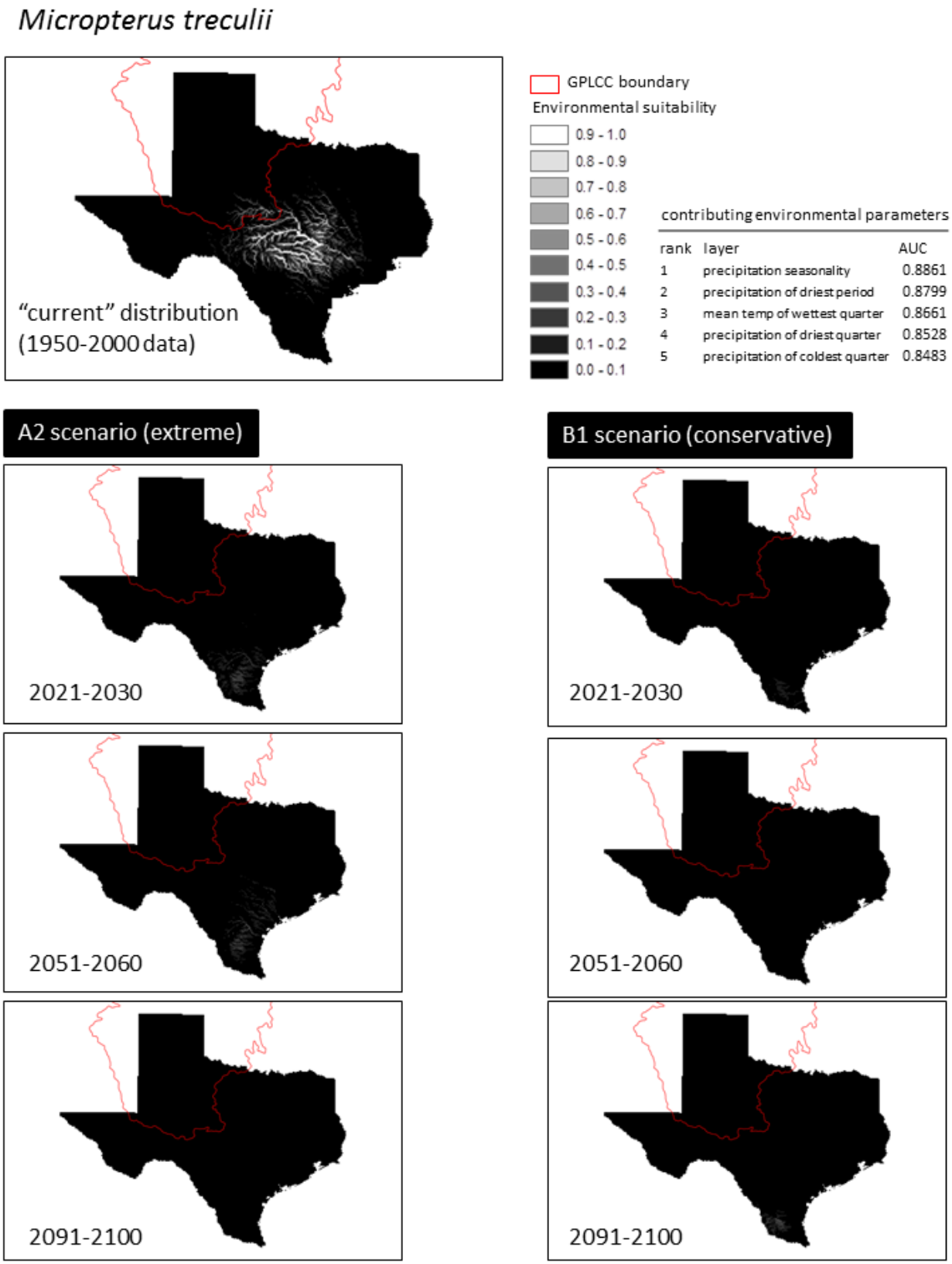

Figure 6. *Micropterus treculii*: Future climatic-based habitat suitability shifts under 2 IPCC climate scenarios. The top 5 species-specific contributing environmental parameters are reported.

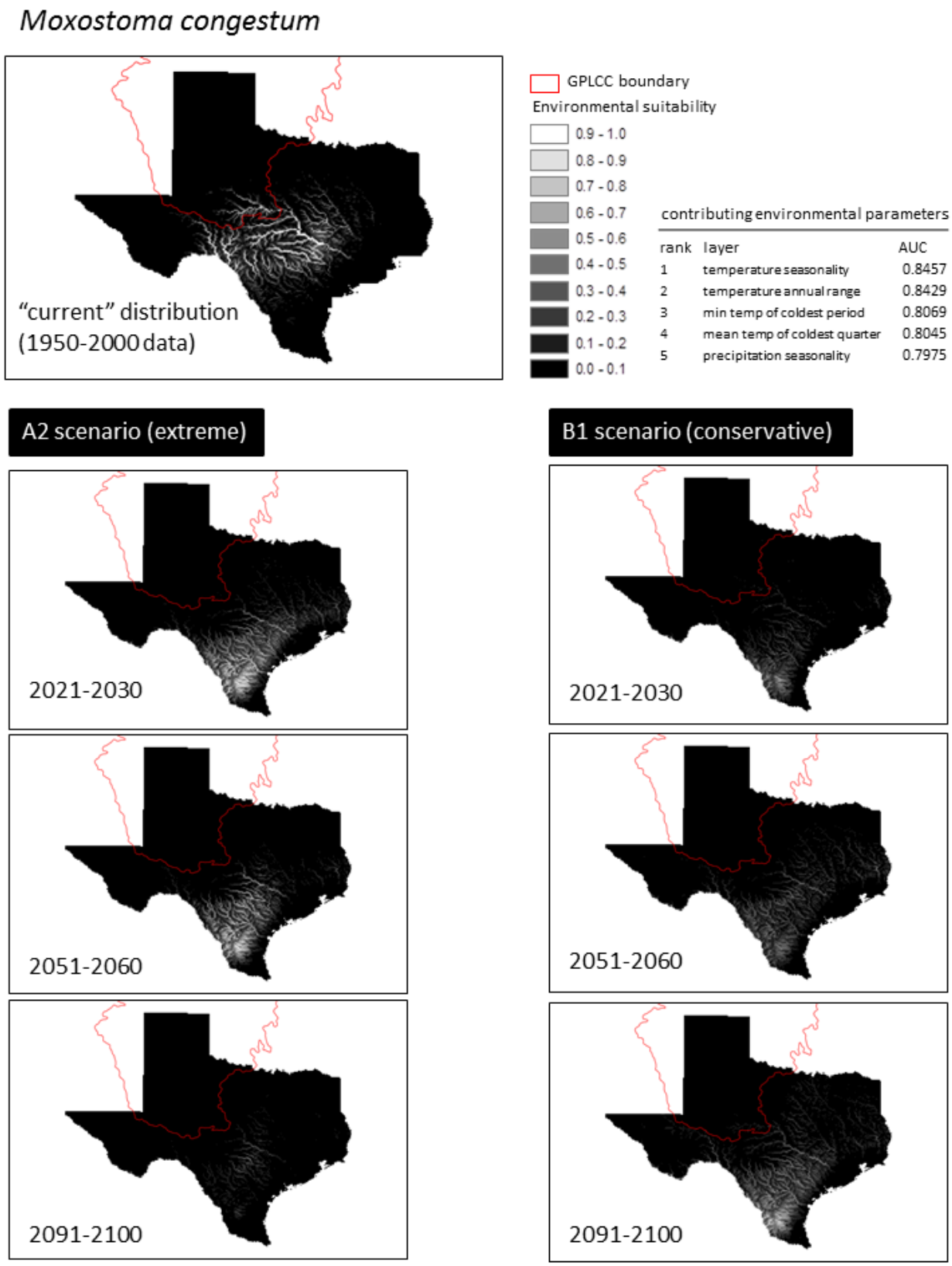

Figure 7. *Moxostoma congestum*: Future climatic-based habitat suitability shifts under 2 IPCC climate scenarios. The top 5 species-specific contributing environmental parameters are reported.

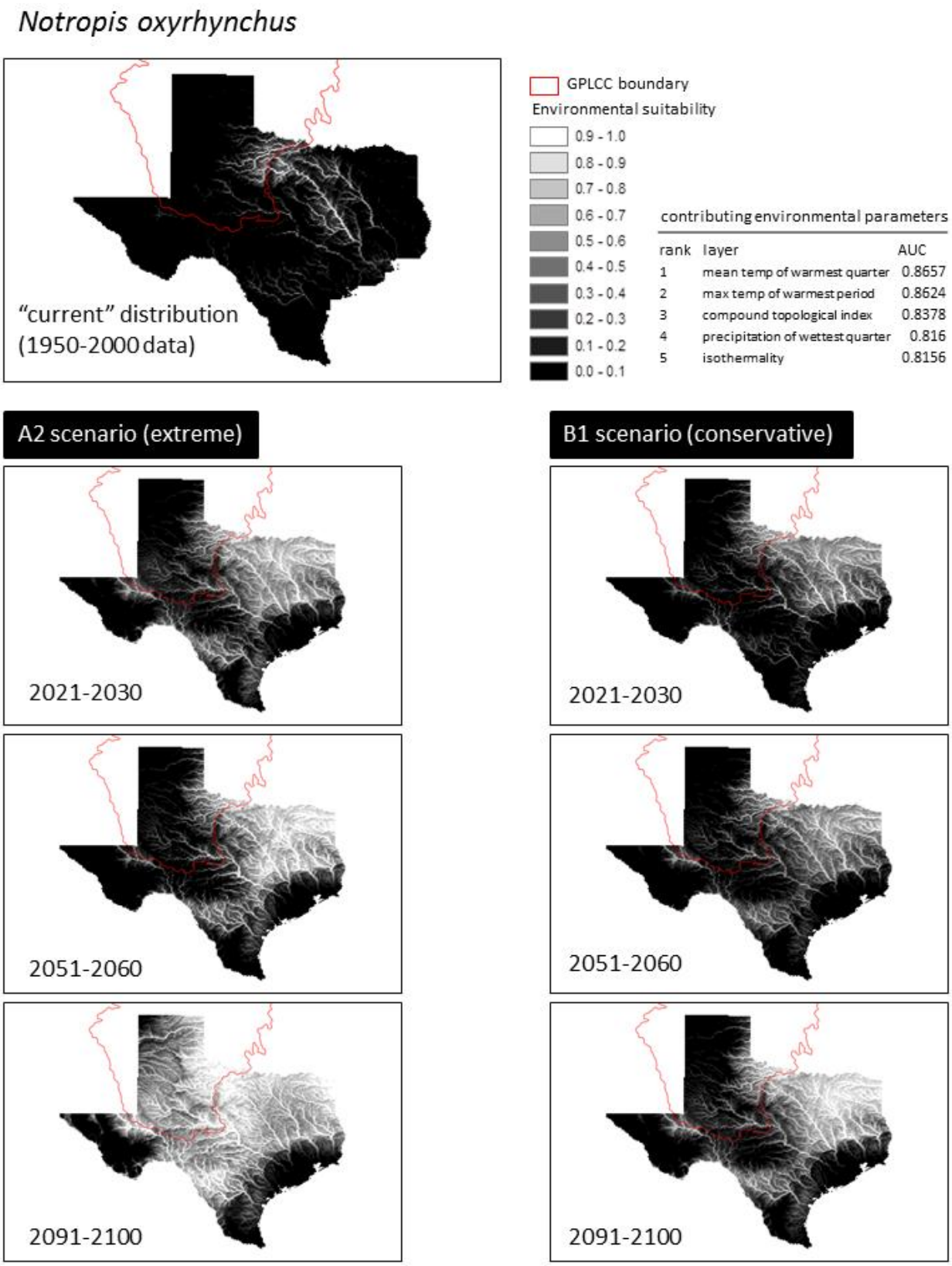

Figure 8. *Notropis oxyrhynchus*: Future climatic-based habitat suitability shifts under 2 IPCC climate scenarios. The top 5 species-specific contributing environmental parameters are reported.

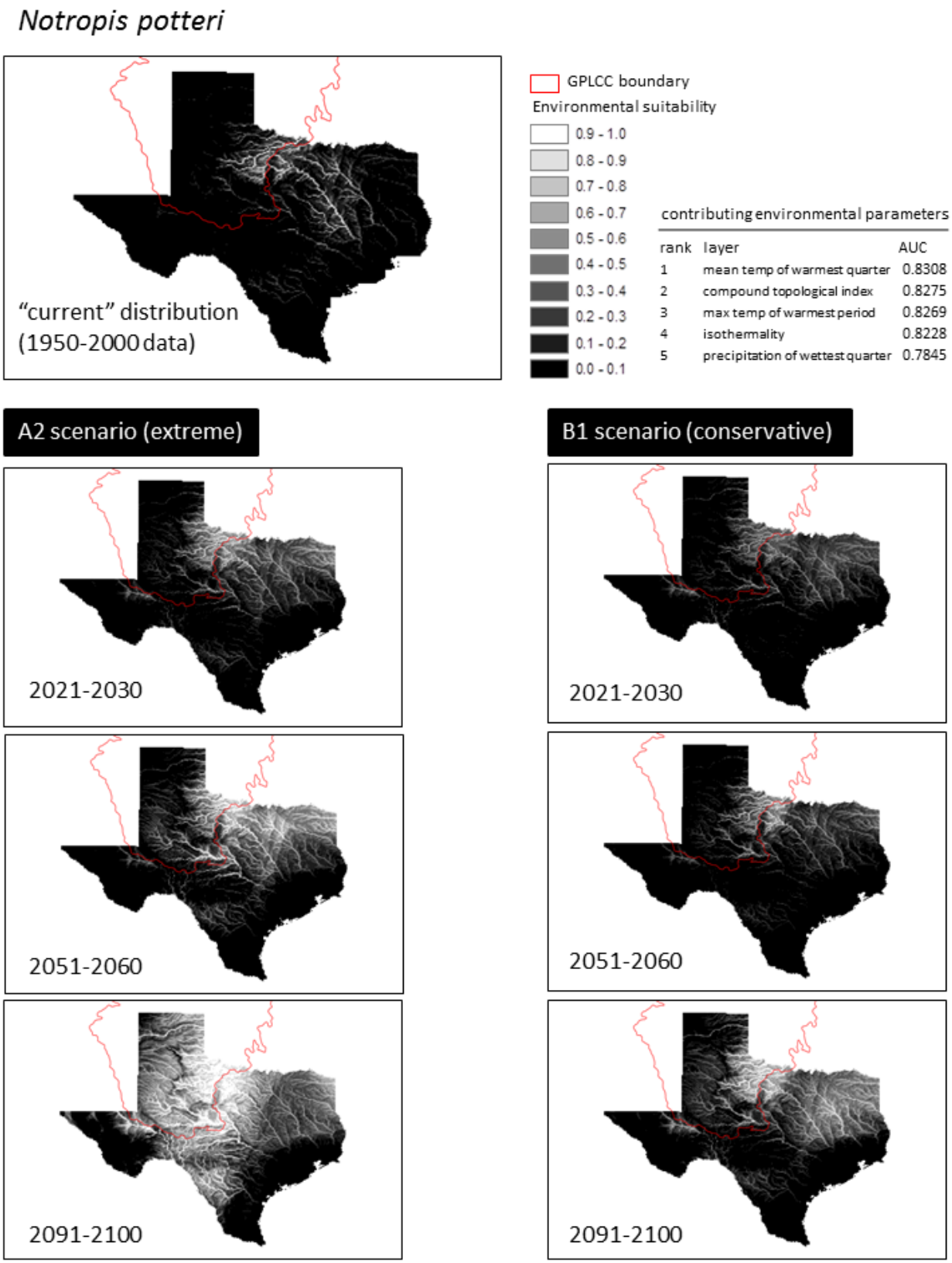

Figure 9. *Notropis potteri*: Future climatic-based habitat suitability shifts under 2 IPCC climate scenarios. The top 5 species-specific contributing environmental parameters are reported.

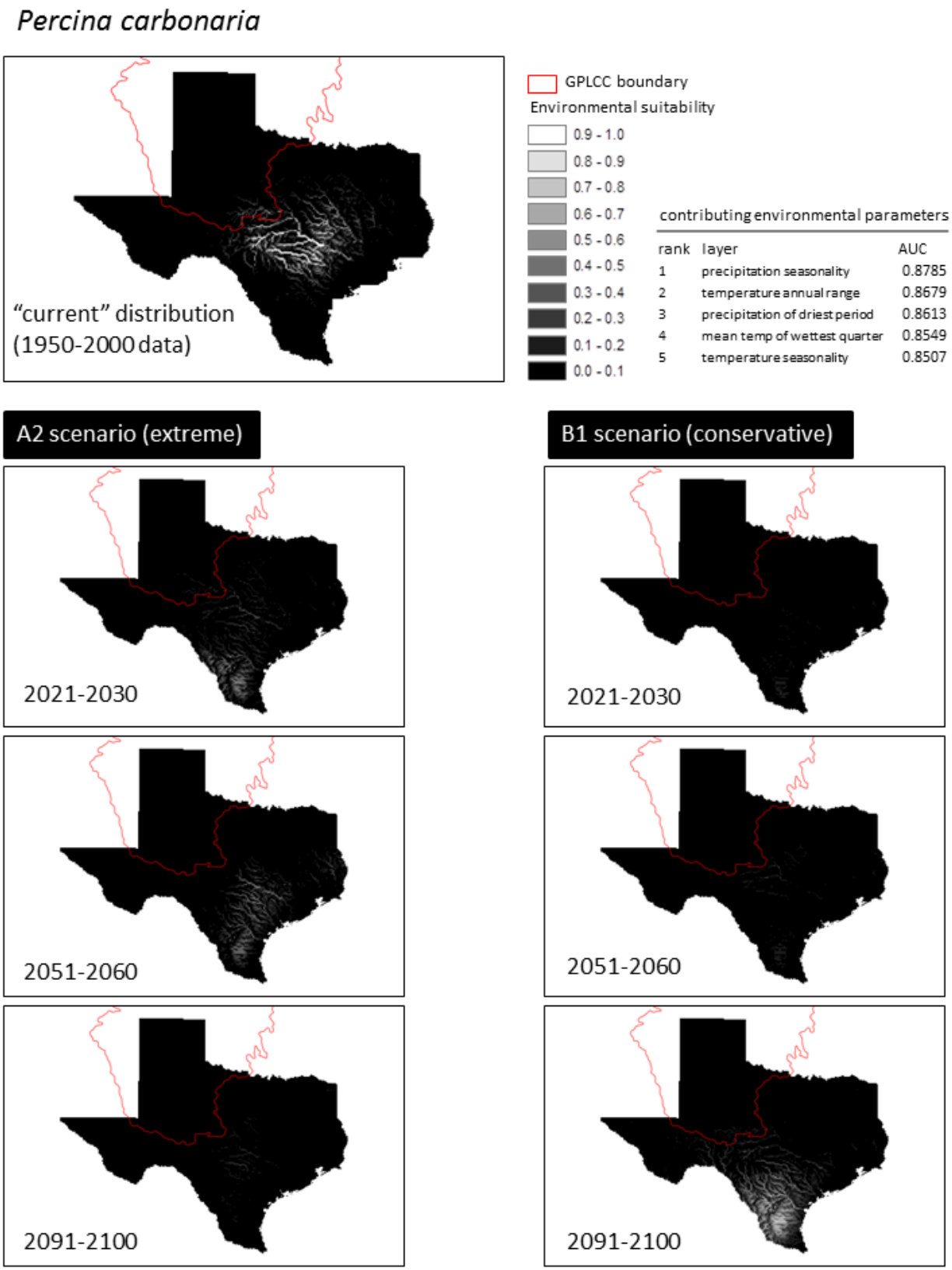

Figure 10. *Percina carbonaria*: Future climatic-based habitat suitability shifts under 2 IPCC climate scenarios. The top 5 species-specific contributing environmental parameters are reported.

Climate figures: models displayed with a Texas political extent to correspond to species occurrence data spatial availability and species distribution model construction extents.

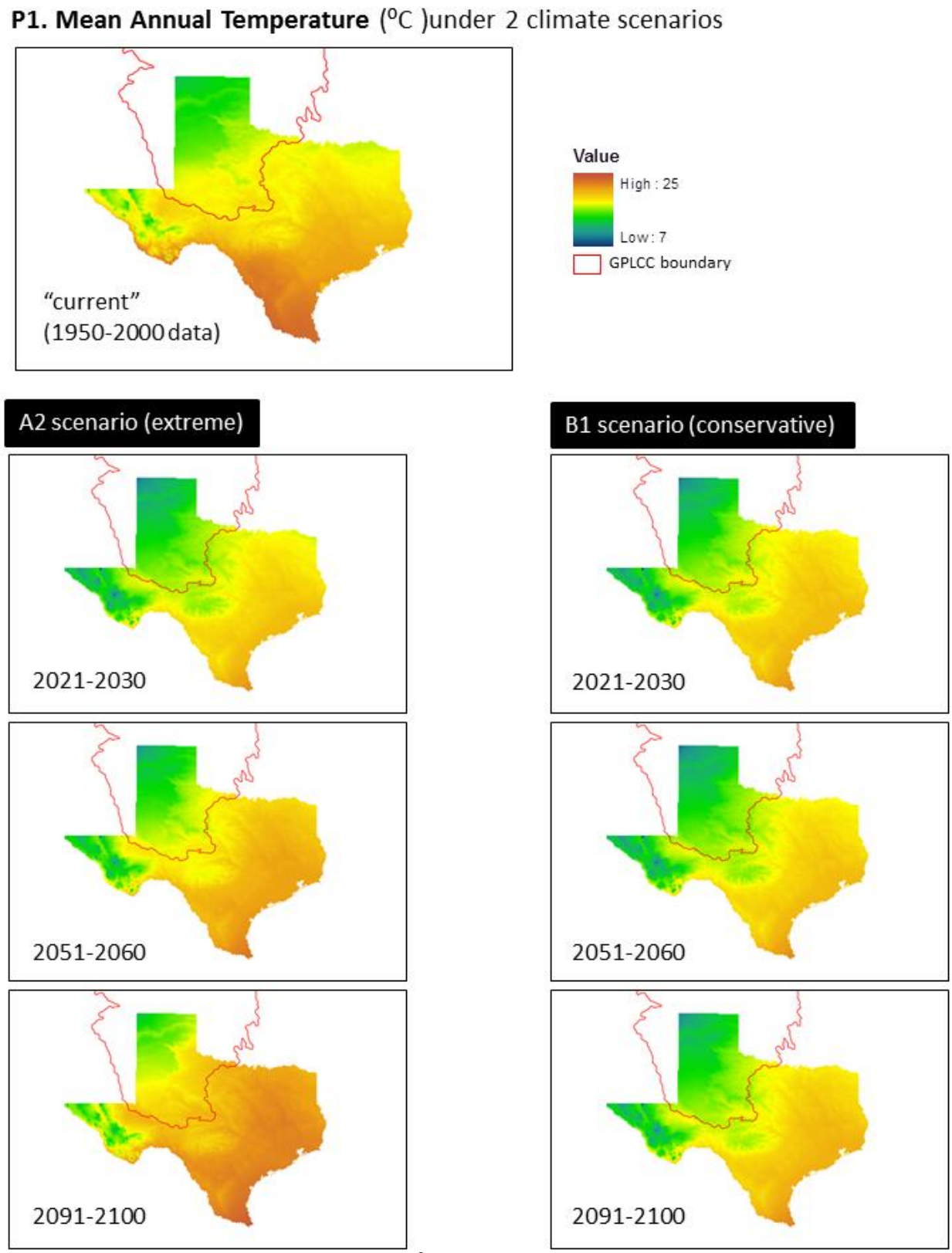

Figure 11. P1. Mean Annual Temperature (^{0}C) under 2 climate scenarios

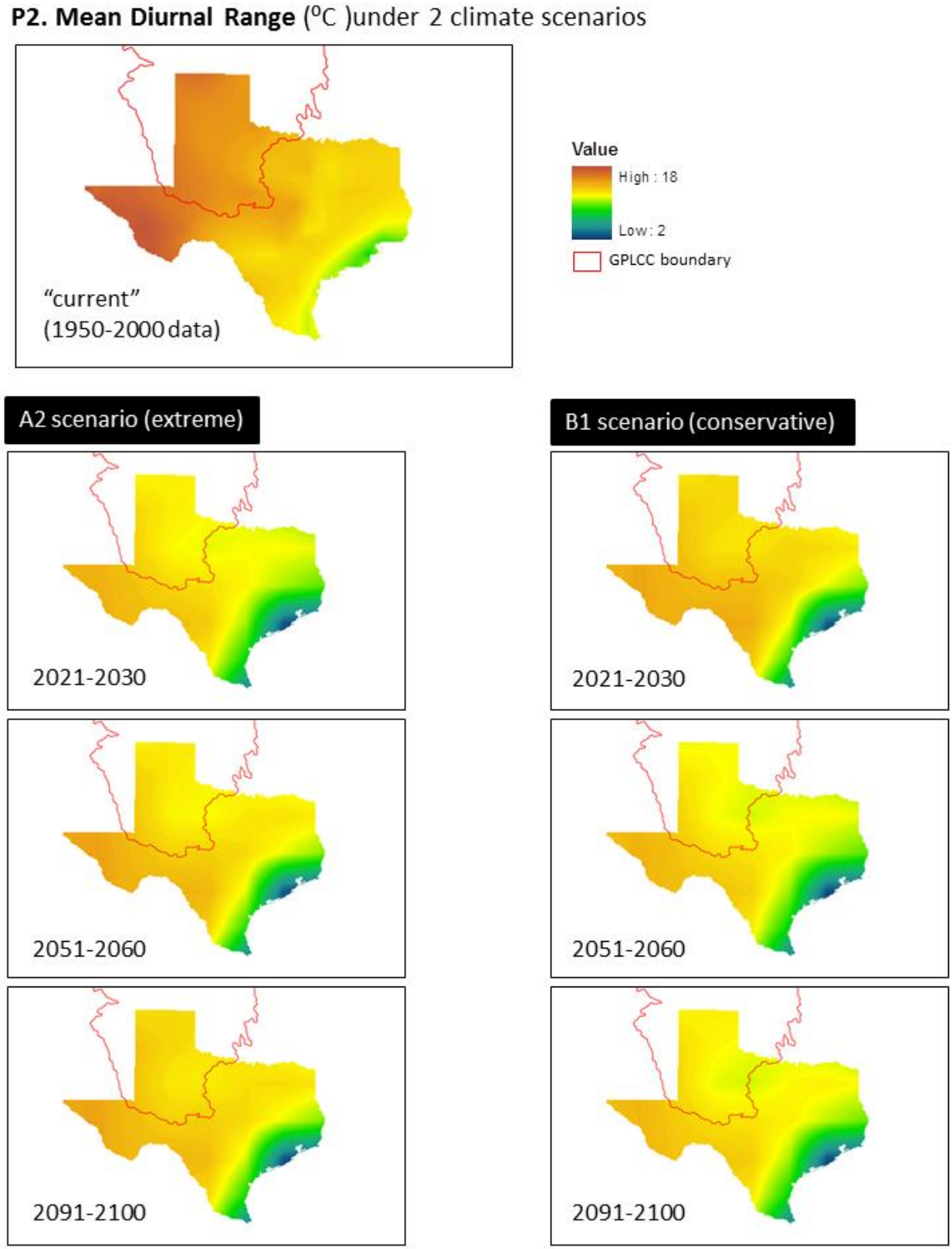

Figure 12. P2. Mean Diurnal Range (^{0}C)under 2 climate scenarios

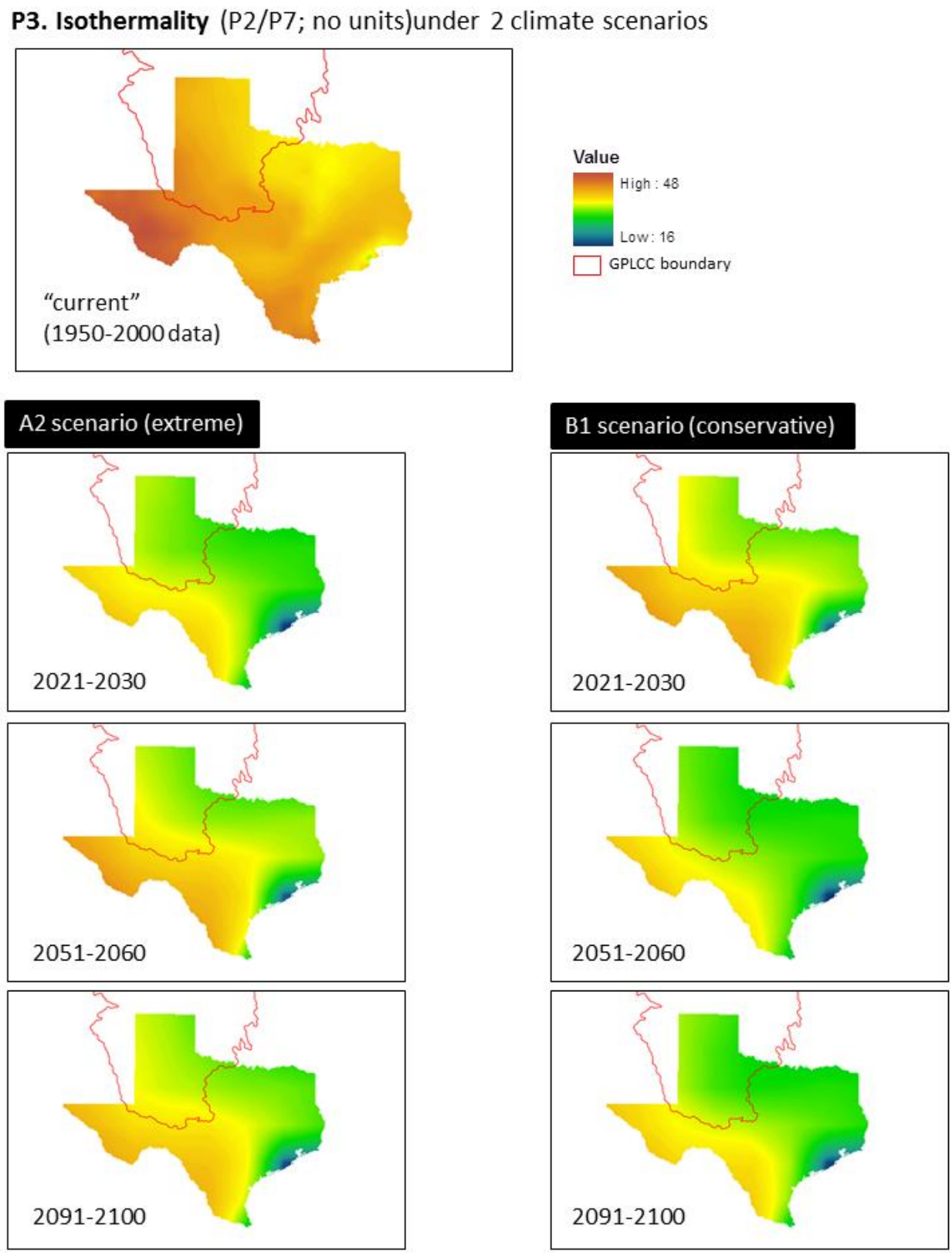

Figure 13. P3. Isothermality (P2/P7; no units)under 2 climate scenarios

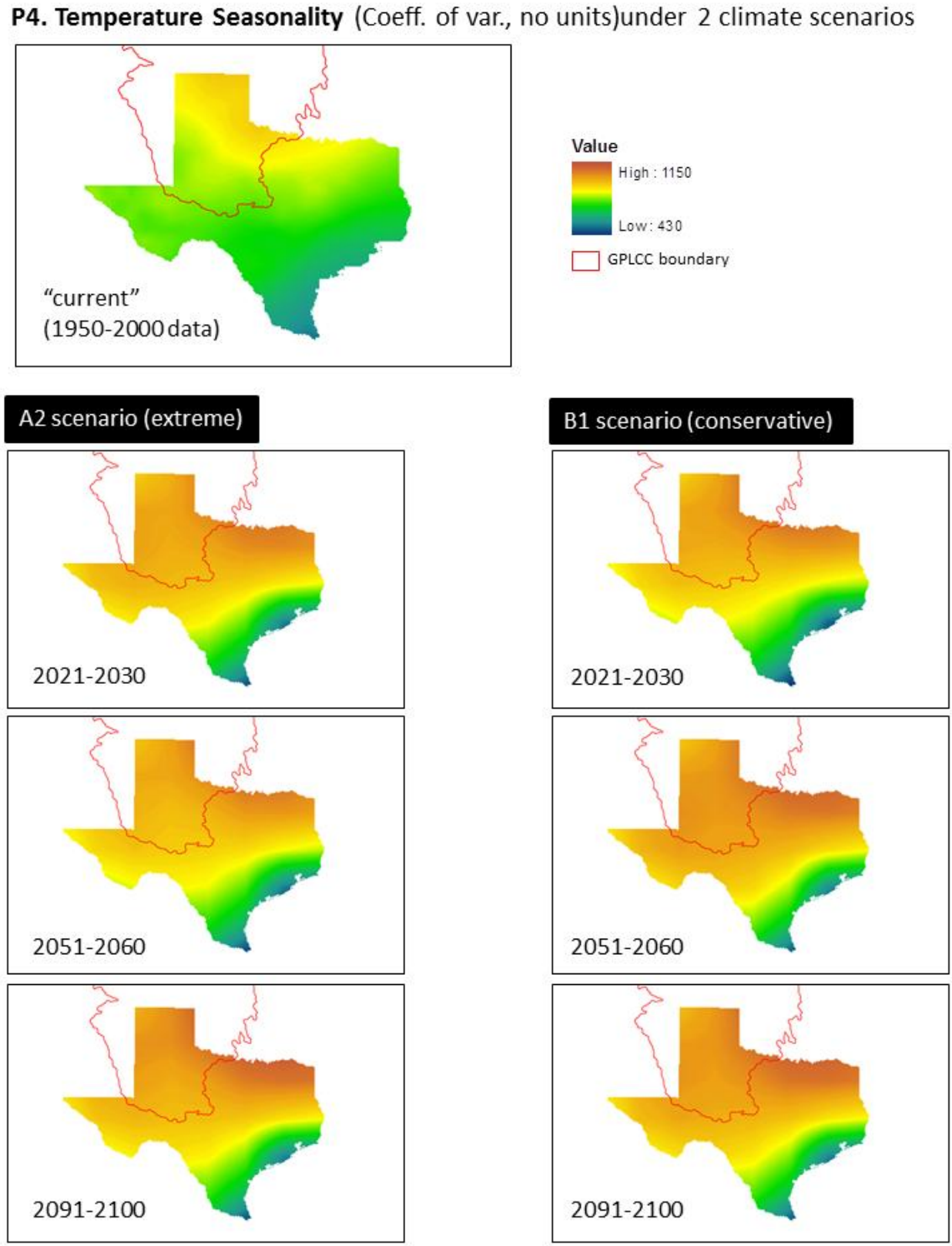

Figure 14. P4. Temperature Seasonality (Coeff. of var., no units) under 2 climate scenarios

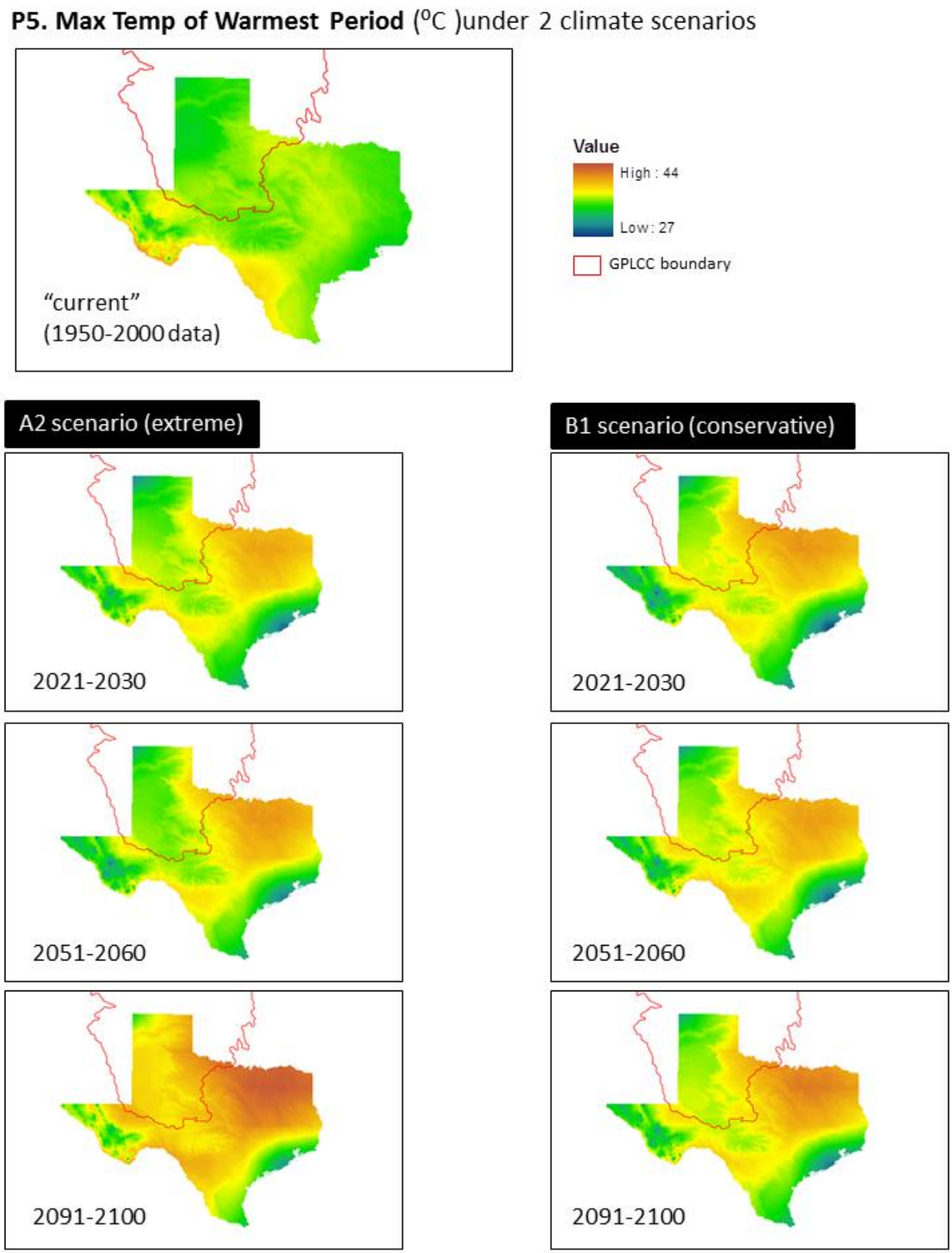

Figure 15. P5. Max Temp of Warmest Period (^{0}C) under 2 climate scenarios

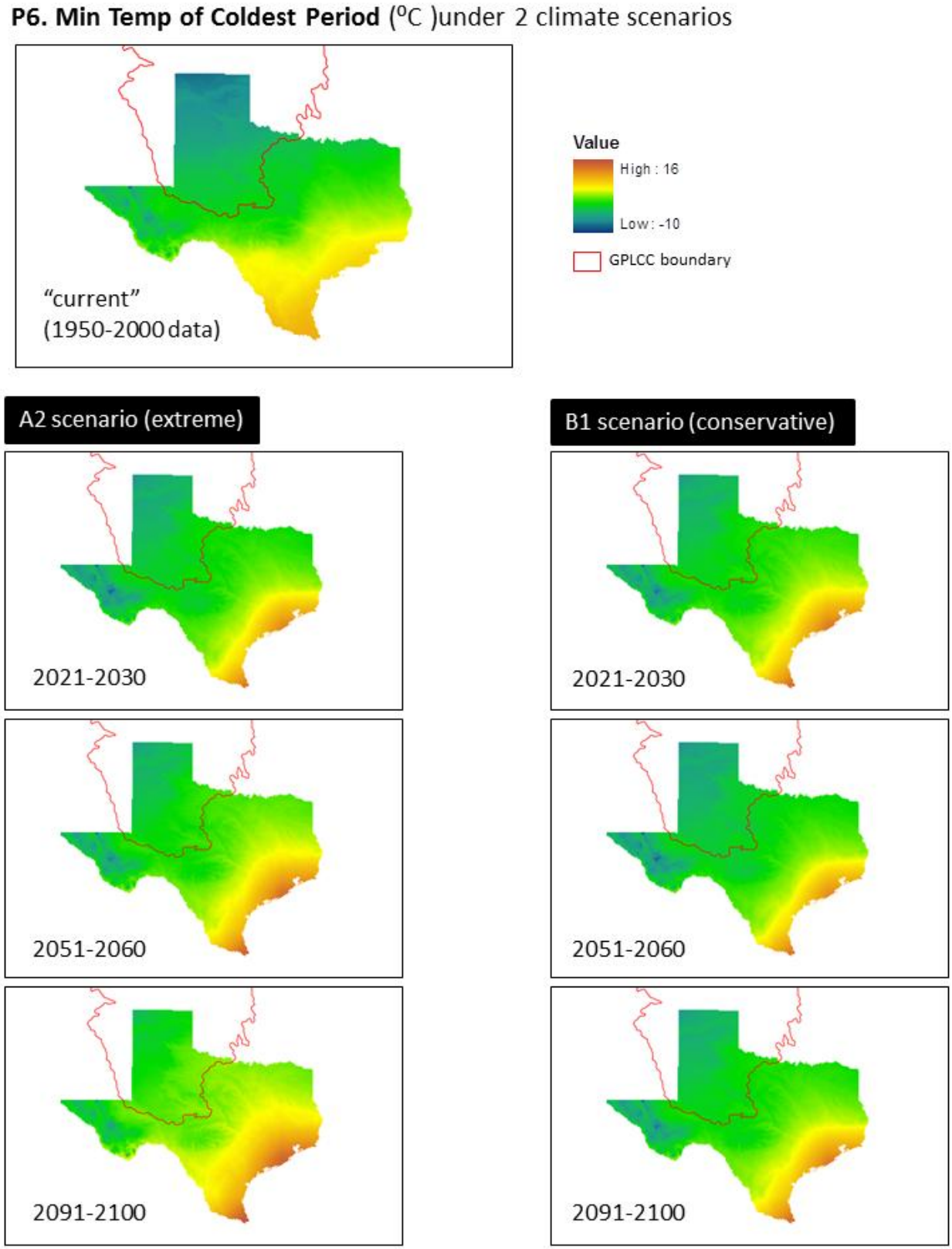

Figure 16. P6. Min Temp of Coldest Period (^{0}C) under 2 climate scenarios

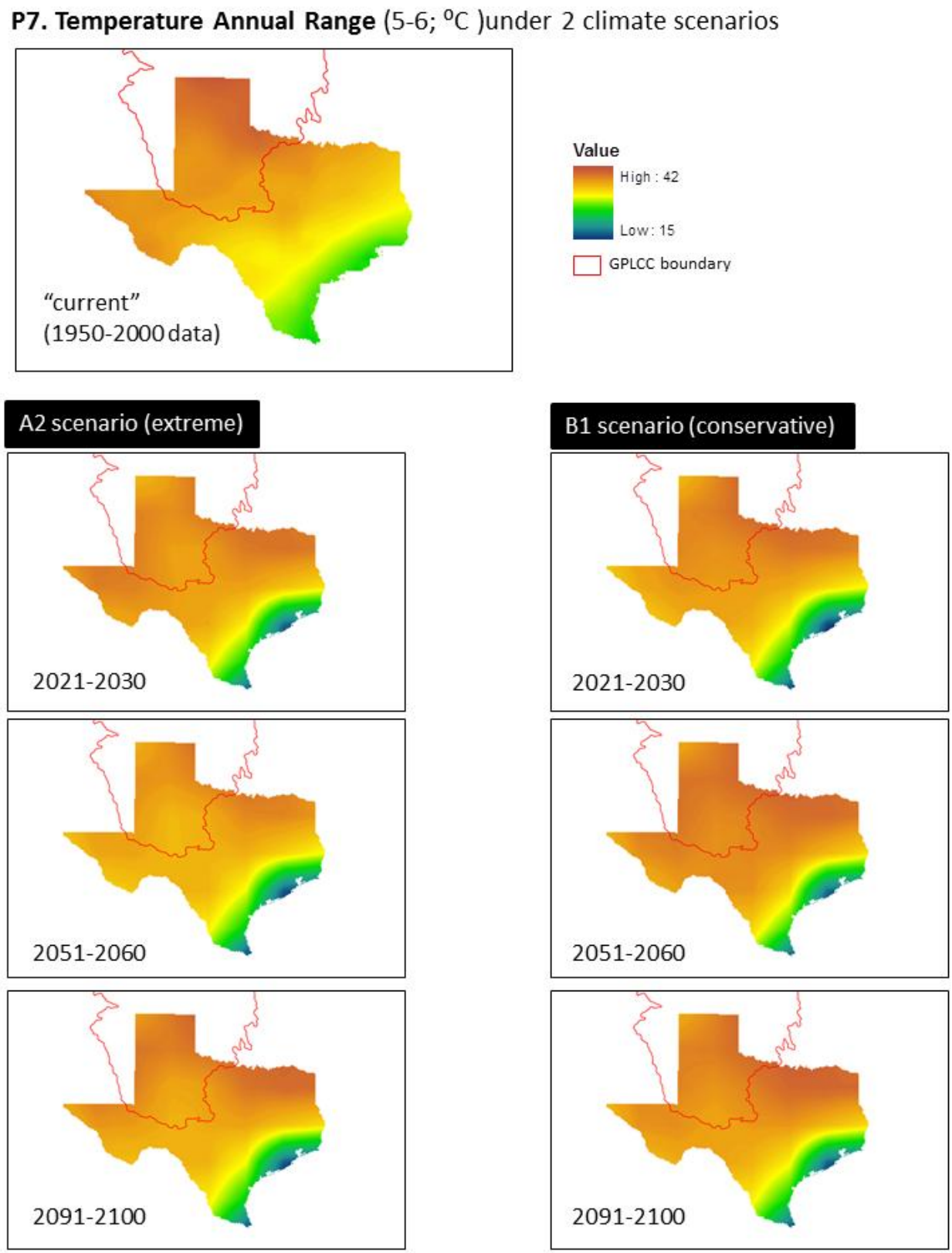

Figure 17. P7. Temperature Annual Range (5-6; ^{0}C) under 2 climate scenarios

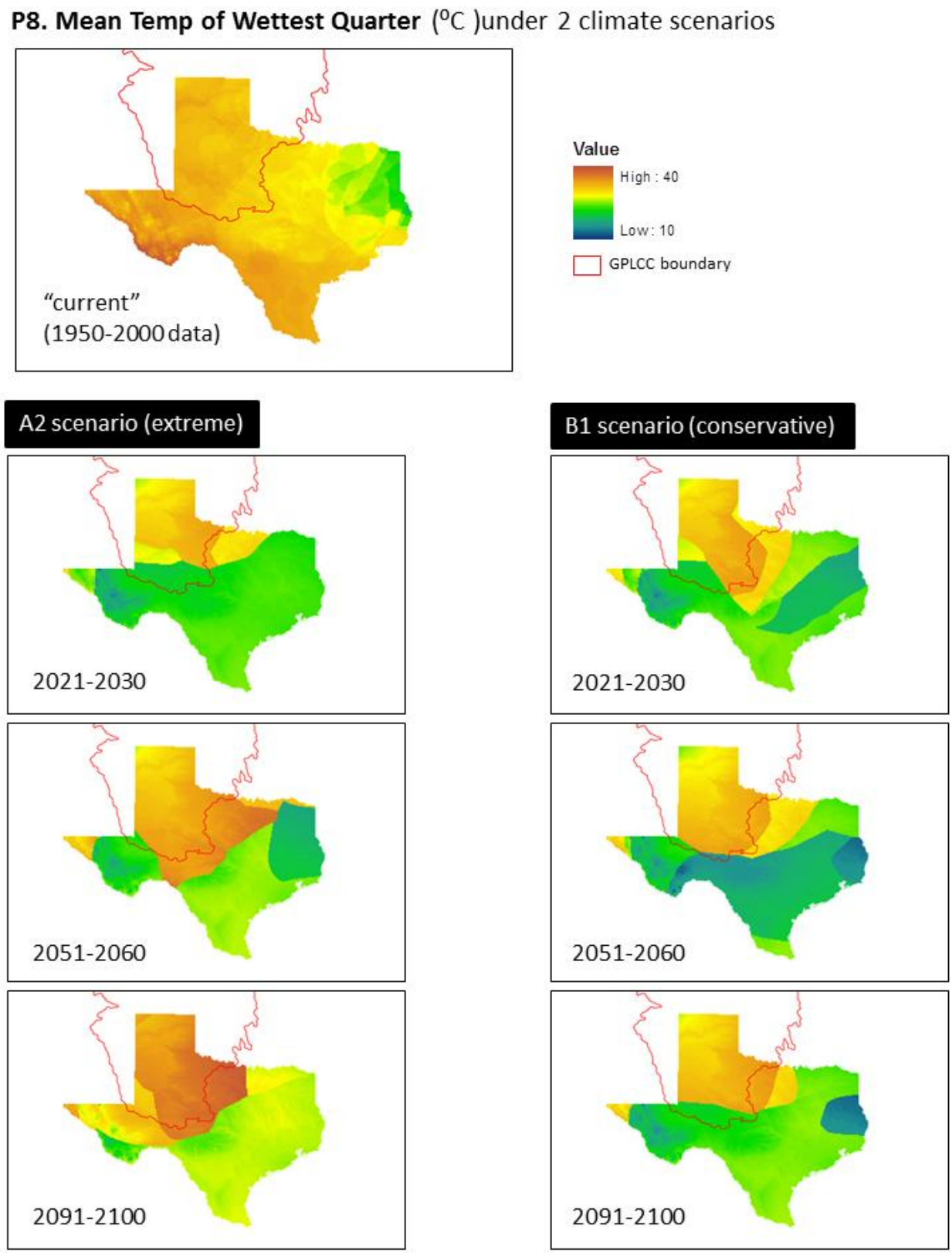

Figure 18. P8. Mean Temp of Wettest Quarter (^{0}C) under 2 climate scenarios

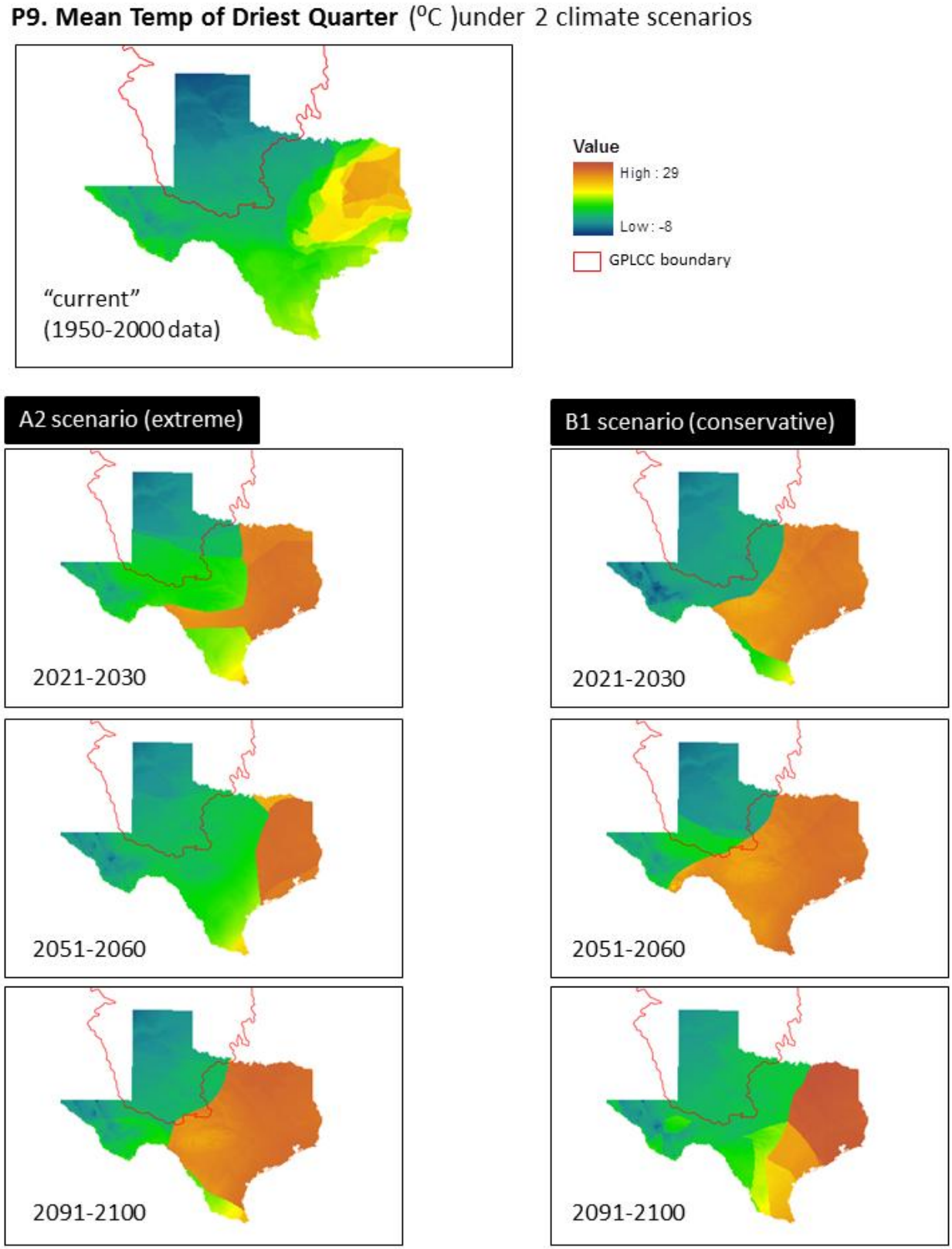

Figure 19. P9. Mean Temp of Driest Quarter (^{0}C) under 2 climate scenarios

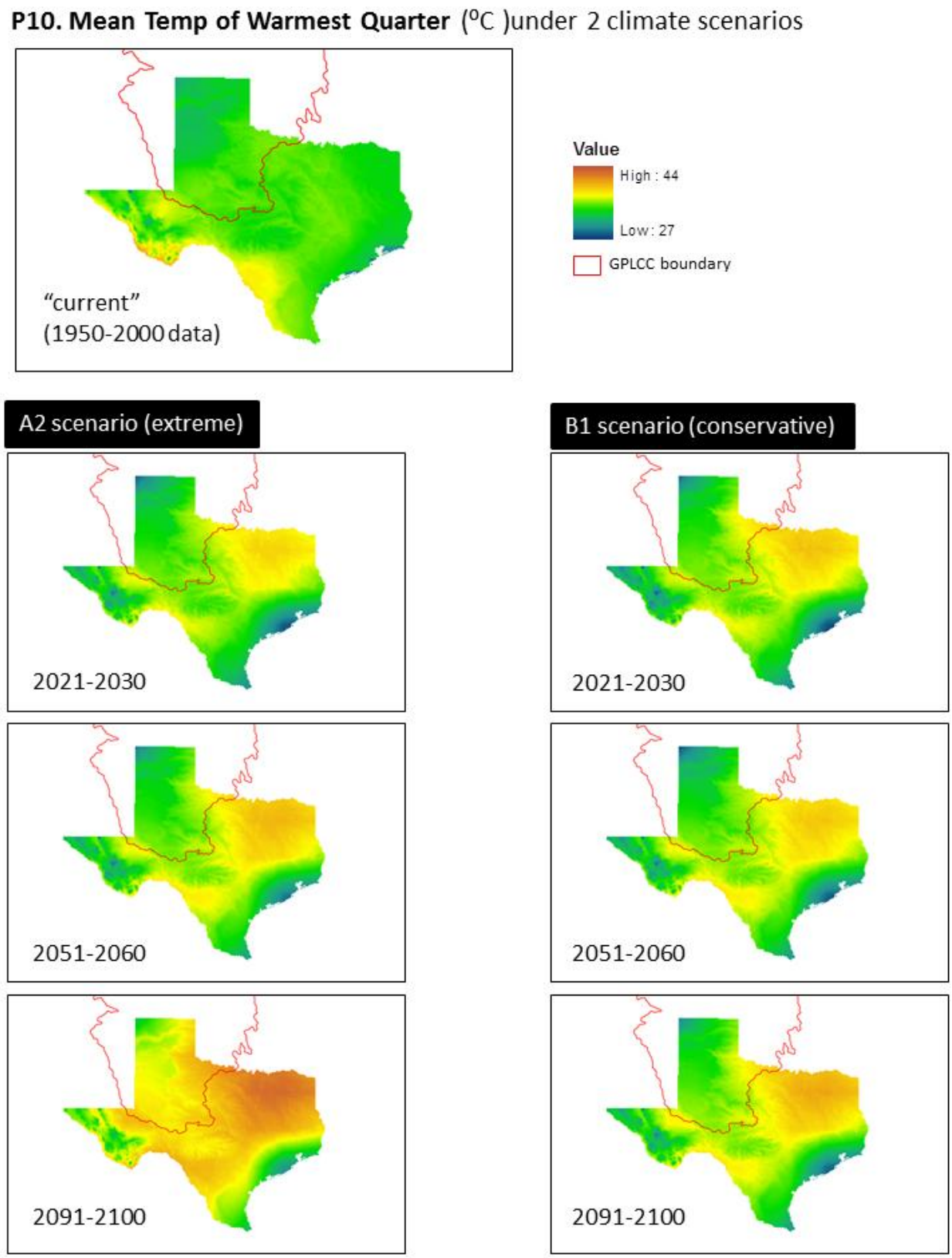

Figure 20. P10. Mean Temp of Warmest Quarter (^{0}C) under 2 climate scenarios

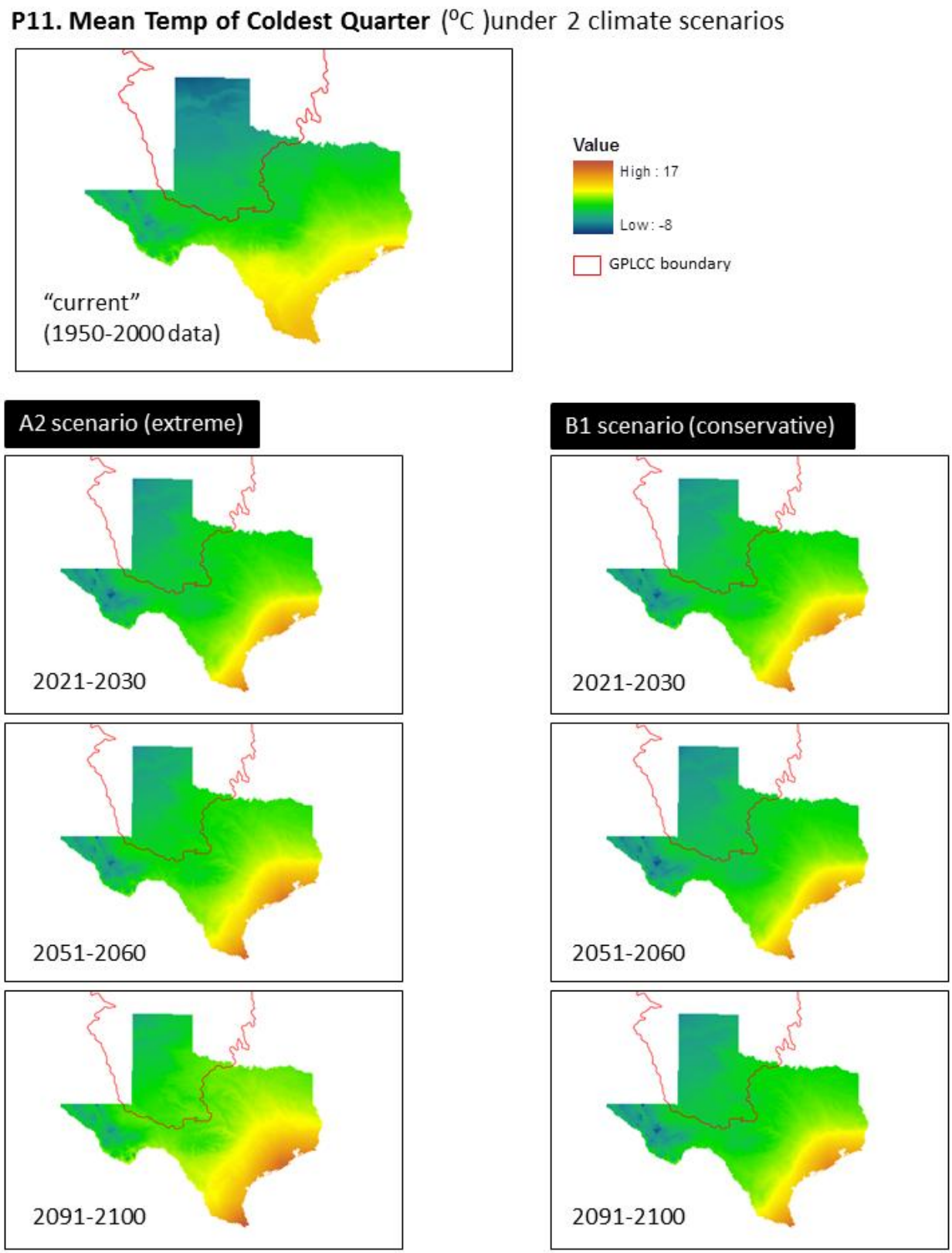

Figure 21. P11. Mean Temp of Coldest Quarter (^{0}C) under 2 climate scenarios

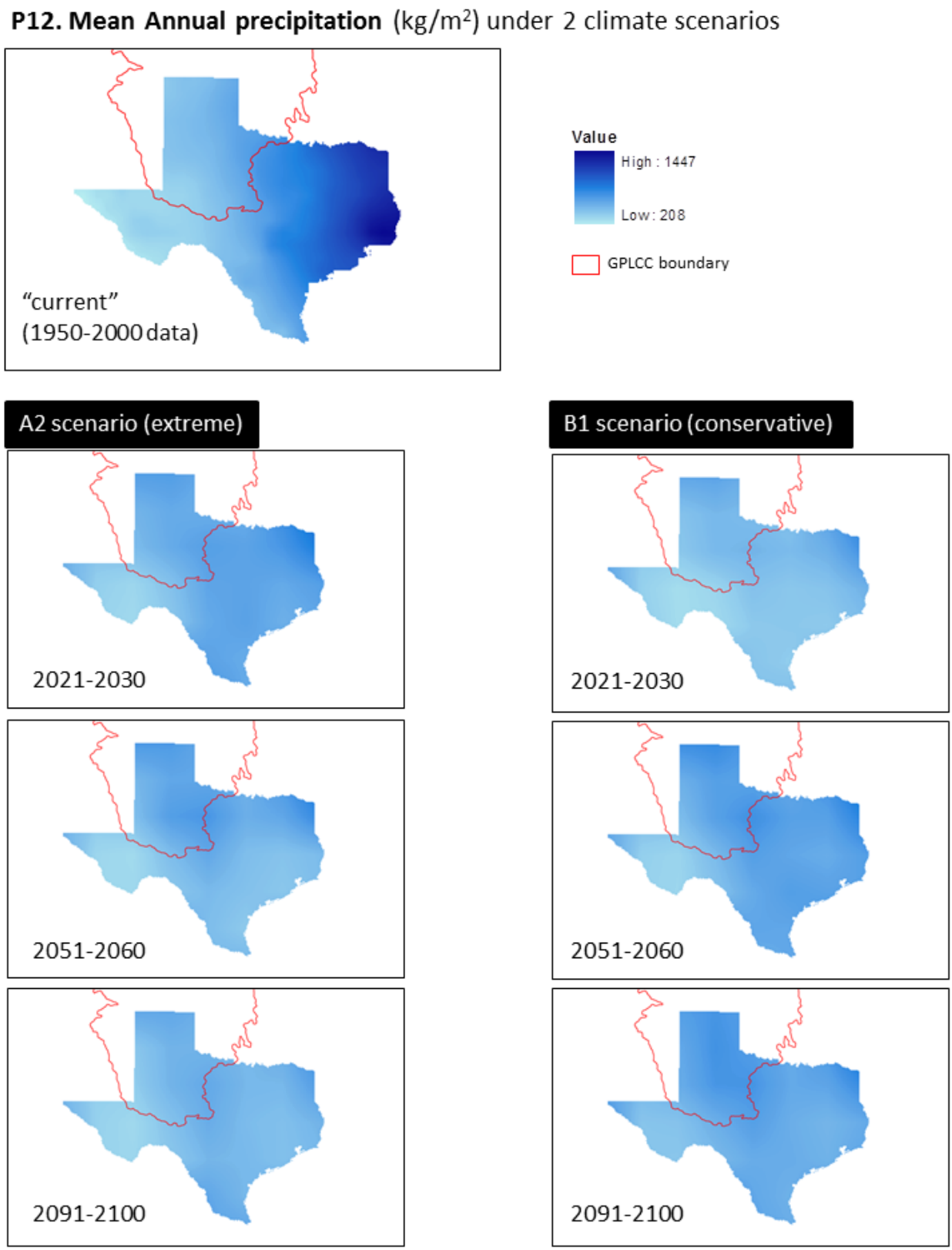

Figure 22. P12. Mean Annual precipitation (kg/m²) under 2 climate scenarios

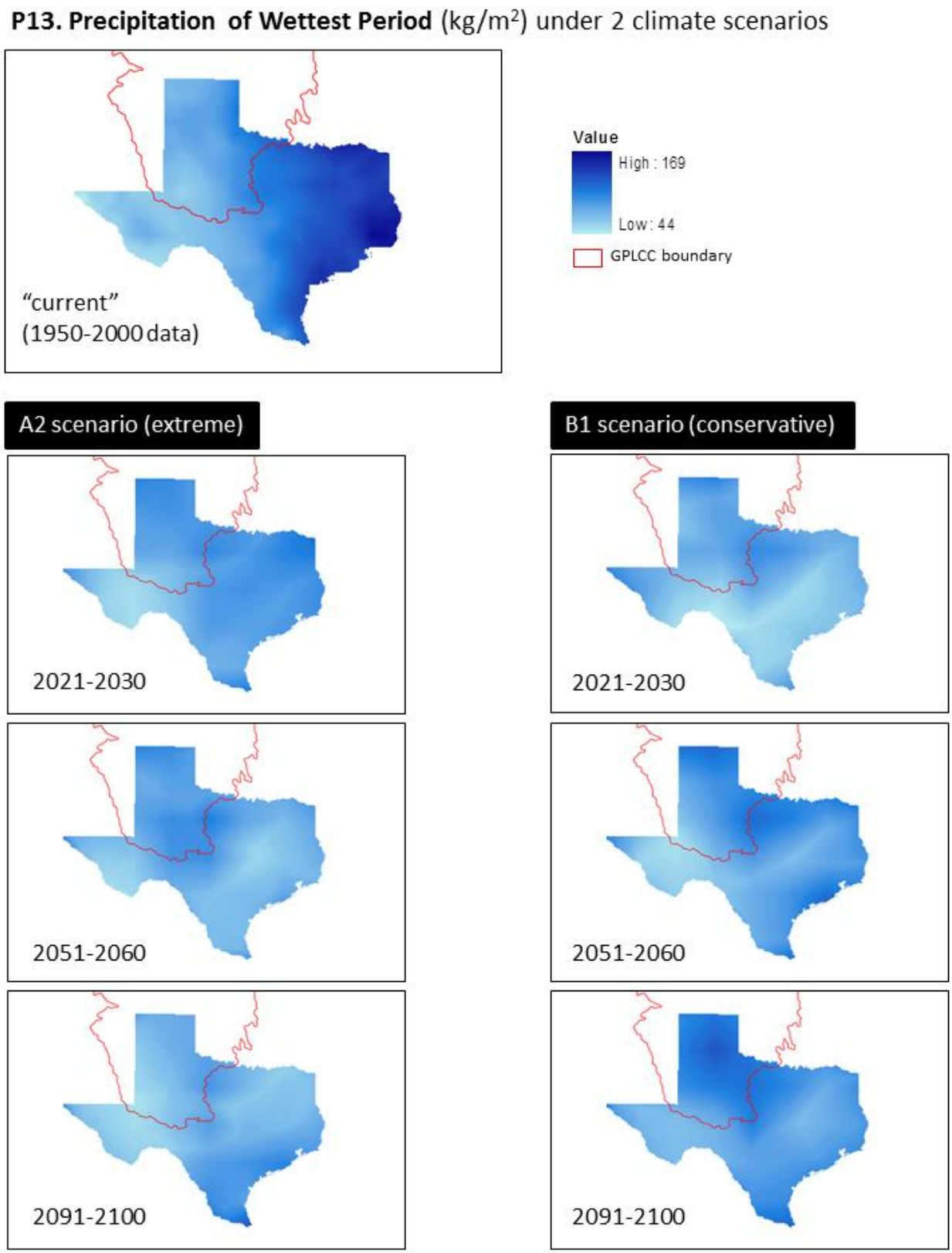

Figure 23. P13. Precipitation of Wettest Period (kg/m²) under 2 climate scenarios

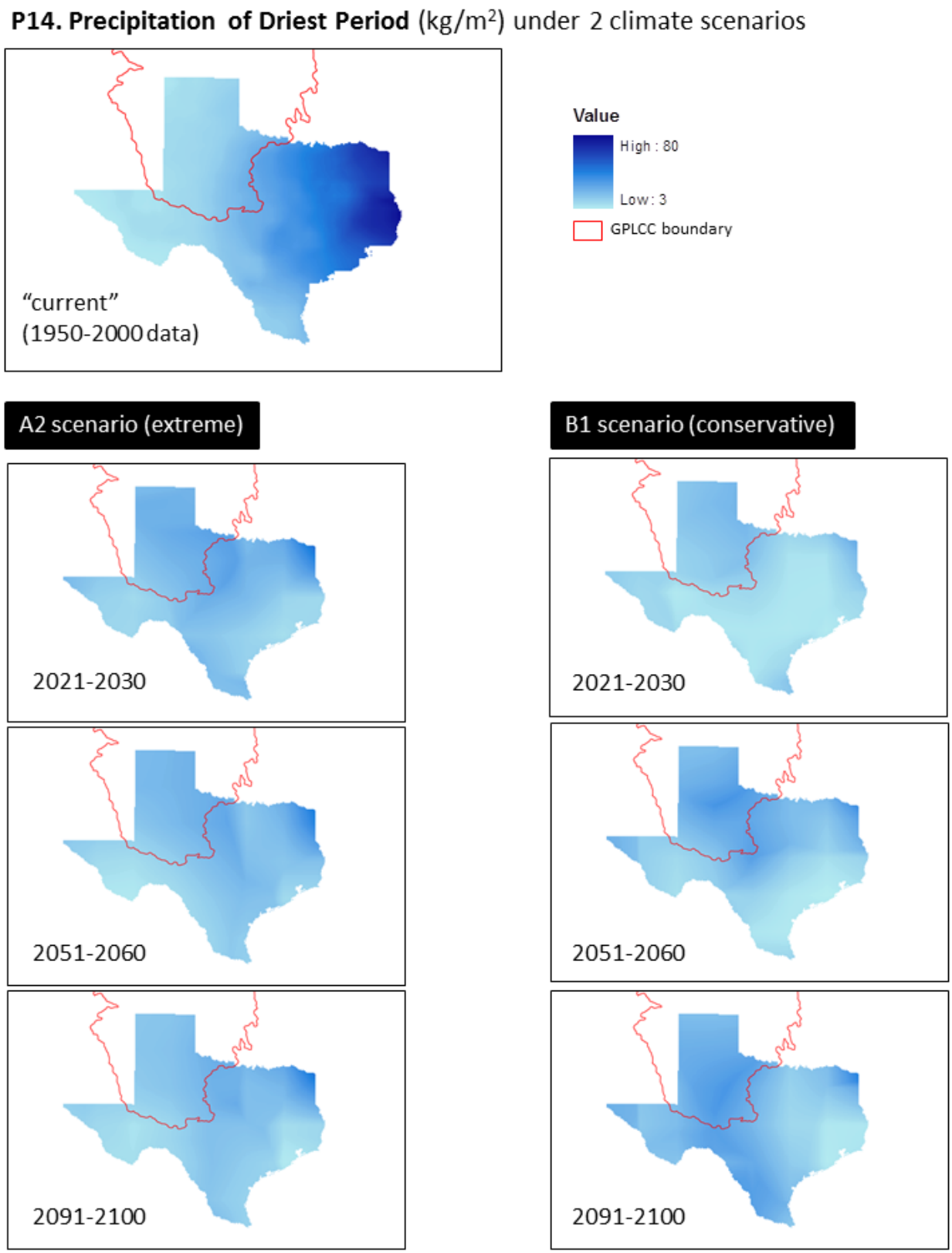

Figure 24. P14. Precipitation of Driest Period (kg/m²) under 2 climate scenarios

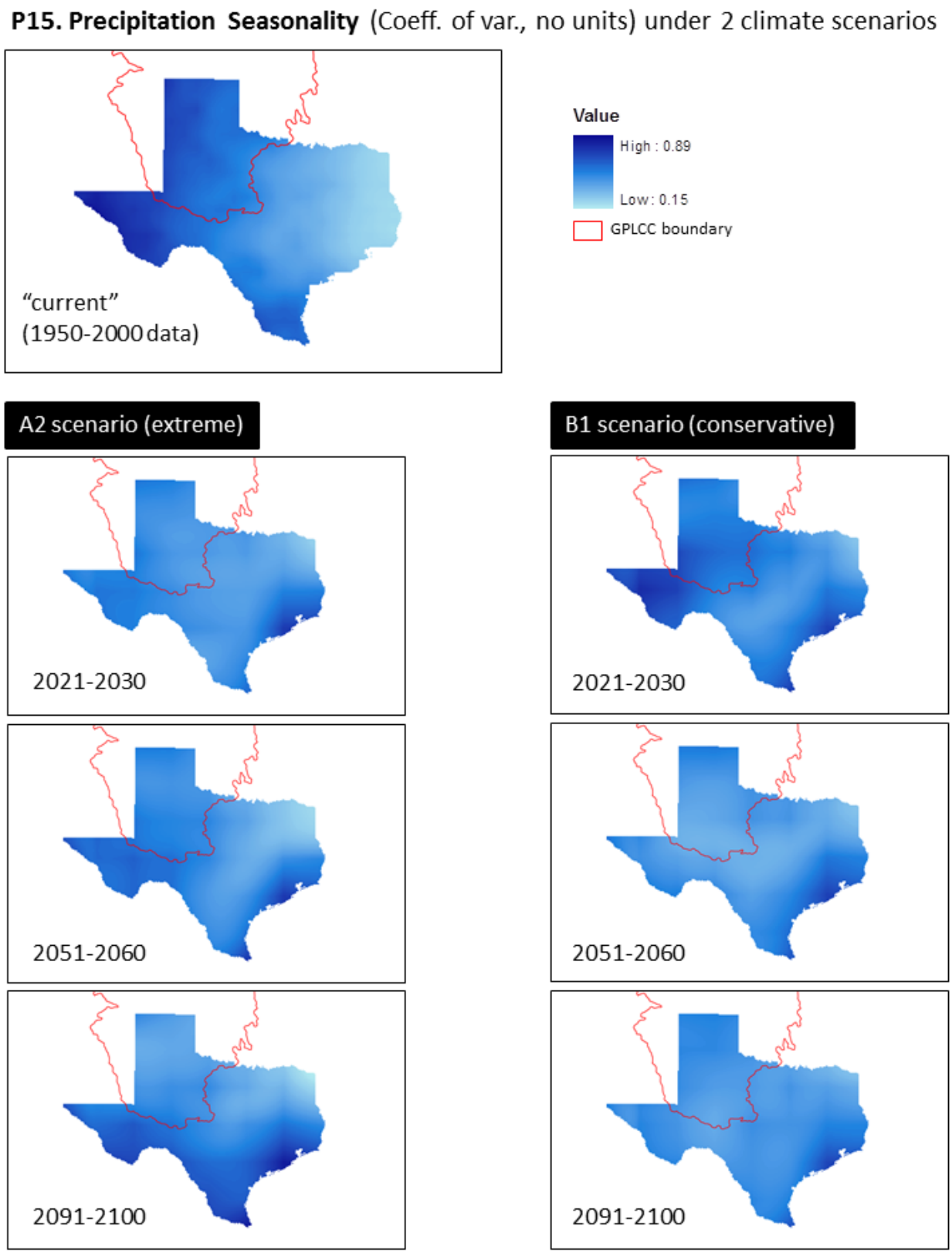

Figure 25. P15. Precipitation Seasonality (Coeff. of var., no units) under 2 climate scenarios

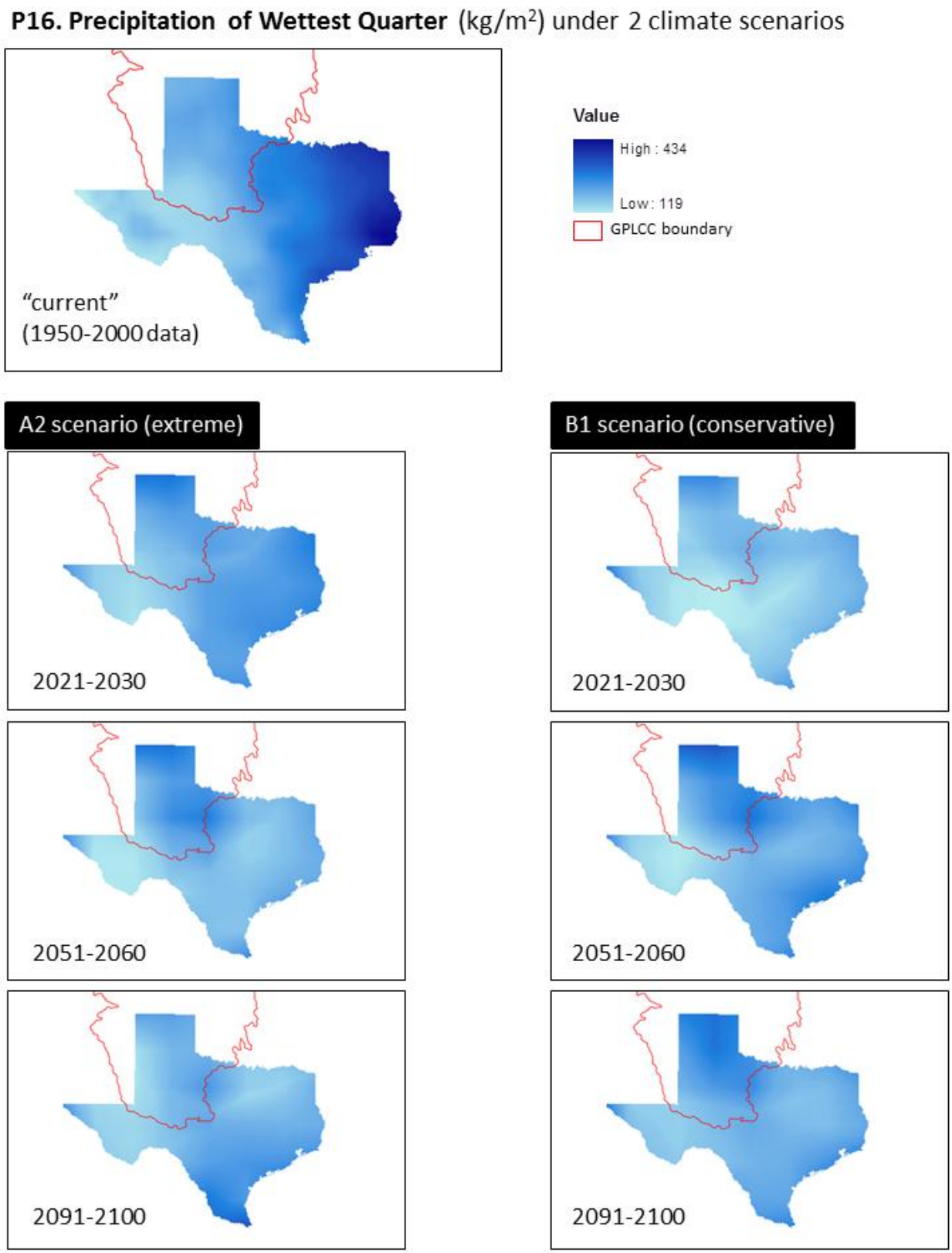

Figure 26. P16. Precipitation of Wettest Quarter (kg/m^2) under 2 climate scenarios

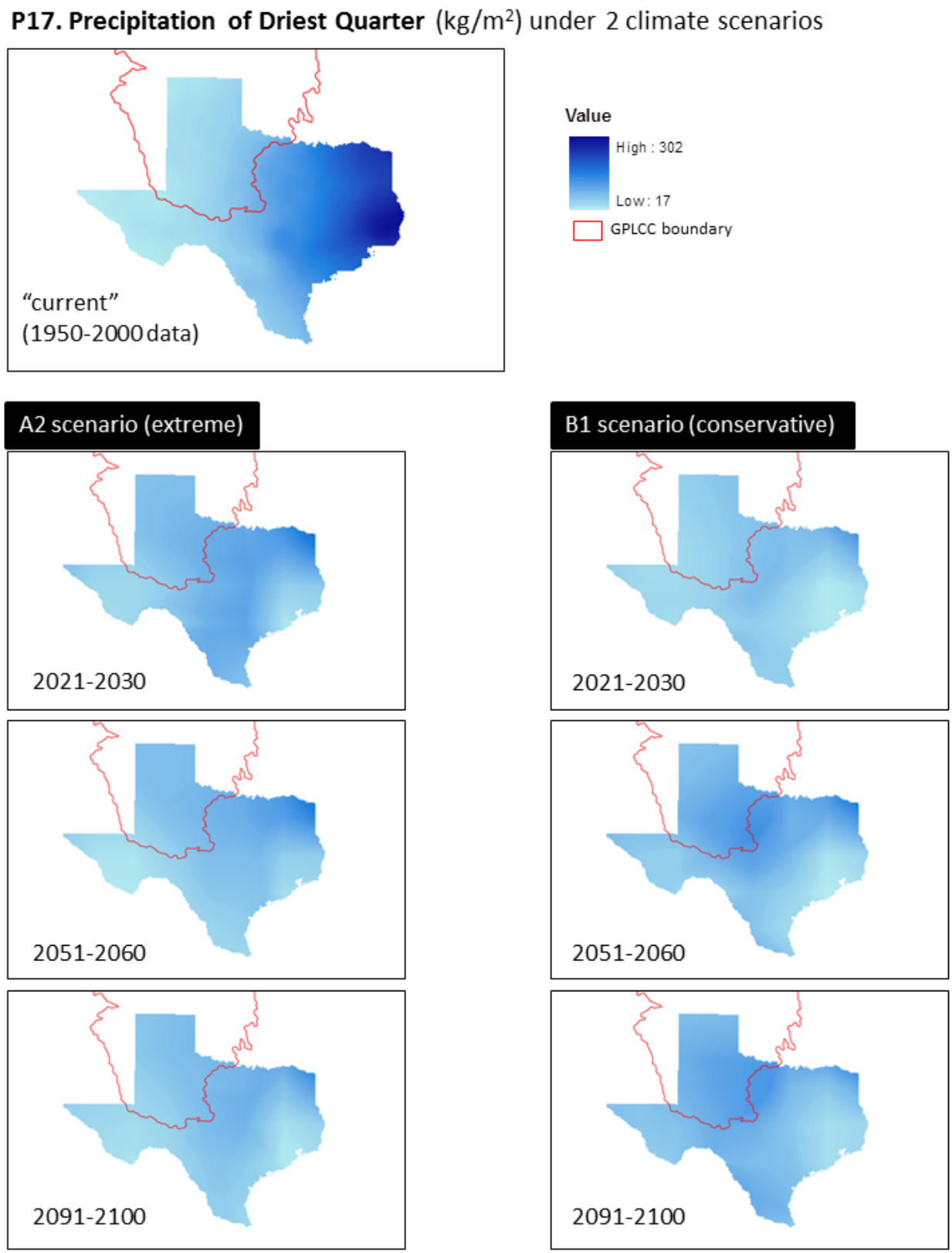

Figure 27. P17. Precipitation of Driest Quarter (kg/m²) under 2 climate scenarios

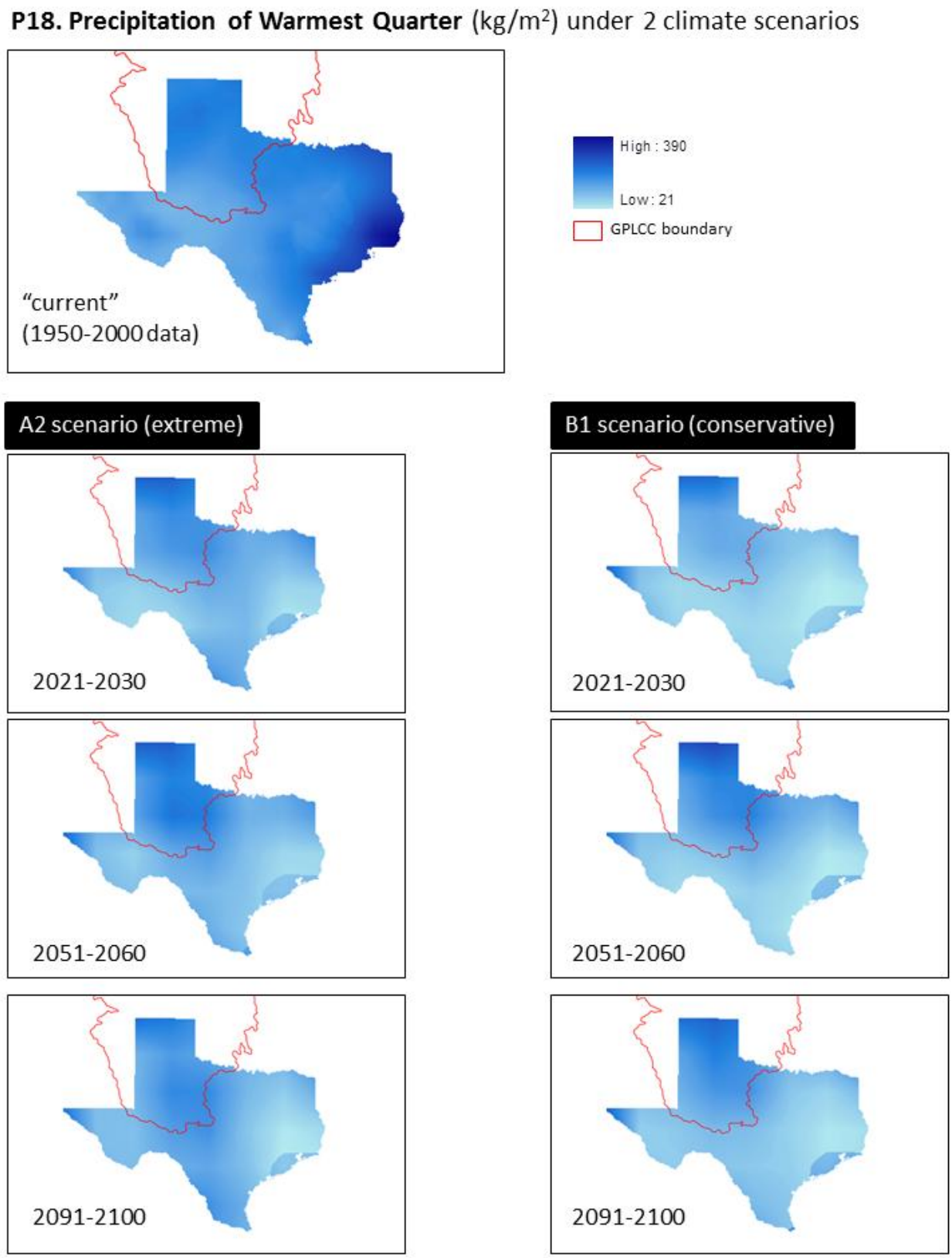

Figure 28. P18. Precipitation of Warmest Quarter (kg/m^2) under 2 climate scenarios

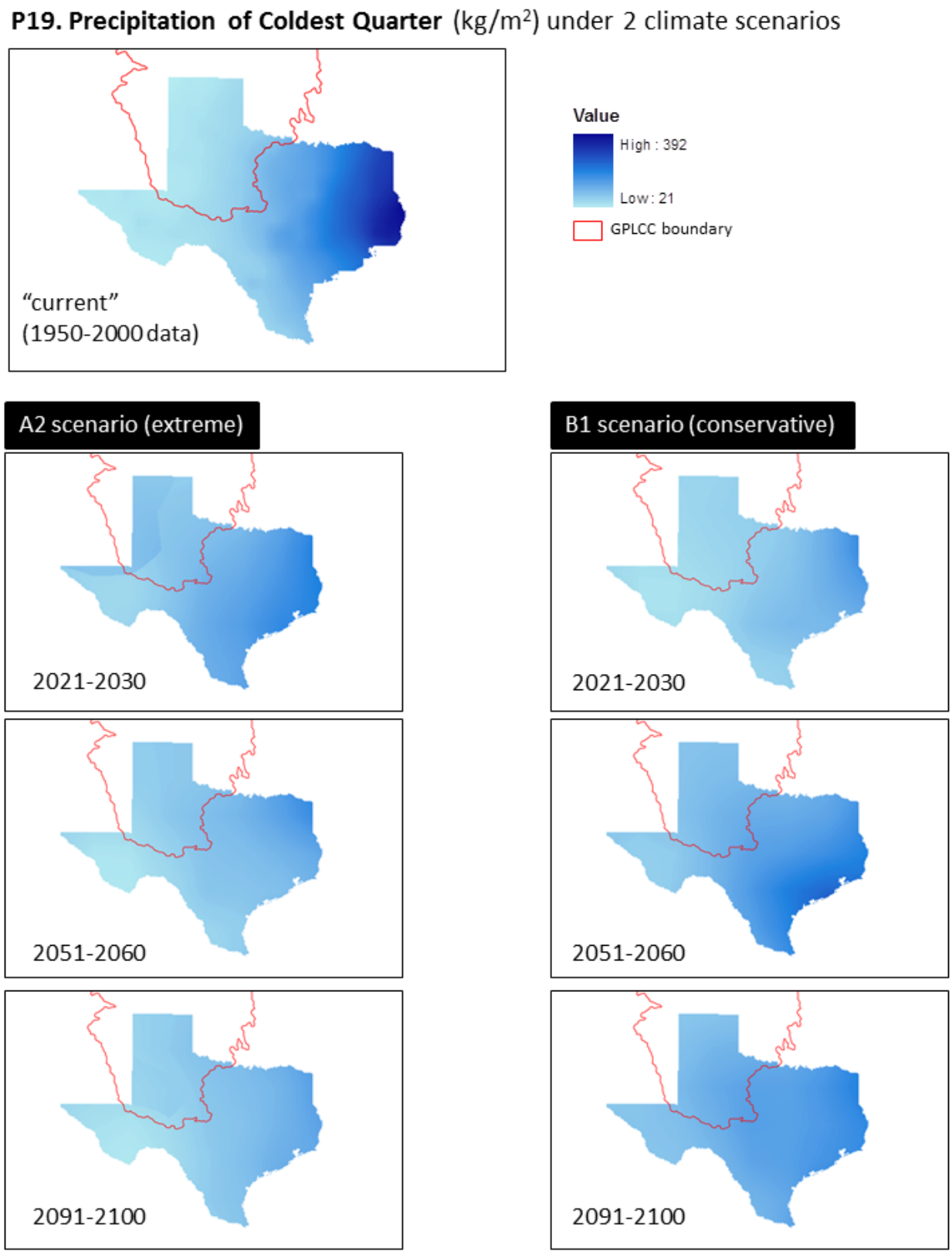

Figure 29. P19. Precipitation of Coldest Quarter (kg/m²) under 2 climate scenarios

Conservation Network Planning figures- systematic conservation network planning demonstration; extent displayed represents the full extent of species distribution models previously constructed and available for consnet input.

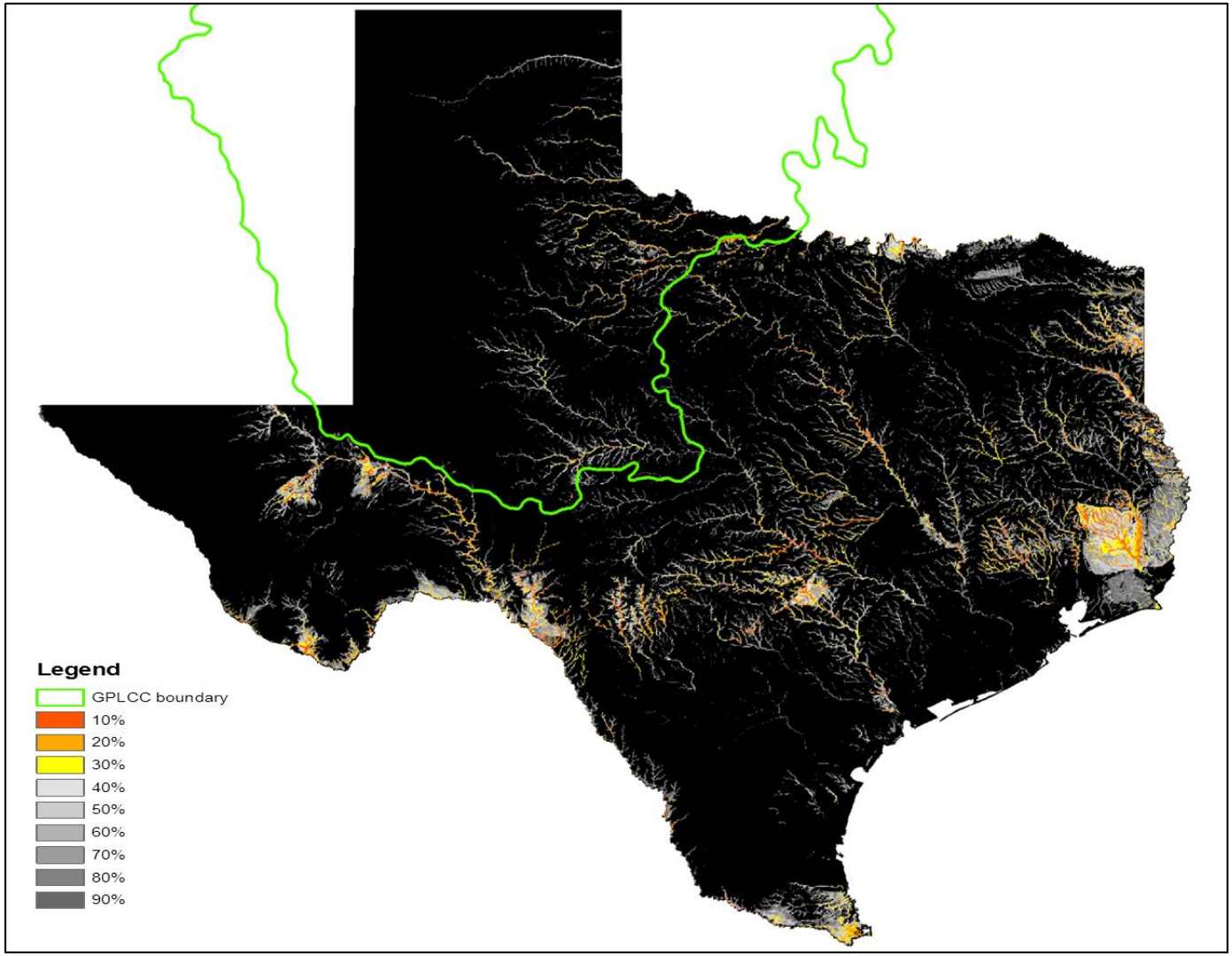

Figure 30. Map of priority areas required for the protection of 10 to 90 percent of the modeled habitat of the selected species. This was done to achieve targeted representation of the species in minimal area while maintaining as much connectivity as possible by minimizing clustering.

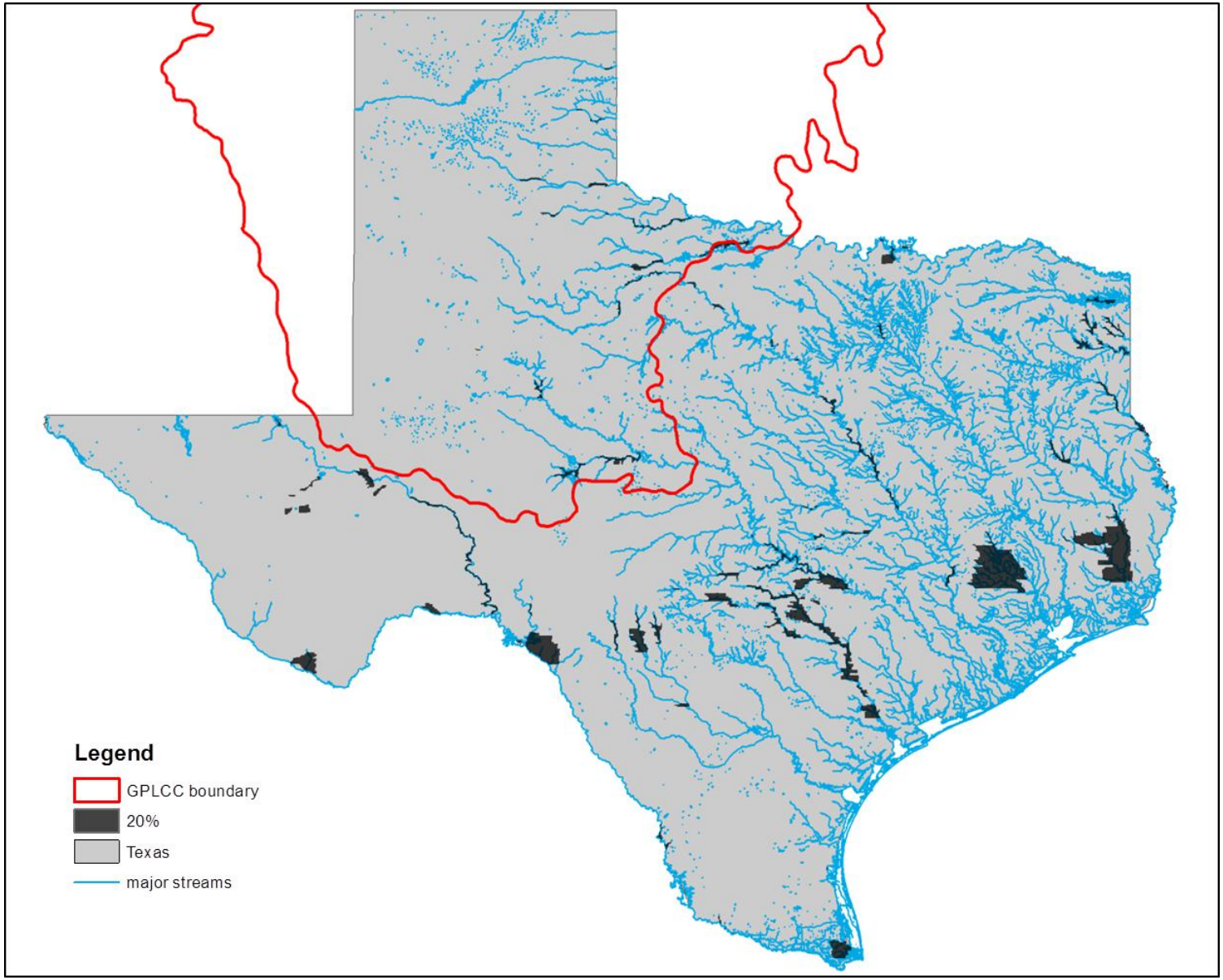

Figure 31. Map of the nominal management areas when the targets of representation were 20 percent.

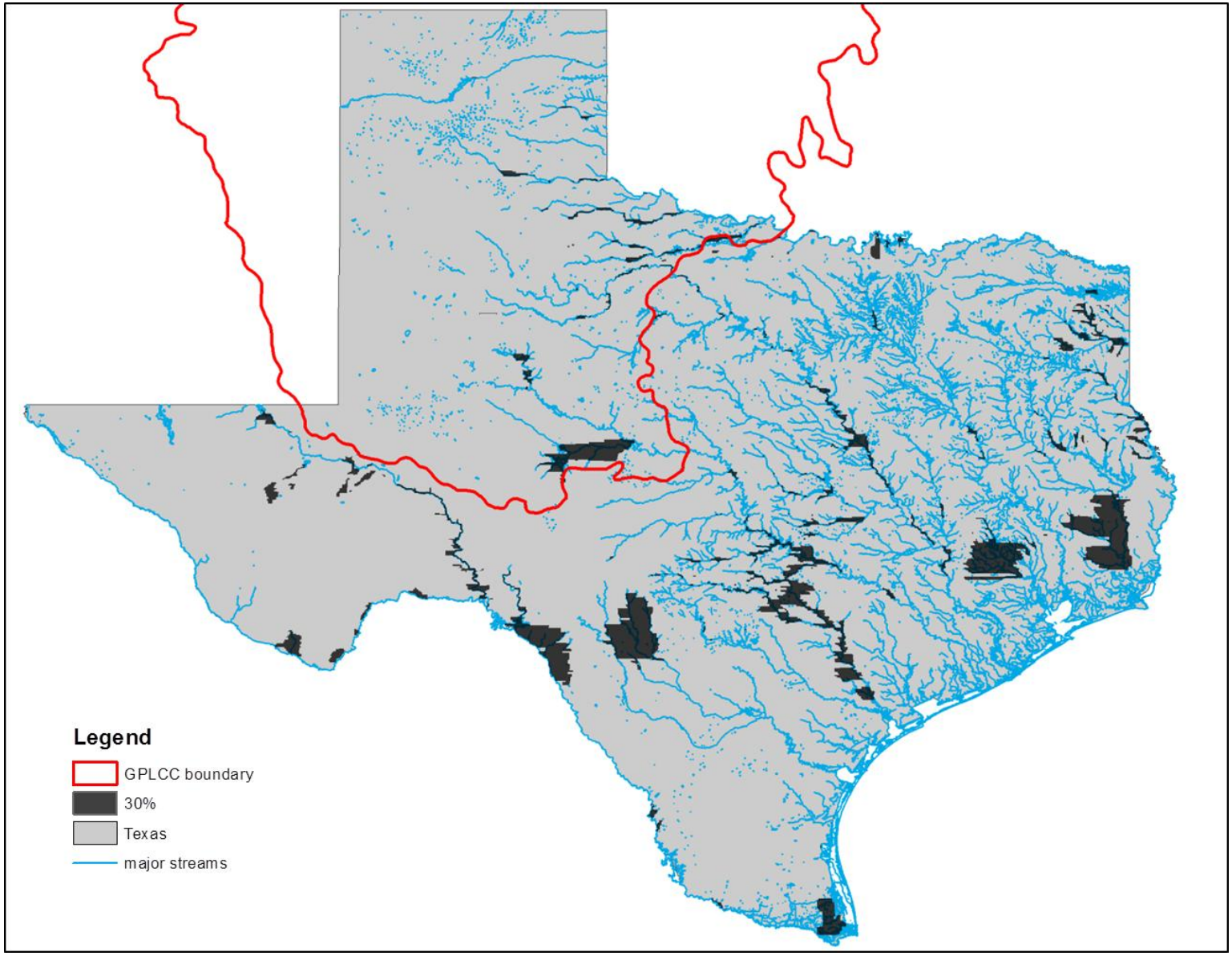

Figure 32. Map of the nominal management areas when the targets of representation were 30 percent.

GBIF data figures and tables

Table 4. GBIF data query summary.

Kingdom		Animalia	Plantae	Fungi	Protista	Bacteria	Total Records
No. Families Represented		1,281	672	68	2,644	3	4,668
No. Genera Represented		4,760	1,719	163	58	5	6,705
No. Species Represented		13,737	12,477	914	335	6	27,469
No. Records with Lat/Long Error Value		41,009	1,731	28	3	1	42,772
No. Records in GBIF		1,706,251	216,602	4,411	2,720	10	1,929,994
Record Type	Observation	1,435,298	110,585	-	424	-	1,546,307
	Specimen	209,416	38,748	1,180	1,908	2	251,254
	Fossil	12,064	843	-	22	8	12,937

Table 5. GBIF section summaries. All sections have longitude boundaries of: -96.543577 to -105.295848

Section	North Lat.	South Lat.	No. Animalia Records	No. Plantae Records	No. Fungi Records	No. Protista Records	No. Unclassified Records	Total No. Records
1	31.763201	30.763201	82,382	7,248	8	12	81	89,731
2	32.763201	31.763201	166,807	11,666	92	16	121	178,707
3.1	33.013201	32.763201	165,497	2,223	4	8	128	167,862
3.2	33.263201	33.013201	96,209	1,955	1	2	25	98,192
3.3	33.513201	33.263201	37,461	1,020	7	3	30	38,521
3.4	33.763201	33.513201	28,726	2,613	11	1	130	31,481
4	34.763201	33.763201	73,551	9,443	53	257	173	83,479
5	35.763201	34.763201	109,134	12,557	212	50	215	122,168
6	36.763201	35.763201	67,217	11,781	48	7	141	79,195
7	37.763201	36.763201	81,142	29,562	721	115	577	112,121
8	38.763201	37.763201	114,834	33,048	849	709	588	150,028
9.1	39.263201	38.763201	92,391	20,623	796	781	746	115,337
9.2	39.763201	39.263201	181,884	14,172	227	275	179	196,737
10.1	40.263201	39.763201	153,946	12,151	310	154	177	166,738
10.2	40.763201	40.263201	117,463	10,225	83	21	27	127,819
11	41.763201	40.763201	67,582	14,239	63	120	41	82,045
12	42.763201	41.763201	45,578	12,314	266	58	144	58,360
13	43.523746	42.763201	24,447	9,762	660	131	368	35,368

Table 6. GBIF data summary of GPLCC species of concern. *E: endangered, T: threatened. Based on the US fish and Wildlife Endangered Species Program Listing

Common Name	Genus species	No. GBIF Records	Listing Status*
American Bison	Bison bison	53	GPLCC Priority, E
Black-footed Ferret	Mustela nigripes	13	GPLCC Priority, E
Black-Tailed Prairie Dog	Cynomys ludovicianus	1386	GPLCC Priority, E
Gray Wolf	Canis lupus	24	E
Black-capped Vireo	Vireo atricapilla	135	E
Burrowing Owl	Athene cunicularia	381	GPLCC Priority, T
Ferruginous Hawk	Buteo regalis	1444	GPLCC Priority, T
Lesser Prairie-Chicken	Tympanuchus pallidicinctus	206	GPLCC Priority, E
Mountain Plover	Charadrius montanus	306	GPLCC Priority, E
Snowy Plover	Charadrius alexandrinus	324	GPLCC Priority, E
Whooping Crane	Grus americana	29	GPLCC Priority, E
Arkansas Darter	Etheostoma cragini	345	GPLCC Priority
Arkansas River Shiner	Notropis girardi	122	GPLCC Priority
Peppered Chub	Macrhybopsis tetranema	5	E
Topeka Shiner	Notropis topeka	132	GPLCC Priority, E

GPLCC species of concern figures from GBIF data query

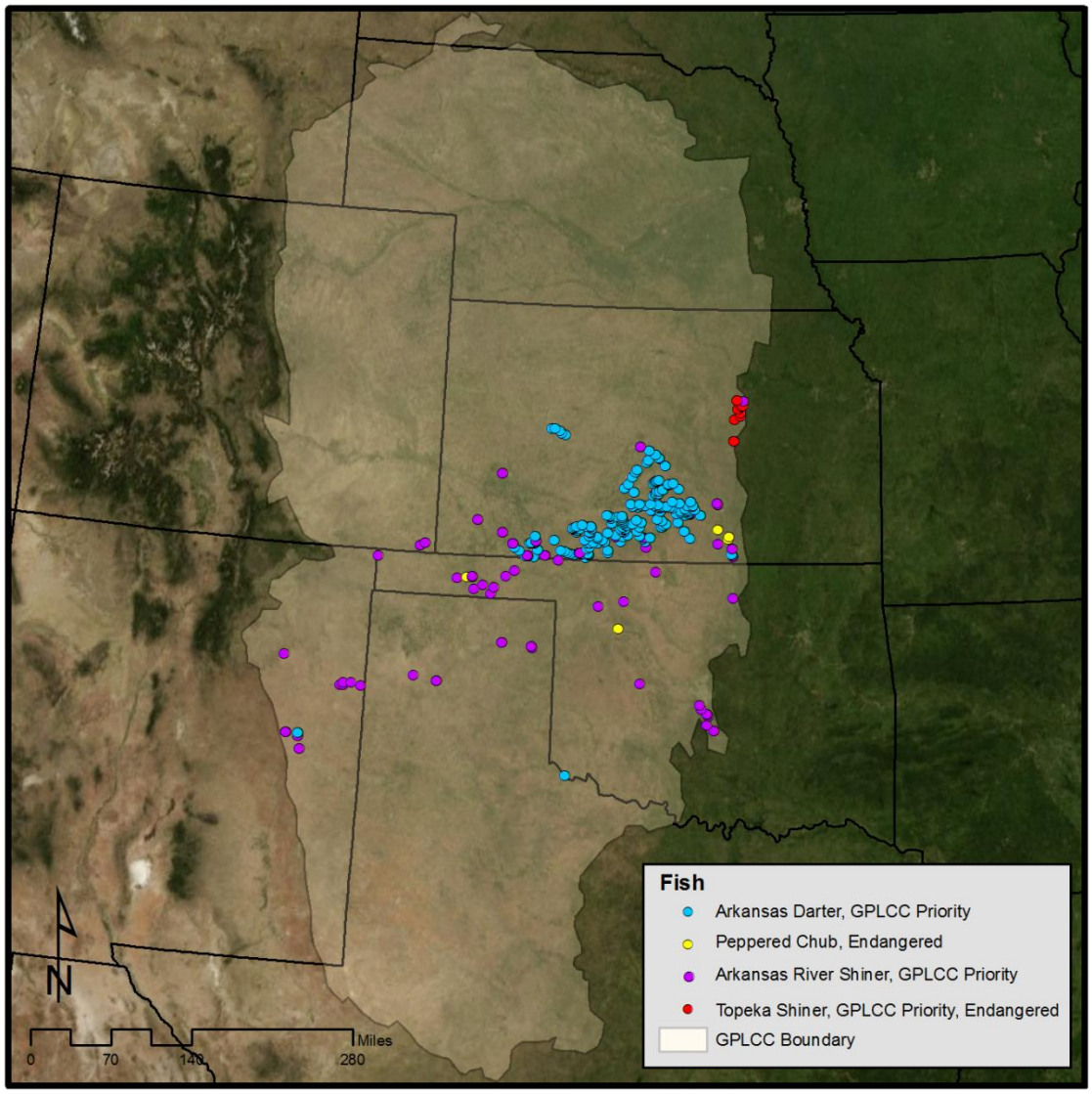

Figure 33. Map of GPLCC fish species of concern from GBIF data query.

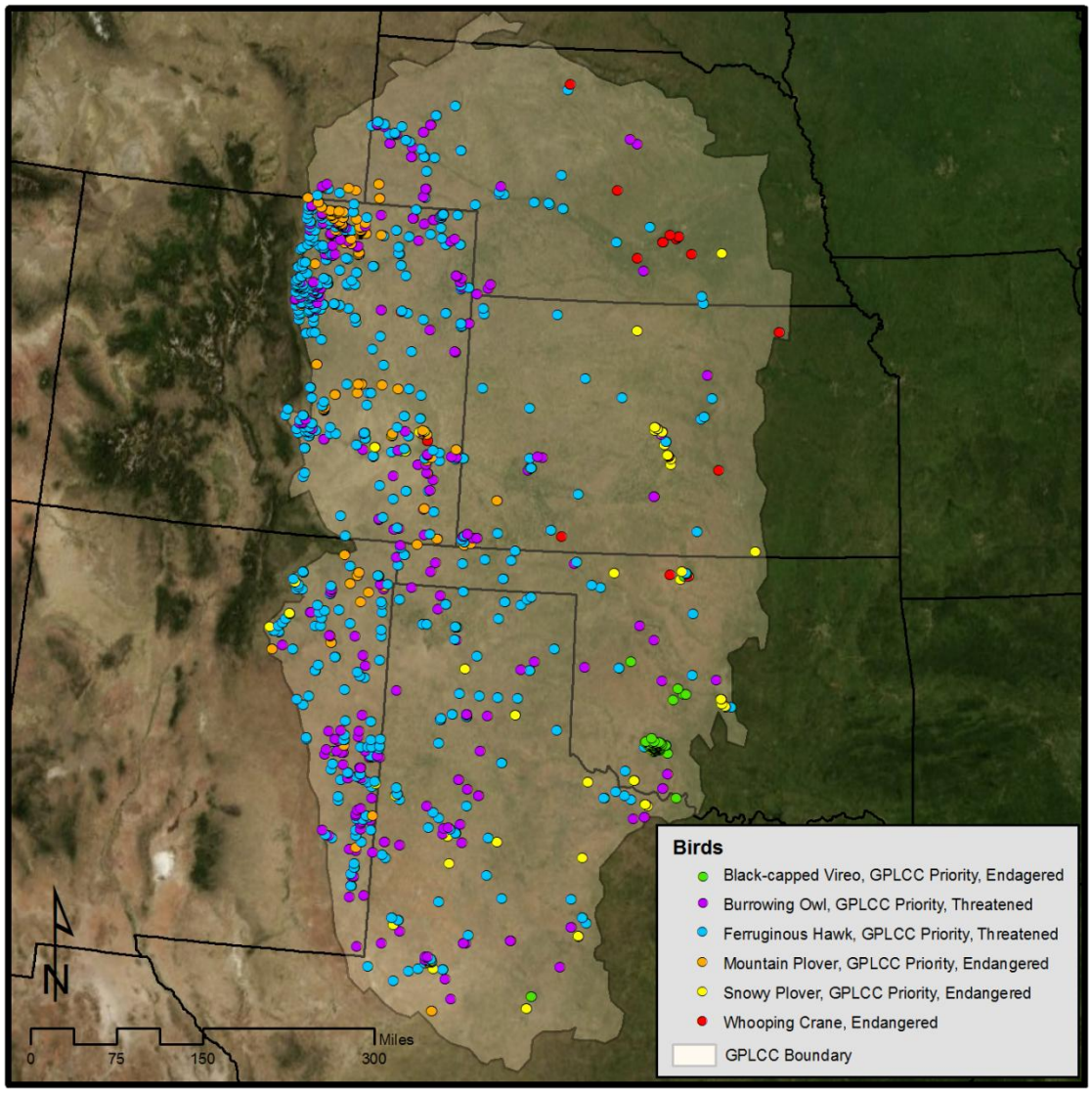

Figure 34. Map of GPLCC bird species of concern from GBIF data query.

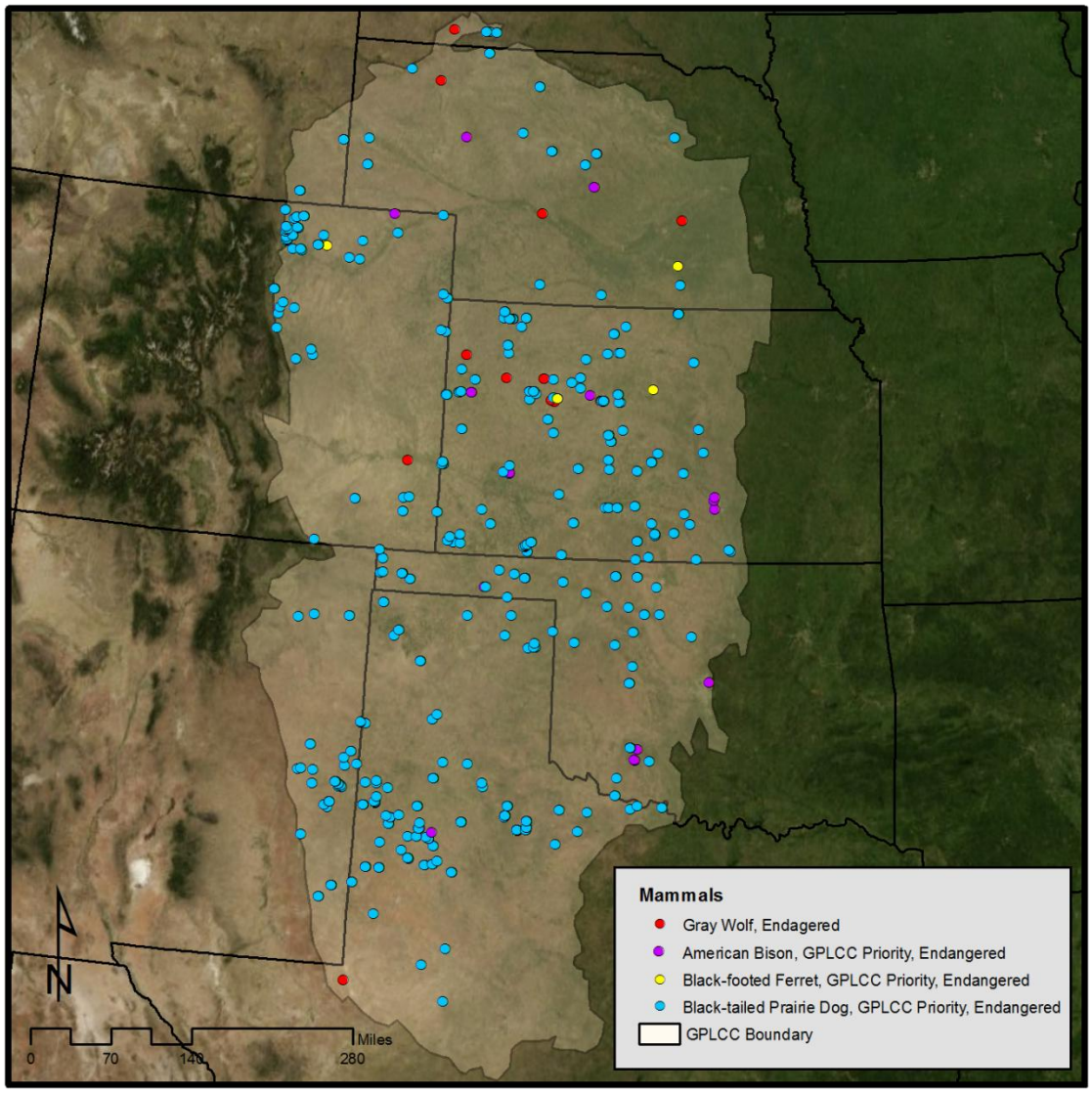

Figure 35. Map of GPLCC mammal species of concern from GBIF data query.

4.2-Appendix 2: Metadata

Colorado State University, Larval Fish Laboratory

Identification_Information:
  Citation:
    Citation_Information:
      Originator: Kevin Bestgen, Director
      Publication_Date: 20100913
      Title: Larval Fish Laboratory, Colorado State University
      Online_Linkage: n/a
  Description:
    Abstract: The LFL collection currently houses > 110,000 lots and > 4,500,000 fish specimens. Most are from the Upper Colorado River Basin but we also house collections from Great Plains reaches in Wyoming, New Mexico, in addition to Colorado. The collection is actively curated and many new lots are added each year. We are in the process of geo-referencing collections that presently do not have such information.
    Purpose: n/a
    Supplemental_Information: Specimen Type: Whole specimens, Partial specimens, Tissue samples, Photographs, Illustrations, X-Rays. Preservative Type: Ethyl Alcohol, Isopropyl Alcohol, Formalin, cleared and stained specimens in glycerol.
  Time_Period_of_Content:
    Time_Period_Information:
      Range_of_Dates/Times:
        Beginning_Date: 19760801
        Ending_Date: 20100913
    Currentness_Reference: publication date
  Status:
    Progress: Complete
    Maintenance_and_Update_Frequency: In work
  Spatial_Domain:
    Description_of_Geographic_Extent: Upper Colorado River Basin, southern Great Plains, including New Mexico, Colorado, and Wyoming.
    Bounding_Coordinates:
      West_Bounding_Coordinate: -111
      East_Bounding_Coordinate: -180
      North_Bounding_Coordinate: 45
      South_Bounding_Coordinate: 29
  Keywords:
    Theme:
      Theme_Keyword_Thesaurus: n/a
      Theme_Keyword: Adult Fish
      Theme_Keyword: Fish Larvae
      Theme_Keyword: Upper Colorado River Basin
      Theme_Keyword: Colorado
      Theme_Keyword: Wyoming
      Theme_Keyword: Utah
      Theme_Keyword: New Mexico
      Theme_Keyword: Early Life History
      Theme_Keyword: Illustrations

Access_Constraints: Certain endangered fish locality data may have access restrictions. Some restrictions based on wishes of depositing agencies or regulations.
Use_Constraints: As needed, consult Kevin Bestgen. Some specimens represent data sets that are presently being used to prepare publications.
Point_of_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Kevin Bestgen
Contact_Organization: Larval Fish Laboratory, Colorado State University
Contact_Address:
Address_Type: Mailing
Address: Department of Fish, Wildlife, and Conservation Biology; Colorado State University
City: Fort Collins
State_or_Province: Colorado
Postal_Code: 80523
Contact_Voice_Telephone: 970-491-1848
Contact_Electronic_Mail_Address: kbestgen@colostate.edu
Metadata_Reference_Information:
Metadata_Date: 20100914
Metadata_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Dean Hendrickson
Contact_Organization: The University of Texas at Austin, Texas Natural History Collections
Contact_Address:
Address_Type: Mailing
Address: 10100 Burnet Road, PRC 176/R4000
City: Austin
State_or_Province: TX
Postal_Code: 78758-4445
Country: USA
Contact_Voice_Telephone: 512-471-9775
Contact_Electronic_Mail_Address: fishesoftexas@gmail.com
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998

Eastern New Mexico University Natural History Museum

Identification_Information:
Citation:
Citation_Information:
Originator: Dr. Darren A. Pollock, Associate Professor & Head Curator of Collections
Publication_Date: 20101011
Title: Eastern New Mexico University Natural History Museum
Online_Linkage: http://www.enmu.edu/services/museums/natural-history/index.shtml
Description:
Abstract: The Eastern New Mexico University Natural History Museum is part of the New Mexico Biodiversity Collections Consortium (NMBCC, http://nmbiodiversity.org/index.php). NMBCC is made up of: The Eastern New Mexico University Natural History Collection, The Western New Mexico University Gila Center for Natural History, The New Mexico University Museum of Southwestern Biology, The New Mexico Museum of Natural History, and The New Mexico State University Center for Natural History Collections. The goal of NMBCC is to increase the availability of information concerning New Mexico biodiversity. We are doing this by supporting basic curation of museum specimens, databasing this information, georeferencing the data, and providing the data on-line in a system that will make it usable to the general, scientific, and professional public. The fish collection was started by Dr. Sublette (author of Fishes of NM) and has many very valuable historic records for NM. The New Mexico Biodiversity project (http://nmbiodiversity.org/) that had NSF funding in the 2001-2002 supported work here to digitalize collections and those records are now online via the project's website.
Purpose: n/a
Supplemental_Information: Currently in the NMBCC system, we have 354,683 New Mexico specimen or lot records from 23 different collections at the four participating New Mexico Universities and the New Mexico Natural History Museum containing: Herbaria (149,679 records), Arthropods (49,456 records), Fishes (11,611 records), Amphibians & Reptiles (50,482 records), Birds (13,609 records), Mammals (79846 records). Specimen Types: Whole specimens, Partial specimens, Field notes. Preservative Types: Isopropyl Alcohol.
Time_Period_of_Content:
Time_Period_Information:
Range_of_Dates/Times:
Beginning_Date: 1924
Ending_Date: 2010
Currentness_Reference: publication date
Status:
Progress: In work
Maintenance_and_Update_Frequency: n/a
Spatial_Domain:
Description_of_Geographic_Extent: Texas, New Mexico
Bounding_Coordinates:
West_Bounding_Coordinate: -109
East_Bounding_Coordinate: -94
North_Bounding_Coordinate: 37
South_Bounding_Coordinate: 26
Keywords:
Theme:
Theme_Keyword_Thesaurus: n/a
Theme_Keyword: Fishes
Theme_Keyword: Retiles
Theme_Keyword: Aquatic Insects
Theme_Keyword: Terrestrial Insects
Theme_Keyword: Plants
Theme_Keyword: Amphibians
Theme_Keyword: Mammals

Theme_Keyword: New Mexico

Access_Constraints: All NMBCC specimen or lot records are from New Mexico, though the museums maintain many more specimens from outside the state and there are other collections in New Mexico for which we do not have data (yet!). Several collections are still developing their specimen databases (see About the Data for more information). Contact the collections directly for more information about their holdings. The NMBCC data are largely uncleaned, which is to say, you see it as it was provided to us by the museum collections.

Use_Constraints: Any use of the documents available from this server must be for informational purposes only and in no instance for commercial purposes. NMBCC data may not be reposted or distributed without express permission of NMBCC and/or the collections which provided the data. Some data may be downloaded to files and altered in format for analytical purposes, however the data should still be referenced using the citation above. Specific specimen or lot records accessed or downloaded via this site should not be dissociated from the acronymns or other identifiers indicating the museum source of the data. When specimen or lot data are used in synthetic form, acknowledgement must be given to both NMBCC and the individual museum collections that provided the data. No graphics available from this server can be used, copied or distributed separate from the accompanying text with the exception of the NMBCC logo. Any rights not expressly granted herein are reserved by NMBCC. Except as expressly provided above, nothing contained herein shall be construed as conferring any license or right under any NMBCC copyright.

Point_of_Contact:

Contact_Information:

Contact_Person_Primary:

Contact_Person: Dr. Darren A. Pollock

Contact_Organization: Eastern New Mexico University Natural History Museum

Contact_Address:

Address_Type: Mailing and Physical

Address: Department of Biology, Eastern New Mexico University

City: Portales

State_or_Province: New Mexico

Postal_Code: 88130

Contact_Voice_Telephone: 575-562-2862

Contact_Electronic_Mail_Address: Darren.Pollock@enmu.edu

Metadata_Reference_Information:

Metadata_Date: 20101110

Metadata_Contact:

Contact_Information:

Contact_Person_Primary:

Contact_Person: Dean Hendrickson

Contact_Organization: The University of Texas at Austin, Texas Natural History Collections

Contact_Address:

Address_Type: Mailing

Address: 10100 Burnet Road, PRC 176/R4000

City: Austin

State_or_Province: TX

Postal_Code: 78758-4445

Country: USA

Contact_Voice_Telephone: 512-471-9775

Contact_Electronic_Mail_Address: fishesoftexas@gmail.com

Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata

Metadata_Standard_Version: FGDC-STD-001-1998

Fishes of Texas Database

Identification_Information:
  Citation:
    Citation_Information:
      Originator: Adam Cohen, Research Associate
      Publication_Date: 20100928
      Title: Fishes of Texas Database
      Online_Linkage: www.fishesoftexas.org
  Description:
    Abstract: The Fishes of Texas database compiled by the Texas Natural History Collection at The University of Texas Austin consists of 81,265 records. (65,876 of those are freshwater) records vouchered by specimens curated at 34 U.S., Mexican and European collections, many unavailable online or in computerized format. An estimated 95% of all fish specimens ever collected in Texas since the early 1850's are represented, as are all known Texas freshwater species. All but 28 of Texas? 254 counties are represented in the 20,664 total localities, all now manually georeferenced. The data have gone through our quality control process and edited to achieve what we believe represents the most accurate and source for Texas fish occurrences. Another 43,223 records have recently been acquired from 9 more institutions and have been georeferenced and will soon be included in the database although data verification and editing remains to be done on those new records. We also have and are developing an extensive digital library including specimen photos and field notes for records in our database.
    Purpose: n/a
    Supplemental_Information: Data Types: Photographs, Illustrations, X-Rays, Digital.
  Time_Period_of_Content:
    Time_Period_Information:
      Range_of_Dates/Times:
        Beginning_Date: 18510101
        Ending_Date: 20060226
    Currentness_Reference: publication date
  Status:
    Progress: In work
    Maintenance_and_Update_Frequency: n/a
  Spatial_Domain:
    Description_of_Geographic_Extent: All of Texas, but some records from neighboring states in Mexico and the United States are included.
    Bounding_Coordinates:
      West_Bounding_Coordinate: -106
      East_Bounding_Coordinate: -94
      North_Bounding_Coordinate: 37
      South_Bounding_Coordinate: 26
  Keywords:
    Theme:
      Theme_Keyword_Thesaurus: n/a
      Theme_Keyword: Texas
      Theme_Keyword: fishes
      Theme_Keyword: occurrence
      Theme_Keyword: museum voucher
      Theme_Keyword: georeference
  Access_Constraints: Access is limited to use as designated by our data donors. We are still waiting on final permissions from our donors to allow release of their data via our world wide web portal.
  Use_Constraints: Anyone can use data from the database provided that all products produced cite the Fishes of Texas Project and donor institutions.

Point_of_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Dean Hendrickson
Contact_Organization: University of Texas, Texas Natural Science Center, Texas Natural History Collections
Contact_Address:
Address_Type: Mailing and Physical
Address: PRC 176/R4000, 10100 Burnet Road
City: Austin
State_or_Province: TX
Postal_Code: 78758
Contact_Voice_Telephone: 512-471-9774
Contact_Electronic_Mail_Address: deanhend@mail.utexas.edu
Metadata_Reference_Information:
Metadata_Date: 20100929
Metadata_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Dean Hendrickson
Contact_Organization: The University of Texas at Austin, Texas Natural History Collections
Contact_Address:
Address_Type: Mailing
Address: 10100 Burnet Road, PRC 176/R4000
City: Austin
State_or_Province: TX
Postal_Code: 78758-4445
Country: USA
Contact_Voice_Telephone: 512-471-9775
Contact_Electronic_Mail_Address: fishesoftexas@gmail.com
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998

C. P. Gillette Museum of Arthropod Diversity

Identification_Information:
  Citation:
    Citation_Information:
      Originator: Dr. Boris Kondratieff
      Publication_Date: 20100913
      Title: C. P. Gillette Museum of Arthropod Diversity
      Online_Linkage: n/a
  Description:
    Abstract: Extensive holdings of aquatic and terrestrial insects, including those from Colorado and surrounding states.
    Purpose: n/a
    Supplemental_Information: n/a
  Time_Period_of_Content:
    Time_Period_Information:
      Range_of_Dates/Times:
        Beginning_Date: n/a
        Ending_Date: n/a
    Currentness_Reference: publication date
  Status:
    Progress: n/a
    Maintenance_and_Update_Frequency: n/a
  Spatial_Domain:
    Description_of_Geographic_Extent: n/a
    Bounding_Coordinates:
      West_Bounding_Coordinate: -114
      East_Bounding_Coordinate: -94
      North_Bounding_Coordinate: 45
      South_Bounding_Coordinate: 26
  Keywords:
    Theme:
      Theme_Keyword_Thesaurus: n/a
      Theme_Keyword: Aquatic Insects
      Theme_Keyword: Terrestrial Insects
  Access_Constraints: n/a
  Use_Constraints: n/a
  Point_of_Contact:
    Contact_Information:
      Contact_Person_Primary:
        Contact_Person: Dr. Boris Kondratieff
        Contact_Organization: n/a
      Contact_Address:
        Address_Type: n/a
        Address: n/a
        City: n/a
        State_or_Province: n/a
        Postal_Code: n/a
      Contact_Voice_Telephone: n/a
      Contact_Electronic_Mail_Address: boris.kondratieff@colostate.edu
Metadata_Reference_Information:
  Metadata_Date: 20100914

Metadata_Contact:
  Contact_Information:
    Contact_Person_Primary:
      Contact_Person: Dean Hendrickson
      Contact_Organization: The University of Texas at Austin, Texas Natural History Collections
    Contact_Address:
      Address_Type: Mailing
      Address: 10100 Burnet Road, PRC 176/R4000
      City: Austin
      State_or_Province: TX
      Postal_Code: 78758-4445
      Country: USA
    Contact_Voice_Telephone: 512-471-9775
    Contact_Electronic_Mail_Address: fishesoftexas@gmail.com
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998

High Resolution Past and Future Climate Layers (0.25 and 0.05 degree)

Identification_Information:
  Citation:
    Citation_Information:
      Originator: Matthew Moskwik, collaborator
      Publication_Date: 20100928
      Title: High Resolution Past and Future Climate Layers (0.25 and 0.05 degree)
      Online_Linkage: n/a
  Description:
    Abstract: Past monthly average, maximum, and minimum temperature and precipitation layers from the Climate Research Unit (CRU) high resolution climate data, version 2.1 were downloaded from the Intergovernmental Panel on Climate Change (IPCC) Data Distribution Centre (http://www.ipcc-data.org/obs/cru_ts2_1.html). Future climate global circulation models (GCM) from the IPCC 4th Assessment were downloaded from the World Climate Research Programme's (WCRP's) Coupled Model Intercomparison Project (CMIP3) Multi-Model Dataset Archive at the Program for Climate Model Diagnosis and Intercomparison (PCMDI) (http://www-pcmdi.llnl.gov/ipcc/about_ipcc.php). Specifically, the Commonwealth Scientific and Industrial Research Organization's (CSIRO) A2 and B1 models, the Community Climate System Model, version 3 (CCSM3) B1 model, and the Model for Interdisciplinary Research on Climate (MIROC3.2) A2 model were selected for future projections. These future scenarios and models encompass the low (B1) and high (A2) projected temperature increases expected this century. Climate layers were averaged for each decade, 1901-2000 for past data and 2001-2100 for future data. Using the Computational Information Systems Laboratory's (CISL's) National Center for Atmospheric Research (NCAR) Command Language, each decadal layer (i.e. average, minimum, and maximum temperature and precipitation) was linearly interpolated and corrected for elevation (6.5 degrees Celsius per 1000 meters), using the Global 30 Arc-Second Elevation Data Set (GTOPO30), to 0.25 and 0.05 degree resolutions. Nineteen bioclimatic layers, corresponding to the standard WorldClim (www.worldclim.org) layers most commonly used in species distribution modeling, were created from the interpolated data.
    Purpose: n/a
    Supplemental_Information: Data Type: GIS
  Time_Period_of_Content:
    Time_Period_Information:
      Range_of_Dates/Times:
        Beginning_Date: 1901
        Ending_Date: 2100
    Currentness_Reference: publication date
  Status:
    Progress: Complete
    Maintenance_and_Update_Frequency: n/a
  Spatial_Domain:
    Description_of_Geographic_Extent: global land surfaces
    Bounding_Coordinates:
      West_Bounding_Coordinate: -180
      East_Bounding_Coordinate: 180
      North_Bounding_Coordinate: 90
      South_Bounding_Coordinate: 90
  Keywords:
    Theme:
      Theme_Keyword_Thesaurus: n/a
      Theme_Keyword: climate layers

Theme_Keyword: environmental layers
Theme_Keyword: interpolation
Theme_Keyword: climate change scenario
Theme_Keyword: climate change
Theme_Keyword: IPCC 4th Assessment
Access_Constraints: These data represent research in progress, any access would have to be granted on a case-by-case basis.
Use_Constraints: These data represent research in progress and appropriate us is limited by assumptions in model construction and validation.
Point_of_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Muhammad J Shaikh
Contact_Organization: The University of Texas at Austin, Department of Geological Sciences, Jackson School of Geosciences
Contact_Address:
Address_Type: Mailing
Address: 1 University Station C1100
City: Austin
State_or_Province: TX
Postal_Code: 78712
Contact_Voice_Telephone: 512-232-7939
Contact_Electronic_Mail_Address: shaikh@jsg.utexas.edu
Metadata_Reference_Information:
Metadata_Date: 20100929
Metadata_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Dean Hendrickson
Contact_Organization: The University of Texas at Austin, Texas Natural History Collections
Contact_Address:
Address_Type: Mailing
Address: 10100 Burnet Road, PRC 176/R4000
City: Austin
State_or_Province: TX
Postal_Code: 78758-4445
Country: USA
Contact_Voice_Telephone: 512-471-9775
Contact_Electronic_Mail_Address: fishesoftexas@gmail.com
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998

Holocene Mussel Collection

Identification_Information:
  Citation:
    Citation_Information:
      Originator: Ann Molineux, co-PI
      Publication_Date: 20100826
      Title: NPL Holocene Mussel Collection
      Online_Linkage: http://www.utexas.edu/tmm/npl/recent_comparative/index.html
  Description:
    Abstract: The NPL Holocene Mussel Collection includes three collections: 1. The historic collection of J. A. Singley and H.G. Askew containing some material collected during the early Texas Geological Surveys and a donated collection (Askew) obtained for UT by Singley. These also contain specimens from states other than Texas. Collection dates range from late 1890's to early twentieth century. This collection is inventoried, conserved and currently in an MSAccess database. The 60 drawers of specimens are currently being imaged and localities georeferenced. The data will be migrated into Specify 6 to join collection data from 2a and 2b. 2. Robert Howells collection -Texas Parks and Wildlife. This Texas collection was used to compile several research reports and books and was reposited at NPL in two stages: 2a: The first (about 1000 lots in 30 boxes) in June 2006. Funding was acquired to curate, conserve, georeference, digitize and image this collection. It is currently being migrated from the database application Specify 5 to Specify 6.Other aspects are completed. 2b: The final collection arrived in mid-2010 and is actively being curated to the level of 2a, funded by the GPLCC grant. All specimens are conserved and imaged, and the georeferences checked against Howells locality listing (provided with this second collection). All specimen data will reside in the same Specify6 database along with the initial collection 2a. 3: Other miscellaneous mussels from various collectors at UT and the Texas Memorial Museum are being moved through the same protocol with data added to the common Specify6 database to be made available through the GBIF portal.
    Purpose: n/a
    Supplemental_Information: Collections include extinct, extirpated and threatened and/or endangered species. Specimen Types: Whole specimens, Partial specimens, Photographs, Digital. Preservative Types: Dried.
  Time_Period_of_Content:
    Time_Period_Information:
      Range_of_Dates/Times:
        Beginning_Date: 18901212
        Ending_Date: 20060606
    Currentness_Reference: publication date
  Status:
    Progress: In work
    Maintenance_and_Update_Frequency: None planned
  Spatial_Domain:
    Description_of_Geographic_Extent: Specimens are mainly from Texas, but the historic collection is more widespread within the USA.
    Bounding_Coordinates:
      West_Bounding_Coordinate: -124
      East_Bounding_Coordinate: -75
      North_Bounding_Coordinate: 49
      South_Bounding_Coordinate: 25.5
  Keywords:
    Theme:
      Theme_Keyword_Thesaurus: n/a
      Theme_Keyword: Mussels

Theme_Keyword: Texas
Theme_Keyword: Howells
Theme_Keyword: Singley
Theme_Keyword: Askew
Theme_Keyword: Nineteenth century survey
Theme_Keyword: Twentieth century survey
Theme_Keyword: Well-preserved
Theme_Keyword: Images
Access_Constraints: none
Use_Constraints: none
Point_of_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Ann Molineux
Contact_Organization: Texas Natural Science Center
University of Texas at Austin
Contact_Address:
Address_Type: Mailing
Address: Non-vertebrate Paleontology Lab, Building 122, J.J.Pickle Research Campus, 10100 Burnet Road
City: Austin
State_or_Province: Texas
Postal_Code: 78758
Contact_Voice_Telephone: 512-232-5384
Contact_Electronic_Mail_Address: annm@austin.utexas.edu
Metadata_Reference_Information:
Metadata_Date: 20100902
Metadata_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Dean Hendrickson
Contact_Organization: The University of Texas at Austin, Texas Natural History Collections
Contact_Address:
Address_Type: Mailing
Address: 10100 Burnet Road, PRC 176/R4000
City: Austin
State_or_Province: TX
Postal_Code: 78758-4445
Country: USA
Contact_Voice_Telephone: 512-471-9775
Contact_Electronic_Mail_Address: fishesoftexas@gmail.com
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998

Museum of Southwestern Biology, Division of Fishes

Identification_Information:
Citation:
Citation_Information:
Originator: Alexandra Snyder, Collections Manager
Publication_Date: 20100831
Title: Museum of Southwestern Biology, Division of Fishes
Online_Linkage: http://www.msb.unm.edu/fishes/index.html
Description:
Abstract: The MSB serves a region in North America noted for a wide range of ecotypes and elevational gradients, from the Rocky Mountains to the Great Basin and the Great Plains, with the convergence of three major deserts, the Chihuahua, Sonora and Mojave. The fish fauna of New Mexico (and the southwestern USA) is characterized by high endemism, diversity, and remarkable physiological tolerances. The MSB collection of fishes provides a 70-year window on the natural history of New Mexico's imperiled native fishes and aquatic systems. The MSB has almost 80,000 catalogued lots of fishes representing 59 families, 165 genera, and 330 species, collected between 1938 and 2010. Genetic materials are available and maintained at ?80o C or in 95% EtOH.
Purpose: n/a
Supplemental_Information: Specimens Types: Whole specimens, Partial specimens, Tissue samples, Photographs, Illustrations, X-Rays, Digital, GIS, Original field notes digitized. Preservative Types: Ethyl Alcohol, Isopropyl Alcohol, Formalin, Dried, -80C frozen whole, tissues, 95% ethanol whole and tissues.
Time_Period_of_Content:
Time_Period_Information:
Range_of_Dates/Times:
Beginning_Date: 19280703
Ending_Date: 20100408
Currentness_Reference: publication date
Status:
Progress: In work
Maintenance_and_Update_Frequency: None planned
Spatial_Domain:
Description_of_Geographic_Extent: New Mexico, Utah (San Juan River), Arizona, Texas (Rio Grande), Wyoming
Bounding_Coordinates:
West_Bounding_Coordinate: -114
East_Bounding_Coordinate: -94
North_Bounding_Coordinate: 45
South_Bounding_Coordinate: 25.5
Keywords:
Theme:
Theme_Keyword_Thesaurus: n/a
Theme_Keyword: Desert Fishes
Theme_Keyword: Southwestern USA
Theme_Keyword: New Mexico
Theme_Keyword: Life History collections
Theme_Keyword: Fish Eggs
Theme_Keyword: Fish Larvae
Access_Constraints: The MSB fishes database and images within them are owned by the Regents of the University of New Mexico. Federal and state collections of specimens and data, under the stewardship of the MSB, remain the property of the US state or the United States Government. Most MSB data and images may be used freely by individuals and organizations for purposes of basic research, education, and

conservation. However, some data are restricted or not available for public disclosure due to sensitive species status, rights of the property owner, and/or proprietary rights of the researcher/collector. All MSB data and images may not be used for commercial or for-profit purposes and may not be repackaged, resold, or redistributed in any form. Use of the data or images in publications, dissertations and theses, or other scientific reports, should be accompanied by an acknowledgment of the Division of Fishes, Museum of Southwestern Biology as the source for the information. Please provide the MSB Division of Fishes with reprints of articles resulting from the use of these data or images.

Use_Constraints: MSB Division of Fishes data that are considered sensitive and/or proprietary will be withheld by the data manager when fulfilling large data requests that may be shared with other (third party) research programs or public information venues.

Point_of_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Alexandra M Snyder
Contact_Organization: Division of Fishes, Museum of Southwestern Biology
Contact_Address:
Address_Type: Mailing and Physical
Address: University of New Mexico MSC03-2020, 302 Yale Blvd NE
City: Albuquerque
State_or_Province: NM
Postal_Code: 87131
Contact_Voice_Telephone: 505-277-6005
Contact_Electronic_Mail_Address: amsnyder@unm.edu

Metadata_Reference_Information:
Metadata_Date: 20100805
Metadata_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Dean Hendrickson
Contact_Organization: The University of Texas at Austin, Texas Natural History Collections
Contact_Address:
Address_Type: Mailing
Address: 10100 Burnet Road, PRC 176/R4000
City: Austin
State_or_Province: TX
Postal_Code: 78758-4445
Country: USA
Contact_Voice_Telephone: 512-471-9775
Contact_Electronic_Mail_Address: fishesoftexas@gmail.com
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998

Oklahoma State University Collection of Vertebrates (Fish)

Identification_Information:
  Citation:
    Citation_Information:
      Originator: Anthony Echelle, Professor
      Publication_Date: 20100909
      Title: Oklahoma State University Collection of Vertebrates (Fish)
      Online_Linkage: n/a
  Description:
    Abstract: There are about 30,000 lots. The collection is being maintained, but the database needs a lot of cleaning up (updating taxonomy, etc.).
    Purpose: n/a
    Supplemental_Information: Specimen Type: Whole Specimens. Preservative Type: Isopropyl Alcohol
  Time_Period_of_Content:
    Time_Period_Information:
      Range_of_Dates/Times:
        Beginning_Date: 1930
        Ending_Date: 2010
    Currentness_Reference: publication date
  Status:
    Progress: n/a
    Maintenance_and_Update_Frequency: In work
  Spatial_Domain:
    Description_of_Geographic_Extent: Widespread over North America (and Nepal) but primarily Oklahoma and nearby states.
    Bounding_Coordinates:
      West_Bounding_Coordinate: -180
      East_Bounding_Coordinate: 180
      North_Bounding_Coordinate: 90
      South_Bounding_Coordinate: 90
  Keywords:
    Theme:
      Theme_Keyword_Thesaurus: n/a
      Theme_Keyword: Freshwater fishes
      Theme_Keyword: Oklahoma
      Theme_Keyword: Texas
      Theme_Keyword: Arkansas
  Access_Constraints: n/a
  Use_Constraints: n/a
  Point_of_Contact:
    Contact_Information:
      Contact_Person_Primary:
        Contact_Person: Anthony A. Echelle
        Contact_Organization: Oklahoma State University
      Contact_Address:
        Address_Type: Mailing
        Address: Oklahoma State University Zoology Department
  Life Sciences West 501
        City: Stillwater
        State_or_Province: Oklahoma

Postal_Code: 74078
Contact_Voice_Telephone: 405-744-9681
Contact_Electronic_Mail_Address: anthony.echelle@okstate.edu
Metadata_Reference_Information:
Metadata_Date: 20100914
Metadata_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Dean Hendrickson
Contact_Organization: The University of Texas at Austin, Texas Natural History Collections
Contact_Address:
Address_Type: Mailing
Address: 10100 Burnet Road, PRC 176/R4000
City: Austin
State_or_Province: TX
Postal_Code: 78758-4445
Country: USA
Contact_Voice_Telephone: 512-471-9775
Contact_Electronic_Mail_Address: fishesoftexas@gmail.com
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998

Species Distribution Models for Freshwater Fishes of Texas

Identification_Information:
  Citation:
    Citation_Information:
      Originator: Ben Labay, Research Associate
      Publication_Date: 20100923
      Title: Species Distribution Models for Freshwater Fishes of Texas
      Online_Linkage: www.fishesoftexas.org
  Description:
    Abstract: Species distribution models were constructed for fish taxa recorded in the Fishes of Texas database. Models were constructed using the maximum entropy algorithm encoded in the Maxent software package version 3.3.4 (Phillips et al. 2006; Phillips and Dudik 2008). Maxent has been shown to be robust for species distribution modeling with presence-only records (Elith et al. 2006). This collection of models represent ongoing research into understanding patterns and drivers of distributions of fishes across time and space. The models are constructed using various combinations of climatic, topographic, and biologic variables.
    Purpose: n/a
    Supplemental_Information: Fishes
  Time_Period_of_Content:
    Time_Period_Information:
      Range_of_Dates/Times:
        Beginning_Date: N/A
        Ending_Date: N/A
    Currentness_Reference: publication date
  Status:
    Progress: N/A
    Maintenance_and_Update_Frequency: n/a
  Spatial_Domain:
    Description_of_Geographic_Extent: N/A
    Bounding_Coordinates:
      West_Bounding_Coordinate: -106
      East_Bounding_Coordinate: -94
      North_Bounding_Coordinate: 37
      South_Bounding_Coordinate: 26
  Keywords:
    Theme:
      Theme_Keyword_Thesaurus: n/a
      Theme_Keyword: species distribution models
      Theme_Keyword: ecological niche models
      Theme_Keyword: environmental niche models
      Theme_Keyword: Texas
      Theme_Keyword: fishes
      Theme_Keyword: maxtent
  Access_Constraints: At the time of this entry, we have constructed high quality, reliable, continuous distribution layers for 128 Texas fishes. Each coverage is a GIS raster grid representing probability of occurrence. Ongoing research includes modeling distribution shifts due to climate change, assessing historic assemblages in impacted streams, understanding and utilizing potential versus realized distributions, and tying probabilities of occurrence to stream segments in the National Hydrography dataset in order to correlate distributions to relevant hydrologic parameters. Data Type: GIS.

Use_Constraints: These data represent research in progress, any access would have to be granted on a case-by-case basis.
Point_of_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Ben Labay or Dean Hendrickson
Contact_Organization: Texas Natural History Collection, University of Texas at Austin
Contact_Address:
Address_Type: Mailing and Physical
Address: 10100 Burnet Rd., PRC176 EAST/R4000
City: Austin
State_or_Province: Texas
Postal_Code: 78758
Contact_Voice_Telephone: 512-471-4823
Contact_Electronic_Mail_Address: benlabay@mail.utexas.edu, deanhend@mail.utexas.edu
Metadata_Reference_Information:
Metadata_Date: 20100927
Metadata_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Dean Hendrickson
Contact_Organization: The University of Texas at Austin, Texas Natural History Collections
Contact_Address:
Address_Type: Mailing
Address: 10100 Burnet Road, PRC 176/R4000
City: Austin
State_or_Province: TX
Postal_Code: 78758-4445
Country: USA
Contact_Voice_Telephone: 512-471-9775
Contact_Electronic_Mail_Address: fishesoftexas@gmail.com
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998

Sam Noble Oklahoma Museum of Natural History Collection of Fishes

Identification_Information:
  Citation:
    Citation_Information:
      Originator: Edie Marsh-Matthews, Associate Curator of Fishes
      Publication_Date: 20100909
      Title: Sam Noble Oklahoma Museum of Natural History Collection of Fishes
      Online_Linkage: http://www.snomnh.ou.edu/collections-research/ichthyology.htm
  Description:
    Abstract: The collection comprises about 50,000 lots representing 285 species and about 100 genera of freshwater fishes.
    Purpose: n/a
    Supplemental_Information: Specimen Type: whole specimens. Preservative Type: isopropyl alcohol.
  Time_Period_of_Content:
    Time_Period_Information:
      Range_of_Dates/Times:
        Beginning_Date: 1916
        Ending_Date: 2010
    Currentness_Reference: publication date
  Status:
    Progress: Completed
    Maintenance_and_Update_Frequency: In work
  Spatial_Domain:
    Description_of_Geographic_Extent: Mostly fishes from the central United States (Oklahoma, Arkansas, Texas) with lots from 22 states total.
    Bounding_Coordinates:
      West_Bounding_Coordinate: -106
      East_Bounding_Coordinate: -89
      North_Bounding_Coordinate: 36
      South_Bounding_Coordinate: 26
  Keywords:
    Theme:
      Theme_Keyword_Thesaurus: n/a
      Theme_Keyword: Freshwater fishes
      Theme_Keyword: Oklahoma
      Theme_Keyword: Texas
      Theme_Keyword: Arkansas
  Access_Constraints: none
  Use_Constraints: none
  Point_of_Contact:
    Contact_Information:
      Contact_Person_Primary:
        Contact_Person: Edie Marsh-Matthews
        Contact_Organization: Sam Noble Oklahoma Museum of Natural History
      Contact_Address:
        Address_Type: Mailing
        Address: 2401 Chautauqua Ave.
        City: Norman
        State_or_Province: Oklahoma
        Postal_Code: 73072

Contact_Voice_Telephone: 405-325-0785
Contact_Electronic_Mail_Address: emarsh@ou.edu
Metadata_Reference_Information:
Metadata_Date: 20100914
Metadata_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Dean Hendrickson
Contact_Organization: The University of Texas at Austin, Texas Natural History Collections
Contact_Address:
Address_Type: Mailing
Address: 10100 Burnet Road, PRC 176/R4000
City: Austin
State_or_Province: TX
Postal_Code: 78758-4445
Country: USA
Contact_Voice_Telephone: 512-471-9775
Contact_Electronic_Mail_Address: fishesoftexas@gmail.com
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998

Texas Natural History Collection, Herpetology

Identification_Information:
Citation:
Citation_Information:
Originator: Travis LaDuc, Assistant Curator
Publication_Date: 20101011
Title: Texas Natural History Collections, Herpetology
Online_Linkage: http://www.utexas.edu/tmm/tnhc/herps/index.html
Description:
Abstract: The Herpetology Division and its collection of amphibians and reptiles is one of the research units of the Texas Natural History Collections in the Texas Natural Science Center at The University of Texas at Austin. The collection began as a nucleus of research and teaching materials assembled by W. Frank Blair and his students in the Zoology Department; these were transferred to the (then) Texas Memorial Museum in 1950's. The holdings consist of about 63,000 catalogued specimens, which are used for research by faculty, staff and students at the University, as well as by qualified researchers throughout the world. The collection is also used for teaching courses (e.g., Vertebrate Natural History, Comparative Anatomy, and Herpetology) in Integrative Biology.

David Cannatella, Curator

Travis LaDuc, Assistant Curator

Preserved Specimens

The majority of specimens in the Herpetology collection were fixed in formaldehyde and are currently stored in 70% ethanol; this is a standard museum procedure for this type of material. The specimens are housed in specially designed rooms at the Texas Natural History Collections building at the J. J. Pickle Research Campus. Each specimen is given a unique number through which the data associated with the specimen (such as where and when the animal was found, and who found it) can be looked up, either on computer or in older, hand-written catalogs. Each jar has a label listing the specimens it contains, and the jars are arranged on shelves by species, genus, family, etc., in a phylogenetic system that indicates the evolutionary relationships of the animals. Over the past few years, the herpetological collections from Texas Tech University (~12,000 specimens) and the University of Texas at Brownsville (~400 specimens) were acquired by the TNHC. We are working on cataloging the specimens into the TNHC herpetology collections and we will make the data available as soon as possible.

Skeletons

There are about 1300 catalogued skeletons, including 500 or so cleared and stained specimens. Cleared and stained skeletons, such as the one at shown here, are treated with an enzyme solution to dissolve muscle tissue, a red stain specific for bone, a blue stain specific for cartilage, and then cleared with a bleaching agent. The skeletons are stored in glycerine, which helps to render the muscle transparent. Dried skeletons are prepared using dermestid beetles, which eat away the muscle while leaving (hopefully) only the bones. The bugged skeletons are then treated to an ammonia bath (to rid them of any excess grease and smell) prior to storage.

Frozen Tissues

The TNSC supports a collection of more than 35,000 tissue samples stored in liquid nitrogen freezers at ultra-low temperatures (-140§C). This material is used primarily for research in which DNA sequences are used to determine evolutionary relationships among the organisms. The entire collection was recently

inventoried through an NSF Biological Research Collections improvement grant ($135K, 2006-2009). The collection supports research of UT personnel, but material is available for loan to other investigators. More information can be obtained from the Curator.

Tape Recordings

The TNHC collection of record frog calls is the second or third largest in the U.S., with about 400 catalogued tapes and as many more waiting to be cataloged. Some sample frog calls:

* Bufo valliceps
* Gastrophryne carolinensis
* Rhinophrynus dorsalis

Geographic Coverage

The geographic coverage of the herpetology collection is world-wide. About 65% of the specimens are from the U.S., mostly Texas (84%) and the Southwest. But there is important material from the New World tropics (Mexico, Central and South America, 15%), tropical Africa (8%) and Southeast Asia (9%).

Taxonomic Coverage

Most of the catalogued specimens are frogs (56%). Lizards make up 23%, and snakes another 12%. Salamanders are 7%, and turtles are only 2%; neither of these groups has many species worldwide. Caecilians, crocodilians, tuataras, and amphisbaenians are each represented by less than 0.1%

Online Database

You can search our database via HerpNet.

Loans and Visits

Loans may be made to qualified researchers associated with scientific institutions. Qualified researchers are welcome to visit the collections provided they contact the Curator/Assistant Curator in advance to arrange logistics.

Purpose: n/a

Supplemental_Information: The skeletal collection consists of both dry, and cleared & stained skeletal preparations. There are just under 1000 dry skeletal specimens (mostly Bufonidae) and over 1200 cleared and stained specimens. In 2000, the TNHC received 16,000 specimens from the TTU herpetology collection, representing the largest collection of herpetological specimens from the Texas Panhandle. Although this was the single largest separate herpetology collection accessioned by the TNHC, other smaller collections have been acquired, including a collection of 199 specimens from Dr. Norman Richard of Brownsville TX and 890 specimens donated by Dr. Thomas Scanlon, formerly at the University of Missouri-Columbia. Specimen Types: Whole specimens, Partial specimens, Tissue samples, Photographs, Tape Recordings, Digital Images. Preservative Types: Ethyl Alcohol (95%, 70%), Formalin (10%), Isopropyl Alcohol (55%), Dried, frozen (-140 degrees C).

Time_Period_of_Content:

Time_Period_Information:

Range_of_Dates/Times:

Beginning_Date: 1918

Ending_Date: 2010

Currentness_Reference: publication date

Status:
Progress: In work
Maintenance_and_Update_Frequency: n/a
Spatial_Domain:
Description_of_Geographic_Extent: The geographic coverage of the herpetology collection is world-wide. About 65% of the specimens are from the U.S., mostly Texas (84%) and the Southwest. But there is important material from the New World tropics (Mexico, Central and South America, 15%), tropical Africa (8%), and Southeast Asia (9%).
Bounding_Coordinates:
West_Bounding_Coordinate: -180
East_Bounding_Coordinate: 180
North_Bounding_Coordinate: 90
South_Bounding_Coordinate: 90
Keywords:
Theme:
Theme_Keyword_Thesaurus: n/a
Theme_Keyword: Reptile
Theme_Keyword: Snake
Theme_Keyword: Lizard
Theme_Keyword: Turtle
Theme_Keyword: Amphibian
Theme_Keyword: Frog
Theme_Keyword: Toad
Theme_Keyword: Salamander
Theme_Keyword: Squirrel
Theme_Keyword: Plethodontidae
Theme_Keyword: Bufonidae
Theme_Keyword: Ranidae
Theme_Keyword: Hylidae
Theme_Keyword: Microhylidae
Theme_Keyword: Phyrnosomatidae
Theme_Keyword: Teiidae
Theme_Keyword: Colubridae
Theme_Keyword: Viperidae
Access_Constraints: The Texas Natural History Collections (TNHC) supports the Natural Science Collection Alliances' [previously known as Association of Systematics Collections' (ASC)] acknowledgement of the "...need to share data from collections as broadly as possible within the constraint of institutional stewardship responsibilities" (Hathaway, E.C. and K.E. Hoagland (eds.) 1993. ASC Guidelines for Institutional Database Policies. 76 pp. The Association of Systematics Collections, Washington, D.C.). It is in the spirit of that document that TNHC offers public access to its databases through this Internet connection, but asks that users be cognizant of the nature of the data, and that they abide by the following policy for database utilization.

The Nature of the data

Texas Natural History Collection (TNHC) specimen databases are defined as records derived from field catalogs, field notes, specimen labels, card files, catalogs and ledgers. These databases include electronic storage media and/or data files or data products in a variety of formats including electronic and printed. They are an integral part of the collections and function not only as a resource for researchers world-wide, but also are used internally for tracking specimen use and collection activities. In spite of the important role played by specimen databases, they ARE NOT to be considered primary data. Despite our best

attempts to assure accuracy, TNHC cannot be responsible for specimen identification, or data verification. It is up to the researcher to verify all database entries or associated information before reporting or publishing data in any form. Information from the TNHC databases is intended to support rather than replace the use of the collections themselves. We encourage researches to visit our collections to inspect specimens or to request loans when that is not possible.

Policy for database utilization

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The data may not be passed through to any other individual or organization without the written consent of the appropriate Curator of the Texas Natural History Collection.

Information contained in TNHC databases is bound by University of Texas regulations on intellectual property. Ownership and copyright are retained by the University and the state of Texas.

TNHC maintains the right to restrict access to certain data fields and to charge reasonable user fees for specialized data retrieval requests.

TNHC does not warrant that any of its data are appropriate for any applications in which users may apply them, and reserves the right to update the online data files at any time.

Use_Constraints: In the spirit of the Natural Science Collection Alliances' acknowledgement of the "...need to share data from collections as broadly as possible within the constraint of institutional stewardship responsibilities" (Hathaway & Hoagland 1993), the Texas Natural History Collections (TNHC) offers this public access to its databases, but asks that users be cognizant of the nature of the data, and that they abide by the following policy for database utilization: Records in this database ARE NOT to be considered primary data. Despite our best attempts to continually update our databases and assure accuracy, TNHC cannot be responsible for specimen identification or data verification. Outdated taxonomy, mistaken identifications, and erroneous localities are inevitable occurrences. Information from the TNHC databases is intended to support rather than replace the use of the collections themselves and researchers should verify all information by direct specimen examination before reporting or publishing data in any form. Data retrieved via this provider may be used freely by researchers and educators for non-commercial research or educational purposes, but may not be repackaged, resold, or redistributed in any form without the express written consent of the Curator of Ichthyology. Any use of data must be acknowledged in any publication, advertisement, correspondence or public testimony that alludes to or mentions such data even if the data have been reorganized or added to for any purpose. TNHC does not warrant that any of its data are appropriate for any applications in which users may employ them, and reserves the right to update the online data files at any time. The TNHC and its staff are not responsible for damages, injury, or loss due to the use of these data. Information contained in TNHC databases is bound by University of Texas regulations on intellectual property. Ownership and copyright are retained by the University and the state of Texas. The TNHC maintains the right to restrict access to certain data fields and to charge reasonable user fees for specialized data retrieval requests. Direct questions or comments to the Curator of Ichthyology. Lit. Cited: Hathaway, E.C. & K.E. Hoagland (eds.) 1993. ASC Guidelines for Institutional Database Policies. 76 pp. The Association of Systematics Collections, Washington, DC.

Point_of_Contact:

Contact_Information:

Contact_Person_Primary:
Contact_Person: Travis LaDuc
Contact_Organization: University of Texas, Texas Natural Science Center, Texas Natural History Collections
Contact_Address:
Address_Type: Mailing and Physical
Address: 10100 Burnet Rd, PRC 176 - R4000
City: Austin
State_or_Province: Texas
Postal_Code: 78758-4445
Contact_Voice_Telephone: 512-475-6339
Contact_Electronic_Mail_Address: travieso@mail.utexas.edu
Metadata_Reference_Information:
Metadata_Date: 20101012
Metadata_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Dean Hendrickson
Contact_Organization: The University of Texas at Austin, Texas Natural History Collections
Contact_Address:
Address_Type: Mailing
Address: 10100 Burnet Road, PRC 176/R4000
City: Austin
State_or_Province: TX
Postal_Code: 78758-4445
Country: USA
Contact_Voice_Telephone: 512-471-9775
Contact_Electronic_Mail_Address: fishesoftexas@gmail.com
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998

Texas Natural History Collection, Ichthyology

Identification_Information:
Citation:
Citation_Information:
Originator: Jess Rosales, Ichthyology Collection Manager
Publication_Date: 20100916
Title: Texas Natural History Collection, Ichthyology
Online_Linkage: http://www.utexas.edu/tmm/tnhc/fish/index.html
Description:
Abstract: The Ichthyology collection contains 45,857 lots (1,020,608 specimens). These specimens represent 1673 species from 781 genera in 244 families. 53 out of 62 orders (following Nelson, 2006) are represented. Nearly all of Texas 266 species are represented. As such, the bulk of our specimens (80%) are Texas freshwater fishes. All Texas specimens (freshwater, saltwater, and brackish water) account for 87% of our collection. Earliest cataloged collections date from the late 1920's, with a few collections from the 1930's and 1940's. There was significant collection growth in the 1950's ? 1980?s, mainly due to Dr. Clark Hubbs, his students and family. In 1990, The University of Texas Marine Science Institute's (UTMSI) collection from the Gulf of Mexico was donated to the TNHC. Orphaned collections, acquired between 2000 and 2003, from Midwestern State University (MWSU), Texas Tech University (TTU), Texas A&M University- Kingsville (TAIC), and The University of Texas at Brownsville (UTB) have added 138,213 specimens (8986 lots) to the collection thus far. Collecting efforts continue to date, with many incoming Texas species being donated as river study voucher specimens by Texas Parks and Wildlife and the USGS. TNHC research associates are focusing on distributions of Texas species, while Dr. Hendrickson and his collaborators continue to add valuable Mexican material.
Purpose: n/a
Supplemental_Information: The osteology collection consists of both dry (481 specimens) and cleared & stained (937 specimens). We have osteological preparations of as many of Texas? 266 species as our holding would allow. The TNHC Fish Tissue Collection is small and uncataloged, but within this calendar year will be formally initiated, and stored in liquid nitrogen freezers already installed in our collection facility. We anticipate rapid growth of the tissue collection in conjunction with extensive fieldwork planned for the near future. Specimens Types: Whole specimens, Partial specimens, Tissue samples, Photographs, Illustrations, X-Rays, Digital, GIS. Preservative Types: Ethyl Alcohol, Isopropyl Alcohol, Formalin, Dried, Glycerine.
Time_Period_of_Content:
Time_Period_Information:
Range_of_Dates/Times:
Beginning_Date: 19270810
Ending_Date: 20100722
Currentness_Reference: publication date
Status:
Progress: In work
Maintenance_and_Update_Frequency: n/a
Spatial_Domain:
Description_of_Geographic_Extent: The bulk of our specimens (80%) are Texas freshwater fishes. All Texas specimens (freshwater, saltwater, and brackish water) account for 87% of our collection, and 213 out of Texas' 254 counties are represented by voucher specimens. Our overall marine holdings, primarily from the Gulf of Mexico, consist of 7% of all localities. Holdings from elsewhere in the United States (states or territories) include: Florida, Arkansas, Oklahoma, Louisiana, 30 other states, Puerto Rico and the Virgin Islands. Twenty non-U.S. countries are represented and account for 9% of the collection, with significant holdings from Mexico, Costa Rica, Venezuela, and Zambia.
Bounding_Coordinates:
West_Bounding_Coordinate: -180

East_Bounding_Coordinate: 180
North_Bounding_Coordinate: 90
South_Bounding_Coordinate: 90
Keywords:
Theme:
Theme_Keyword_Thesaurus: n/a
Theme_Keyword: Fish
Theme_Keyword: Texas
Theme_Keyword: Freshwater
Theme_Keyword: Gulf of Mexico
Theme_Keyword: Saltwater
Theme_Keyword: Cyprinidae
Theme_Keyword: Ictaluridae
Theme_Keyword: Percidae
Theme_Keyword: Poecilidae
Theme_Keyword: Fundulidae
Theme_Keyword: Catostomidae
Theme_Keyword: Amiidae
Theme_Keyword: Lepisosteidae
Theme_Keyword: Anguillidae
Theme_Keyword: Cichlidae
Theme_Keyword: Centrarchidae
Theme_Keyword: Fishes of Texas
Theme_Keyword: Cyprinodontidae
Theme_Keyword: Atherinopsidae
Theme_Keyword: Cave Catfish
Theme_Keyword: Hubbs
Theme_Keyword: Specify
Access_Constraints: The Texas Natural History Collections (TNHC) supports the Natural Science Collection Alliances' [previously known as Association of Systematics Collections' (ASC)] acknowledgement of the "...need to share data from collections as broadly as possible within the constraint of institutional stewardship responsibilities" (Hathaway, E.C. and K.E. Hoagland (eds.) 1993. ASC Guidelines for Institutional Database Policies. 76 pp. The Association of Systematics Collections, Washington, D.C.). It is in the spirit of that document that TNHC offers public access to its databases through this Internet connection, but asks that users be cognizant of the nature of the data, and that they abide by the following policy for database utilization.

The Nature of the data

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Policy for database utilization

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The data may not be passed through to any other individual or organization without the written consent of the appropriate Curator of the Texas Natural History Collection.

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TNHC maintains the right to restrict access to certain data fields and to charge reasonable user fees for specialized data retrieval requests.

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Use_Constraints: In the spirit of the Natural Science Collection Alliances' acknowledgement of the ...need to share data from collections as broadly as possible within the constraint of institutional stewardship responsibilities (Hathaway & Hoagland 1993), the Texas Natural History Collections (TNHC) offers this public access to its databases, but asks that users be cognizant of the nature of the data, and that they abide by the following policy for database utilization: Records in this database ARE NOT to be considered primary data. Despite our best attempts to continually update our databases and assure accuracy, TNHC cannot be responsible for specimen identification or data verification. Outdated taxonomy, mistaken identifications, and erroneous localities are inevitable occurrences. Information from the TNHC databases is intended to support rather than replace the use of the collections themselves and researchers should verify all information by direct specimen examination before reporting or publishing data in any form. Data retrieved via this provider may be used freely by researchers and educators for non-commercial research or educational purposes, but may not be repackaged, resold, or redistributed in any form without the express written consent of the Curator of Ichthyology. Any use of data must be acknowledged in any publication, advertisement, correspondence or public testimony that alludes to or mentions such data even if the data have been reorganized or added to for any purpose. TNHC does not warrant that any of its data are appropriate for any applications in which users may employ them, and reserves the right to update the online data files at any time. The TNHC and its staff are not responsible for damages, injury, or loss due to the use of these data. Information contained in TNHC databases is bound by University of Texas regulations on intellectual property. Ownership and copyright are retained by the University and the state of Texas. The TNHC maintains the right to restrict access to certain data fields and to charge reasonable user fees for specialized data retrieval requests. Direct questions or comments to the Curator of Ichthyology. Lit. Cited: Hathaway, E.C. & K.E. Hoagland (eds.) 1993. ASC Guidelines for Institutional Database Policies. 76 pp. The Association of Systematics Collections, Washington, DC.

Point_of_Contact:

Contact_Information:

Contact_Person_Primary:

Contact_Person: Jess Rosales

Contact_Organization: Texas Natural History Collections, Texas Natural Science Center, The University of Texas at Austin

Contact_Address:

Address_Type: Mailing and Physical

Address: 10100 Burnet RD, PRC 176/R4000
City: Austin
State_or_Province: Texas
Postal_Code: 78758
Contact_Voice_Telephone: 512-471-8845
Contact_Electronic_Mail_Address: rosales@mail.utexas.edu
Metadata_Reference_Information:
Metadata_Date: 20100914
Metadata_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Dean Hendrickson
Contact_Organization: The University of Texas at Austin, Texas Natural History Collections
Contact_Address:
Address_Type: Mailing
Address: 10100 Burnet Road, PRC 176/R4000
City: Austin
State_or_Province: TX
Postal_Code: 78758-4445
Country: USA
Contact_Voice_Telephone: 512-471-9775
Contact_Electronic_Mail_Address: fishesoftexas@gmail.com
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998

Texas Natural History Collection, Invertebrate Zoology

Identification_Information:
Citation:
Citation_Information:
Originator: James Reddell, Curator
Publication_Date: 20101011
Title: Texas Natural History Collections, Invertebrate Zoology
Online_Linkage: http://www.utexas.edu/tmm/tnhc/invertzoology/index.html
Description:
Abstract: The Invertebrate Zoology collection contains approximately 400,000 slide-mounted and alcohol-preserved specimens of terrestrial, freshwater, and marine organisms from many parts of the world, but with emphasis on the United States and Mexico. The general collection contains significant material from Texas, other parts of the United States, Central America, and the Galapagos Islands. Maintained as a separate unit is the biospeleology collection. This collection contains specimens obtained from caves in essentially every county in Texas and state in Mexico known to have caves. The marine invertebrate collection includes significant voucher material from projects in Alaska and the Texas Gulf Coast.
Purpose: n/a
Supplemental_Information: Specimen Types: Whole specimens, Partial specimens, Photographs, Illustrations, Digital, slide-mounted. Preservative Types: Ethyl Alcohol, Dried.
Time_Period_of_Content:
Time_Period_Information:
Range_of_Dates/Times:
Beginning_Date: 1960
Ending_Date: 2010
Currentness_Reference: publication date
Status:
Progress: In work
Maintenance_and_Update_Frequency: n/a
Spatial_Domain:
Description_of_Geographic_Extent: World-wide
Bounding_Coordinates:
West_Bounding_Coordinate: -180
East_Bounding_Coordinate: 180
North_Bounding_Coordinate: 90
South_Bounding_Coordinate: 90
Keywords:
Theme:
Theme_Keyword_Thesaurus: n/a
Theme_Keyword: invertebrate
Theme_Keyword: biospeleology
Theme_Keyword: cave biology
Access_Constraints: The Texas Natural History Collections (TNHC) supports the Natural Science Collection Alliances' [previously known as Association of Systematics Collections' (ASC)] acknowledgement of the "...need to share data from collections as broadly as possible within the constraint of institutional stewardship responsibilities" (Hathaway, E.C. and K.E. Hoagland (eds.) 1993. ASC Guidelines for Institutional Database Policies. 76 pp. The Association of Systematics Collections, Washington, D.C.). It is in the spirit of that document that TNHC offers public access to its databases through this Internet connection, but asks that users be cognizant of the nature of the data, and that they abide by the following policy for database utilization.

The Nature of the data

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Policy for database utilization

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TNHC maintains the right to restrict access to certain data fields and to charge reasonable user fees for specialized data retrieval requests.

TNHC does not warrant that any of its data are appropriate for any applications in which users may apply them, and reserves the right to update the online data files at any time.

Use_Constraints: In the spirit of the Natural Science Collection Alliances' acknowledgement of the "...need to share data from collections as broadly as possible within the constraint of institutional stewardship responsibilities" (Hathaway & Hoagland 1993), the Texas Natural History Collections (TNHC) offers this public access to its databases, but asks that users be cognizant of the nature of the data, and that they abide by the following policy for database utilization: Records in this database ARE NOT to be considered primary data. Despite our best attempts to continually update our databases and assure accuracy, TNHC cannot be responsible for specimen identification or data verification. Outdated taxonomy, mistaken identifications, and erroneous localities are inevitable occurrences. Information from the TNHC databases is intended to support rather than replace the use of the collections themselves and researchers should verify all information by direct specimen examination before reporting or publishing data in any form. Data retrieved via this provider may be used freely by researchers and educators for non-commercial research or educational purposes, but may not be repackaged, resold, or redistributed in any form without the express written consent of the Curator of Ichthyology. Any use of data must be acknowledged in any publication, advertisement, correspondence or public testimony that alludes to or mentions such data even if the data have been reorganized or added to for any purpose. TNHC does not warrant that any of its data are appropriate for any applications in which users may employ them, and reserves the right to update the online data files at any time. The TNHC and its staff are not responsible for damages, injury, or loss due to the use of these data. Information contained in TNHC databases is

bound by University of Texas regulations on intellectual property. Ownership and copyright are retained by the University and the state of Texas. The TNHC maintains the right to restrict access to certain data fields and to charge reasonable user fees for specialized data retrieval requests. Direct questions or comments to the Curator of Ichthyology. Lit. Cited: Hathaway, E.C. & K.E. Hoagland (eds.) 1993. ASC Guidelines for Institutional Database Policies. 76 pp. The Association of Systematics Collections, Washington, DC.

Point_of_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: James R. Reddell
Contact_Organization: University of Texas, Texas Natural Science Center, Texas Natural History Collections
Contact_Address:
Address_Type: Mailing and Physical
Address: 10100 Burnet Rd, PRC 176 - R4000
City: Austin
State_or_Province: Texas
Postal_Code: 78758-4445
Contact_Voice_Telephone: 512-471-1075
Contact_Electronic_Mail_Address: jreddell.caves@mail.utexas.edu

Metadata_Reference_Information:
Metadata_Date: 20101012
Metadata_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Dean Hendrickson
Contact_Organization: The University of Texas at Austin, Texas Natural History Collections
Contact_Address:
Address_Type: Mailing
Address: 10100 Burnet Road, PRC 176/R4000
City: Austin
State_or_Province: TX
Postal_Code: 78758-4445
Country: USA
Contact_Voice_Telephone: 512-471-9775
Contact_Electronic_Mail_Address: fishesoftexas@gmail.com
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998

Texas Parks and Wildlife, Inland Fisheries Division

Identification_Information:
  Citation:
    Citation_Information:
      Originator: John Taylor
      Publication_Date: 20101011
      Title: Inland Fisheries Division, Texas Parks and Wildlife Department
      Online_Linkage: http://www.tpwd.state.tx.us/business/about/divisions/inland_fisheries/
  Description:
    Abstract: The Inland Fisheries Division is responsible for managing the state's diverse freshwater fisheries resources. The goal of this management is to provide the best possible angling while protecting and enhancing freshwater aquatic resources. The resources include approximately 800 public impoundments covering 1.7 million acres and 80,000 miles of rivers and streams. These resources are used by about 1.84 million anglers 16 years of age and older whose fishing activities provide great benefit to the Texas economy through an estimated $1.5 billion per year in direct angler spending on food, lodging, transportation and equipment. The division's activities include fisheries management and research, ecosystem and habitat assessment, instream flow and river studies, fish production, fish kill assessments, environmental contaminant analysis, natural resources damage recovery, wetlands conservation, permitting, angler education and information, and fishing access. Division staff are located in Austin, San Marcos, three regional offices, 15 district offices, one research center, and five fish hatcheries. This includes the Texas Freshwater Fisheries Center in Athens, which combines a state-of-the-art fish hatchery with an educational visitor’s center.
    Purpose: n/a
    Supplemental_Information: n/a
  Time_Period_of_Content:
    Time_Period_Information:
      Range_of_Dates/Times:
        Beginning_Date: n/a
        Ending_Date: n/a
    Currentness_Reference: publication date
  Status:
    Progress: In work
    Maintenance_and_Update_Frequency: n/a
  Spatial_Domain:
    Description_of_Geographic_Extent: Texas
    Bounding_Coordinates:
      West_Bounding_Coordinate: -106
      East_Bounding_Coordinate: -94
      North_Bounding_Coordinate: 37
      South_Bounding_Coordinate: 26
  Keywords:
    Theme:
      Theme_Keyword_Thesaurus: n/a
      Theme_Keyword: freshwater
      Theme_Keyword: fishes
      Theme_Keyword: aquatic resources
      Theme_Keyword: TPWD
      Theme_Keyword: fisheries
      Theme_Keyword: wetlands
      Theme_Keyword: environmental contamination
  Access_Constraints: n/a

Use_Constraints: n/a
Point_of_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: John Taylor
Contact_Organization: Inland Fisheries Division, Texas Parks and Wildlife Department
Contact_Address:
Address_Type: Mailing and Physical
Address: 4200 Smith School Road
City: Austin
State_or_Province: Texas
Postal_Code: 78744
Contact_Voice_Telephone: 512-389-4338
Contact_Electronic_Mail_Address: john.taylor@tpwd.state.tx.us
Metadata_Reference_Information:
Metadata_Date: 20101011
Metadata_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Dean Hendrickson
Contact_Organization: The University of Texas at Austin, Texas Natural History Collections
Contact_Address:
Address_Type: Mailing
Address: 10100 Burnet Road, PRC 176/R4000
City: Austin
State_or_Province: TX
Postal_Code: 78758-4445
Country: USA
Contact_Voice_Telephone: 512-471-9775
Contact_Electronic_Mail_Address: fishesoftexas@gmail.com
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998

Texas Parks and Wildlife, Kills and Spills Team

Identification_Information:
  Citation:
    Citation_Information:
      Originator: Jack Ralph, Team Leader
      Publication_Date: 20101011
      Title: Kills and Spills Team, Texas Parks and Wildlife
      Online_Linkage:
http://www.tpwd.state.tx.us/landwater/water/environconcerns/kills_and_spills/kills.phtml
  Description:
    Abstract: From 1958 to 1997 Texas Parks and Wildlife investigated over 4500 incidents of pollution or kills involving fish and wildlife. The leading cause of fish and wildlife kills was low dissolved oxygen. The main human activity causing these type of kills is the stagnation of water due to construction of dead-end canals in industrial or residential developments along the coast. Other significant human-induced factors leading to low dissolved oxygen kills are the release of pollutants into the water and the reduction or stoppage of flow in a stream. Natural causes of low dissolved oxygen include storms and drought. After dissolved oxygen, the most common causes of fish and wildlife mortality included cold fronts or freezes and harmful algal blooms. Our database catalogs over 3000+ fish kills in Texas over the past 35+ years. County, Texas Commission on Environmental Quality water segment number, lat/long, and species ID info are available for each incident, and are maintained in a Microsoft Access database. Our field investigations are time sensitive and time limited, with our efforts being centered on identifying, counting, and measuring representative sample areas to determine the extent of the kill. Every fish kill drill we have completed in Texas confirms that fishes sink or are taken quite quickly by scavengers. Collecting data quickly for possible litigation takes precedence over other options. Additionally, samples we examine are rarely fresh, and early notification is not the norm. Logistical constraints (8 biologists [3 are on the coast] to cover the state) limit how material is handled. In 1997 the Kills and Spills Team worked to enter over 4500 historical kill and spill incident reports into a custom-designed Microsoft Access database application known as PRISM (Pollution Response Incident and Species Mortality). The type of information stored in PRISM includes incident type (fish kill, wildlife kill, both F & W, pollution, other), start date, habitat type and size affected, notification record, county, TCEQ water quality segment number, location, source and cause, and information about species, sizes, and numbers killed in cases involving kills.
    Purpose: n/a
    Supplemental_Information: Data Type: Photographs, Digital, GIS
  Time_Period_of_Content:
    Time_Period_Information:
      Range_of_Dates/Times:
        Beginning_Date: 1958
        Ending_Date: 2010
    Currentness_Reference: publication date
  Status:
    Progress: In work
    Maintenance_and_Update_Frequency: n/a
  Spatial_Domain:
    Description_of_Geographic_Extent: Texas
    Bounding_Coordinates:
      West_Bounding_Coordinate: -106
      East_Bounding_Coordinate: -94
      North_Bounding_Coordinate: 37
      South_Bounding_Coordinate: 26
  Keywords:

Theme:
Theme_Keyword_Thesaurus: n/a
Theme_Keyword: fish kill
Theme_Keyword: Texas
Theme_Keyword: pollution
Theme_Keyword: dissolved oxygen
Theme_Keyword: TPWD
Theme_Keyword: TCEQ
Theme_Keyword: wildlife kill
Access_Constraints: n/a
Use_Constraints: n/a
Point_of_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Jack Ralph
Contact_Organization: Kills and Spills Team, Texas Parks and Wildlife
Contact_Address:
Address_Type: n/a
Address: n/a
City: n/a
State_or_Province: n/a
Postal_Code: n/a
Contact_Voice_Telephone: 512-389-8153
Contact_Electronic_Mail_Address: Jack.Ralph@tpwd.state.tx.us
Metadata_Reference_Information:
Metadata_Date: 20101011
Metadata_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Dean Hendrickson
Contact_Organization: The University of Texas at Austin, Texas Natural History Collections
Contact_Address:
Address_Type: Mailing
Address: 10100 Burnet Road, PRC 176/R4000
City: Austin
State_or_Province: TX
Postal_Code: 78758-4445
Country: USA
Contact_Voice_Telephone: 512-471-9775
Contact_Electronic_Mail_Address: fishesoftexas@gmail.com
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998

University of Colorado Fish Collection

Identification_Information:
  Citation:
    Citation_Information:
      Originator: Kevin Bestgen, Director
      Publication_Date: 20100913
      Title: University of Colorado Fish Collection
      Online_Linkage: n/a
  Description:
    Abstract: Curent Holdings are unknown. Specimens are present that were used in preparation of works such as the Fishes of Colorado by Maxwell Ellis in 1914. They also possess many mussel specimens and perhaps much more.
    Purpose: n/a
    Supplemental_Information: Specimen Type: Whole Specimens. Preservative Type: Ethyl Alcohol.
  Time_Period_of_Content:
    Time_Period_Information:
      Range_of_Dates/Times:
        Beginning_Date: 19120101
        Ending_Date: n/a
    Currentness_Reference: publication date
  Status:
    Progress: n/a
    Maintenance_and_Update_Frequency: n/a
  Spatial_Domain:
    Description_of_Geographic_Extent: n/a
    Bounding_Coordinates:
      West_Bounding_Coordinate: -180
      East_Bounding_Coordinate: 180
      North_Bounding_Coordinate: 90
      South_Bounding_Coordinate: 90
  Keywords:
    Theme:
      Theme_Keyword_Thesaurus: n/a
      Theme_Keyword: Fishes
      Theme_Keyword: Mussels
      Theme_Keyword: Mammals
  Access_Constraints: n/a
  Use_Constraints: n/a
  Point_of_Contact:
    Contact_Information:
      Contact_Person_Primary:
        Contact_Person: n/a
        Contact_Organization: n/a
      Contact_Address:
        Address_Type: n/a
        Address: n/a
        City: n/a
        State_or_Province: n/a
        Postal_Code: n/a
      Contact_Voice_Telephone: n/a
      Contact_Electronic_Mail_Address: n/a

Metadata_Reference_Information:
  Metadata_Date: 20100914
  Metadata_Contact:
    Contact_Information:
      Contact_Person_Primary:
        Contact_Person: Dean Hendrickson
        Contact_Organization: The University of Texas at Austin, Texas Natural History Collections
      Contact_Address:
        Address_Type: Mailing
        Address: 10100 Burnet Road, PRC 176/R4000
        City: Austin
        State_or_Province: TX
        Postal_Code: 78758-4445
        Country: USA
      Contact_Voice_Telephone: 512-471-9775
      Contact_Electronic_Mail_Address: fishesoftexas@gmail.com
  Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
  Metadata_Standard_Version: FGDC-STD-001-1998

University of New Mexico, Museum of Southwestern Biology

Identification_Information:

Citation:

Citation_Information:

Originator: Tom Giermakowski, Collection Manager

Publication_Date: 20100924

Title: University of New Mexico - Museum of Southwestern Biology - Division of Amphibians and Reptiles

Online_Linkage: http://www.msb.unm.edu/herpetology/

Description:

Abstract: Currently, there are more than 87,000 specimens mostly from the Southwestern United States, primarily from New Mexico, Texas, Arizona and Colorado. However, substantial numbers of specimens from elsewhere in the U.S., Mexico, the Caribbean region, the Galapagos Islands, and Vietnam are also included. The division maintains representative skeletal material, a small type collection, and a collection of uncatalogued specimens for teaching purposes. Other important collections in the division's holdings are from the Big Bend National Park by W.G. Degenhardt and T.L. Brown (all taxa), the Appalachian Plateau by G.B. Wilmott (salamanders), the West Indies by K.L. Jones (leptodactylid frogs), and the Delmarva Peninsula by R. Conant (all taxa).

Personnel associated with the division conduct research in the Southwest involving functional and evolutionary ecology of reptiles and conservation of biological diversity. Collaborative projects are coordinated with the New Mexico Department of Game and Fish and other state and federal agencies. These projects investigate the effects of habitat alteration on populations of amphibians and reptiles as well as restoration efforts for endangered populations. The division has strong graduate and undergraduate programs in herpetology and conservation biology.

Purpose: n/a

Supplemental_Information: Taxonomic Representation - The collection currently holds more than 21,000 amphibian (25%) and over 64,000 reptile (75%) specimens. The catalogued specimens at MSB are very diverse, covering over 60 different families of amphibians and reptiles (representing over 60% of known families), and 1100 genera (representing ~74% of all known genera world-wide). Furthermore, the representation is reasonably complete, with 25 families from the collection containing over 80% of all genera from within that particular family. Several families are especially well represented in numbers of specimens, including Phrynosomatidae (>14,000), Teiidae (>9000), and Colubridae (>8000) for reptiles; and Ranidae (>4300) and Bufonidae (>4000) for amphibians. The Division also maintains representative skeletal material, a small type collection, and a collection of uncatalogued specimens for teaching purposes. Over the last five years the collection has grown by 10,000 specimens, a rate we envision maintaining for the predictable future. Specimen Types: Whole specimens, Partial specimens, Tissue samples, Digital, GIS. Preservative Types: Ethyl Alcohol, Isopropyl Alcohol, Formalin, Dried.

Time_Period_of_Content:

Time_Period_Information:

Range_of_Dates/Times:

Beginning_Date: 19051014

Ending_Date: 20100831

Currentness_Reference: publication date

Status:

Progress: In work

Maintenance_and_Update_Frequency: n/a

Spatial_Domain:

Description_of_Geographic_Extent: The Division of Amphibians and Reptiles contains the most comprehensive and complete collection of New Mexican amphibians and reptiles in the world and the second largest collection from the Four Corner states of Arizona, Colorado, New Mexico, and Utah. Most

specimens in the collection (>51%) are from New Mexico and represent all known species occurring in the state, including one holotype and 107paratypes of seven species. While regional in scope, MSB also possesses a large collection of specimens from Galapagos Islands of Ecuador (>7,600) and Nevada (>4,500). The holdings also contain important numbers of specimens from surrounding states including Colorado (>5400 specimens), Texas (>3600 specimens), Arizona (>3,300 specimens), and Chihuahua, Mexico (>1,000 specimens). Of particular note are the early collections from the Appalachian Plateau by G.B. Wilmott (524 salamanders), the West Indies by K.L. Jones (802 leptodactylid frogs), and the Delmarva Peninsula, New Jersey by the late Roger Conant, whose collections contain more than 1600 specimens.

Bounding_Coordinates:
West_Bounding_Coordinate: -125
East_Bounding_Coordinate: -75
North_Bounding_Coordinate: 49
South_Bounding_Coordinate: 26

Keywords:
Theme:
Theme_Keyword_Thesaurus: n/a
Theme_Keyword: Retiles
Theme_Keyword: Amphibians

Access_Constraints: Taxonomic Representation - The collection currently holds more than 21,000 amphibian (25%) and over 64,000 reptile (75%) specimens. The catalogued specimens at MSB are very diverse, covering over 60 different families of amphibians and reptiles (representing over 60% of known families), and 1100 genera (representing ~74% of all known genera world-wide). Furthermore, the representation is reasonably complete, with 25 families from the collection containing over 80% of all genera from within that particular family. Several families are especially well represented in numbers of specimens, including Phrynosomatidae (>14,000), Teiidae (>9000), and Colubridae (>8000) for reptiles; and Ranidae (>4300) and Bufonidae (>4000) for amphibians. The Division also maintains representative skeletal material, a small type collection, and a collection of uncatalogued specimens for teaching purposes. Over the last five years the collection has grown by 10,000 specimens, a rate we envision maintaining for the predictable future. Specimen Types: Whole specimens, Partial specimens, Tissue samples, Digital, GIS. Preservative Types: Ethyl Alcohol, Isopropyl Alcohol, Formalin, Dried.

Use_Constraints: All requests for herpetological collection data require a hard-copy letter or an email. This letter must be on institutional letterhead or originating from an educational domain and state exactly what specimen data are being requested and why. A request from a student must be countersigned or authorized by the major professor or other responsible staff member. To help researchers decide which specimens they wish to examine, we provide general data (county, state, country, and date) without requiring examination of the specimens. We generally restrict the access of more detailed locality data to investigators who have examined the specimens and confirmed their identification. We will evaluate requests for more detailed locality data on a case-by-case basis, but it is unlikely that such requests will be approved unless exceptional conditions are met. These data are for the individual researcher's personal use, as originally requested, and should not be further distributed without express written consent of the curator.

Point_of_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Tom Giermakowski
Contact_Organization: University of New Mexico
Contact_Address:
Address_Type: Mailing and Physical
Address: 302 Yale Blvd NE, CERIA bldg #83
City: Albuquerque

State_or_Province: New Mexico
Postal_Code: 87131-0001
Contact_Voice_Telephone: 505-277-5130
Contact_Electronic_Mail_Address: msbherp@unm.edu
Metadata_Reference_Information:
Metadata_Date: 20100928
Metadata_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Dean Hendrickson
Contact_Organization: The University of Texas at Austin, Texas Natural History Collections
Contact_Address:
Address_Type: Mailing
Address: 10100 Burnet Road, PRC 176/R4000
City: Austin
State_or_Province: TX
Postal_Code: 78758-4445
Country: USA
Contact_Voice_Telephone: 512-471-9775
Contact_Electronic_Mail_Address: fishesoftexas@gmail.com
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998.

University of Wyoming Fish Teaching Collection

Identification_Information:
  Citation:
    Citation_Information:
      Originator:Frank Rahel
      Publication_Date: 20100913
      Title: University of Wyoming Fish Teaching Collection
      Online_Linkage: n/a
  Description:
    Abstract: Current holding are unknown. Specimens may be present that were used in the compilation of works such as the Fishes of Wyoming by George Baxter.
    Purpose: n/a
    Supplemental_Information: n/a
  Time_Period_of_Content:
    Time_Period_Information:
      Range_of_Dates/Times:
        Beginning_Date: n/a
        Ending_Date: n/a
    Currentness_Reference: publication date
  Status:
    Progress: n/a
    Maintenance_and_Update_Frequency: n/a
  Spatial_Domain:
    Description_of_Geographic_Extent: n/a
    Bounding_Coordinates:
      West_Bounding_Coordinate: -180
      East_Bounding_Coordinate: 180
      North_Bounding_Coordinate: 90
      South_Bounding_Coordinate: 90
  Keywords:
    Theme:
      Theme_Keyword_Thesaurus: n/a
      Theme_Keyword: n/a
  Access_Constraints: n/a
  Use_Constraints: n/a
  Point_of_Contact:
    Contact_Information:
      Contact_Person_Primary:
        Contact_Person: Frank Rahel
        Contact_Organization: University of Wyoming
      Contact_Address:
        Address_Type: Mailing
        Address: Dept. of Zoology
        City: Laramie
        State_or_Province: Wyoming
        Postal_Code: n/a
      Contact_Voice_Telephone: n/a
      Contact_Electronic_Mail_Address: n/a
Metadata_Reference_Information:
  Metadata_Date: 20100914
  Metadata_Contact:

Contact_Information:
Contact_Person_Primary:
Contact_Person: Dean Hendrickson
Contact_Organization: The University of Texas at Austin, Texas Natural History Collections
Contact_Address:
Address_Type: Mailing
Address: 10100 Burnet Road, PRC 176/R4000
City: Austin
State_or_Province: TX
Postal_Code: 78758-4445
Country: USA
Contact_Voice_Telephone: 512-471-9775
Contact_Electronic_Mail_Address: fishesoftexas@gmail.com
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998

Worldwide Topographical Variable set at 0.05 degrees

Identification_Information:
Citation:
Citation_Information:
Originator: Blake Sissel, Research Associate
Publication_Date: 20100927
Title: Worldwide Topographical Variable set at 0.05 degrees
Online_Linkage: www.fishesoftexas.org
Description:
Abstract: A new set of topographical layers (altitude, slope, aspect, and compound topographic index) were constructed in order to correspond in resolution to climate layers created in parallel for on going research projects. This task required a large amount of GIS time in order for calculations of these variables to be processed with a minimal loss in data precision and for these independently derived data to align properly with the climatic data layers. Thus they complement the climatic data layers also created for the Fishes of Texas project which are described in an independent metadata submission.
Purpose: n/a
Supplemental_Information: Altitude was derived from a 2.5 arc-minute worldwide data layer obtained from Worldclim.org. It was resampled to a 3 arc-minute resolution (0.05 degree) registering it to a layer at the desired spatial extent. Aspect was created from this using spatial analyst tools in Arcmap 9.3. Slope in degrees was calculated using an altitude layer that was reprojected and resampled to a mercator projected coordinate system at a 6 kilometer square resolution. CTI was created using the following formula: ln(((flowAccumulation+1)*pixel area)/tan(slope in radians)). Note slope in radians (not degrees) is needed for CTI calculations. Flow Accumulation was calculated also using spatial analyst tools in Arcmap 9.3. Data Type: GIS.
Time_Period_of_Content:
Time_Period_Information:
Range_of_Dates/Times:
Beginning_Date: n/a
Ending_Date: n/a
Currentness_Reference: publication date
Status:
Progress: Complete
Maintenance_and_Update_Frequency: n/a
Spatial_Domain:
Description_of_Geographic_Extent: World wide
Bounding_Coordinates:
West_Bounding_Coordinate: -180
East_Bounding_Coordinate: 180
North_Bounding_Coordinate: 90
South_Bounding_Coordinate: 90
Keywords:
Theme:
Theme_Keyword_Thesaurus: n/a
Theme_Keyword: Altitude
Theme_Keyword: Slope
Theme_Keyword: CTI
Theme_Keyword: Aspect
Theme_Keyword: Topographic
Theme_Keyword: GIS
Theme_Keyword: Environmental Layers

Access_Constraints: Altitude was derived from a 2.5 arc-minute worldwide data layer obtained from Worldclim.org. It was resampled to a 3 arc-minute resolution (0.05 degree) registering it to a layer at the desired spatial extent. Aspect was created from this using spatial analyst tools in Arcmap 9.3. Slope in degrees was calculated using an altitude layer that was reprojected and resampled to a mercator projected coordinate system at a 6 kilometer square resolution. CTI was created using the following formula: ln(((flowAccumulation+1)*pixel area)/tan(slope in radians)). Note slope in radians (not degrees) is needed for CTI calculations. Flow Accumulation was calculated also using spatial analyst tools in Arcmap 9.3. Data Type: GIS.

Use_Constraints: These data represent research in progress, any access would have to be granted on a case-by-case basis.

Point_of_Contact:

Contact_Information:

Contact_Person_Primary:

Contact_Person: Blake Sissel or Sahotra Sarkar

Contact_Organization: Biodiversity and Biocultural Conservation Laboratory, University of Texas at Austin

Contact_Address:

Address_Type: Mailing

Address: J.T. Patterson Laboratory, 2401 Speedway Ave.

City: Austin

State_or_Province: Texas

Postal_Code: 78712

Contact_Voice_Telephone: 512-471-8240

Contact_Electronic_Mail_Address: bsissel@mail.utexas.edu, sarkar@mail.utexasedu

Metadata_Reference_Information:

Metadata_Date: 20100928

Metadata_Contact:

Contact_Information:

Contact_Person_Primary:

Contact_Person: Dean Hendrickson

Contact_Organization: The University of Texas at Austin, Texas Natural History Collections

Contact_Address:

Address_Type: Mailing

Address: 10100 Burnet Road, PRC 176/R4000

City: Austin

State_or_Province: TX

Postal_Code: 78758-4445

Country: USA

Contact_Voice_Telephone: 512-471-9775

Contact_Electronic_Mail_Address: fishesoftexas@gmail.com

Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata

Metadata_Standard_Version: FGDC-STD-001-1998

4.3-Appendix 3: Digital data

See included digital material in these directories in the digital files provided:

modeling: Includes high res images of those provided in Appendix 1, as well as raster grids of all models for taxa modeled onto future climate scenarios.

donor occurrence data: excel files of occurrence data and summary figures

metadata: FDGC formatted text files of metadata material

gbif: raw images of gbif figures provided in Appendix 1, as well as an excel file of the GBIF occurrence data compilation