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November 5, 2010

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Ms. Cindy K. Bladey
Chief, Rulemaking and Directives Branch
Office of Administration
Mail Stop: TWB-05-B01M
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

RE: Proposed Comanche Peak Nuclear Power Plants Units 3 and 4 Combined License Application Review, Draft Environmental Impact Statement (DEIS), Somervell and Hood Counties

Dear Ms. Bladey:

Texas Parks and Wildlife Department (TPWD) received the August 6, 2010 notification for issuance of and request for comment on the above-referenced DEIS. The notification was submitted in accordance with the National Environmental Policy Act of 1969, as amended (NEPA), and the Fish and Wildlife Coordination Act of 1934, as amended. Nuclear Regulatory Commission (NRC) prepared the DEIS as part of its review of Luminant Generation Company LLC (Luminant) application for combined licenses for construction and operation of two new nuclear units at its existing Comanche Peak Nuclear Power Plant (CPNPP) site near Glen Rose, Texas. U.S. Army Corps of Engineers Fort Worth District (USACE) is a cooperating agency in the DEIS so that the EIS can be used to decide on issuance of permits pursuant to Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act.

Based on TPWD staff review of the information provided, TPWD offers specific recommendations regarding the DEIS and concerns regarding the project that can be found in Attachment A to this letter. Listed below are TPWD's principal concerns, which are more fully addressed in Attachment A:

- Hydrologic changes in the Brazos River ecosystem will result from increased withdrawals and consumptive water losses and associated alterations in water management from Possum Kingdom Lake to the Brazos River below Lake Granbury. Impacts on aquatic and wetlands biota and habitat could be substantial as a result of hydrologic alterations to the Brazos River system, particularly Lake Granbury, Possum Kingdom Lake, and the river below Lake Granbury. The reductions in water levels would likely change shoreline vegetation, affect shallow water habitats, and affect access to both public and private boat docks and ramps, especially during drought conditions. Reduced Brazos River flows downstream of Lake Granbury may impact aquatic

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resources including the state-threatened Brazos Water Snake (*Nerodia harteri*) and state-threatened and rare mussels.

- Proposed new location 345-kV transmission line routes have not been fully assessed through a routing and alternatives evaluation, thus impacts associated with the proposed new lines are not fully articulated. Without an assessment of routes and their alternatives for inclusion in the DEIS, the NRC may be segmenting project impacts under Section 1508.27 (7) of NEPA. This section states, "Significance [of impacts] cannot be avoided by terming an action temporary or by breaking it down into small component parts."

- Because the new transmission lines are in the vicinity of potential habitat, known occurrences, and migratory corridors of endangered species, there may be unforeseen impacts to the federal- and state-endangered Black-capped Vireo (*Vireo atricapilla*) (BCV), Golden-cheeked Warbler (*Dendroica chrysoparia*) (GCW), and Whooping Crane (*Grus americana*). Potential impacts to these species associated with transmission line construction and operation cannot be determined from the information presented in the DEIS, as site surveys along the routes for suitable breeding and/or migratory stopover habitat have not been conducted.

- The approximate location of the proposed 345-kV Whitney transmission line shown in the DEIS crosses Dinosaur Valley State Park. In addition to providing habitat for the BCV and GCW, this state park offers public recreation activities that would be impacted by construction of a transmission line across or in sight of the park. This park and its viewshed should be avoided if at all possible. If the final project design requires that transmission lines cross any state-owned or managed lands, such as Dinosaur Valley State Park, the NRC, Luminant, and Oncor should be aware of the requirements of Chapter 26 of TPW Code (Chapter 26) discussed in Attachment A.

TPWD appreciates the opportunity to provide comments on this important project and participate in the NEPA process. Please direct any questions to Kathy Boydston at (512) 389-4638.

Sincerely,

Ross Melinchuk
Deputy Executive Director, Natural Resources

RM:KB:CB:KH:gg

Attachments

Attachment A

This attachment contains Texas Parks and Wildlife Department (TPWD) specific recommendations regarding the Draft Environmental Impact Statement (DEIS) and concerns regarding Luminant Generation Company LLC's (Luminant's) construction and operation of two new nuclear units at its existing Comanche Peak Nuclear Power Plant (CPNPP) site near Glen Rose, Texas. This attachment has been affixed to TPWD's November 5, 2010 cover letter to the Nuclear Regulatory Commission (NRC).

These recommendations are organized to parallel the DEIS format. TPWD provided scoping comments for the project, as follows:

- August 3, 2007, Letter to William Wenstrom, Enercon Services, Inc. for preliminary rare, threatened and endangered species information from Celeste Brancel

- February 16, 2009, Letter to Michael Lesar, NRC for scoping comments on Environmental Report for preparation of Draft Environmental Impact Statement from Carter Smith via e-mail from Kathy Boydston

- April 24, 2009, Letter to Michael Lesar, NRC follow-up to site audit visit on February 2, 2009 from Karen Hardin

Project Description

The proposed project involves construction and operation of two new Mitsubishi Heavy Industries U.S. Advanced Pressurized-Water Reactors, Units 3 and 4, to be located within the 7,950-acre property boundary that includes Luminant's existing reactors, Units 1 and 2. The new units would be 0.5 miles from the existing units and placed within a previously disturbed site. The project includes construction of two wet mechanical draft cooling towers for each nuclear reactor. Cooling water would be obtained from Lake Granbury in Hood County by way of two new 42-inch pipelines. A new 400-acre blowdown water treatment facility (BDTF), including two large ponds, would be built to reduce total dissolved solids (TDS) and chlorides of blowdown water. The BDTF would produce a treated permeate stream, which would then be blended with the remaining untreated blowdown and routed to Lake Granbury via two new 42-inch pipelines and underwater diffusers in the lake. Potable water for personnel and support activities would be obtained from Wheeler Branch Reservoir (WBR). The Somervell County Water District recently built WBR to supply water to the City of Glen Rose, the CPNPP and surrounding communities. Additionally, the project would require associated construction of five new 345-kilovolt (kV) transmission lines, three of which would be single-circuit lines located on existing tower structures and two of which would be double-circuit expansions requiring new or expanded 160-foot wide right-of-ways (ROW). The transmission lines requiring new ROW include a 45-mile line to Whitney and a 17-mile line to DeCordova.

The proposed action evaluated three alternative sites within Texas, referred to as the Coastal (Victoria-Refugio County), Pineland (near Pineland, Sabine County) and Tradinghouse (near Waco, McLennan County) sites. In addition to site location alternatives, the DEIS included a no action alternative, system design alternatives and onsite mitigation alternatives to minimize impacts.

General Comments

The NRC transmittal letter indicated that the NRC and USACE have different regulatory authorities and requests that if TPWD issues an incidental take statement then TPWD should specify within the statement which terms and conditions are imposed on which agency.

Under Chapter 68, Texas Parks and Wildlife (TPW) Code, state-listed species are prohibited from take. TPW Code does not establish an incidental take permit analogous to the U. S. Fish and Wildlife Service (USFWS) Section 10 permit established under the Endangered Species Act. TPWD cannot provide an incidental take permit in response to a DEIS.

Recommendation: Although TPWD does not provide incidental take permits, only personnel with a TPWD scientific collection permit are allowed to handle and move state-listed species. Should the applicant require moving state-listed species out of harms way for construction activities, the person handling the species must possess a scientific collection permit, which can be obtained from TPWD Permitting Specialist, Chris Maldonado, at (512) 389-4647 or at Chris.Maldonado@tpwd.state.tx.us.

TPWD notes various inconsistencies in the DEIS including the following:

- The number of potable groundwater wells stated on Page 2–20 differs from what is stated on Page 2–24.
- Section 5 species-specific reference for the Guadalupe bass (*Micropterus treculli*), TPWD 2009d, is used for the reference on every state-listed species on Page 5–23.
- Section 7, Page 7–4 states the Squaw Creek Reservoir (SCR) is closed to recreational activities, though Section 2 and most other references have been updated to indicate SCR is now open for boating and fishing.

Recommendation: TPWD recommends all numerics, references and duplicative statements between sections of the DEIS be checked for consistency and accuracy to ensure the proposed action is represented accurately and any contradictory statements have been removed from DEIS.

Specific Comments

1.0 Introduction

1.1.2 Preconstruction Activities

The NRC defines "construction" as those activities within its regulatory authority. NRC indicates activities associated with the project that are not within the purview of the NRC action to license Units 3 and 4 are grouped under the term "preconstruction" and include clearing and grading, excavating, erection of support buildings and transmission lines, and other associated activities. The NRC does not consider the preconstruction activities as direct impacts from the proposed action and has evaluated preconstruction activities in the cumulative impacts analysis.

Recommendation: TPWD does not agree with NRC's decision regarding the exclusion of preconstruction activities from the proposed action. TPWD finds the scope as defined by NRC to

be too narrow to meet the requirements and intent of NEPA regulations. Under Council on Environmental Quality regulations, Section 1502.4, "(a) Agencies shall make sure the proposal which is the subject of the environmental impact statement (EIS) is properly defined...Agencies shall use the criteria for scope (Section1508.25)."

Section 1508.25 clarifies the Scope criteria to include "connected actions," defined in part as "(ii) Cannot or will not proceed unless other actions are taken previously or simultaneously; (iii) Are interdependent parts of a larger action and depend on the larger action for their justification."

TPWD recommends the scope of the DEIS be revised to include the preconstruction activities. Activities such as clearing, grading, excavating, and erection of support buildings and transmission lines, and other associated activities are necessary to build, operate and maintain the nuclear reactor. These preconstruction activities are an integral part of the larger action and should be under the scope of the DEIS.

2.0 Affected Environment

2.1 Site Location

The DEIS refers to the site plan Figure 2-3 when discussing various features of the facility, though not all features are included or labeled on the figure. Major water features not represented on the site plan include the safety shutdown impoundment, non-radioactive wastewater evaporation ponds, an emergency spillway, stormwater retention ponds, and drainage swales. The terminology referring to several features is inconsistent or overlaps current features that support Units 1 and 2.

Recommendation: TPWD recommends the DEIS clearly label various features as they relate to the current units and the proposed units on the site. TPWD recommends all water features discussed in the DEIS be shown and labeled on Figure 2-3 or a new figure to facilitate reader clarity of the water features.

2.2.2 Transmission Lines and Other Offsite Corridors

Figure 2–9 *Federal Lands and State Parks in the Region* does not include a representation of state parks within the project vicinity.

Recommendation: Geographic information system (GIS) shapefiles of park boundaries can be obtained from TPWD GIS Laboratory Manager Kim Ludeke at (512) 389-8071 or Kim.Ludeke@tpwd.state.tx.us. Figure 2-9 should include state parks or wildlife management areas that occur within the vicinity of the project including Cleburne State Park (SP), Dinosaur Valley SP, Lake Whitney SP, Meridian SP, Lake Mineral Wells SP and Trailway, Possum Kingdom SP, and Cedar Hill SP. The Eagle Mountain State Recreation Area is no longer owned by TPWD, though identification of this park should be delineated on the map.

Section 2.3.2 Water Use

Page 2–20 includes information regarding regional water projections of annual consumptive water demand across the region, however the DEIS indicates that the regional water demand projections do not include water requirements for the project nor for expanded development of natural gas from the

Barnett Shale. Section 5.2.2 indicates that Luminant has participated in the Brazos Region G Water Planning Group process to ensure that Units 3 and 4 water use impacts are managed in coordination with other users. The DEIS lacks a summary of Luminant's involvement in the process, does not reveal an estimated projection of water demand based on the project or the Barnett Shale gas developments, nor does it reveal when reports supporting such information would be available. These factors are essential to future projections and should be analyzed.

Recommendation: Because the water consumption of the project and the gas development of the Barnett Shale are essential to future water demand and supply projections, TPWD recommends these water use requirements be included in the discussion of Texas Water Development Board's regional water demand projections and the Texas State Water Plan. The DEIS should indicate why these projections were left out of the Texas Water Development Board's projections and Texas State Water Plan. The DEIS should indicate when Luminant began its involvement in the Region G water planning process for Units 3 and 4 and should provide an estimate of water demand projections based on the project. The DEIS should indicate when reports supporting future water demands for the project and for expanded development of natural gas from the Barnett Shale will be available.

Section 2.3.2.1 Surface Water Use

TPWD recommended in its February 16, 2009 comments that SCR be opened for recreational use. As such, DEIS page 2-24 indicates Luminant has reopened the reservoir for limited public use, including boating and fishing.

Comment: TPWD recognizes and appreciates Luminant's efforts at providing public recreation opportunity at SCR.

Section 2.4.1.1 Terrestrial Resources – Site and Vicinity

Page 2–40 indicates the CPNPP site is a migratory stopover for birds, especially waterfowl. Within Texas, the federal- and state-listed endangered Whooping Crane (*Grus americana*) utilizes a 200-mile wide primary migration corridor. The CPNPP site occurs within the central-most 60-mile wide corridor within which 75 percent of migration sightings have been documented.

Recommendation: TPWD recommends the DEIS Page 2-40 reflect the Whooping Crane migration corridor as an important migratory and stopover route that crosses the CPNPP site.

In addition to the ecologically oriented recreational areas and wildlife protection areas listed on page 2-40 and 2-41 of the DEIS, the Paluxy River and the section of the Brazos River below the Lake Granbury dam down to its confluence with Camp Creek are both identified by TPWD as ecologically significant stream segments (ESSS). Through extensive review by TPWD staff, ESSSs throughout the state were identified to assist regional water planning groups in designating ecologically unique stream segments under Texas Administrative Code Title 31 Section 357.8. Until approved by the legislature, they are not a legal designation. The Brazos River ESSS was identified because it was a Texas Natural Rivers System nominee for outstandingly remarkable wildlife values and was rated the number one scenic and recreational river in the northern half of Texas by the National Parks Service (NPS) in 1995. The Paluxy River ESSS was identified as a riparian conservation area containing Dinosaur Valley State Park, which is a National Natural Landmark. Additional information about

ESSSs can be found at http://www.tpwd.state.tx.us/landwater/water/environconcerns/water_quality/sigsegs/.

Recommendation: TPWD recommends these two stream segments be included as ecologically oriented recreational areas and wildlife protection areas in the DEIS.

Section 2.4.1.3 Important Terrestrial Species and Habitats

Page 2–45 indicates the federal- and state-listed endangered Black-capped Vireo (*Vireo atricapilla*) (BCV) is only found in Oklahoma and Texas. BCV are known to nest in Mexico and winter exclusively in Mexico.

Recommendation: TPWD recommends the DEIS include BCV current range.

Pages 2-46 and 2-47 and Chapter 4 pages 4-20 and 4-21 correctly indicate the BCV and the federal- and state-listed endangered Golden-cheeked Warbler (*Dendroica chrysoparia*) (GCW) have been observed as foraging and nesting within Dinosaur Valley SP. TPWD records indicate the BCV and GCW have also been observed at Fossil Rim Wildlife Center (Fossil Rim) and are identified as Texas Natural Diversity Database (TXNDD) Element Occurrence Record (EOID) 7664 and EOID 2780, respectively. These occurrences were mapped and provided in DEIS reference TPWD 2009i. Please refer to the additional attached detail records for these locations.

Recommendation: The DEIS should be updated to indicate that the BCV and GCW have been recorded at Fossil Rim, which tentatively occurs within the proposed corridor of the 45-mile Whitney transmission line. TPWD recommends the NRC contact Fossil Rim directly for more current information on the documented rare, threatened and endangered species present at the site. This facility conducts research and breeding programs for endangered species, including native and exotic endangered species. Subsequent chapters that address impacts should include potential impacts at Fossil Rim. Please note that later sections in this letter address TPWD concerns related to transmission lines in the vicinity of state parks and impacts of transmission line construction on wildlife, habitats and paleontological resources.

Page 2-47 indicated the Whooping Crane could possibly migrate over the project area, though no natural heritage records for occurrence exist for the species in Hood, Somervell or Bosque counties, nor are there natural heritage records for occurrences within 10 miles of the site, transmission lines, and pipelines.

It is important to understand the basis and limitations of the TXNDD dataset for appropriate interpretation. For the Whooping Crane, methodology includes mapping only wintering grounds and repeated-use stopover sites in Texas. Because observations of birds in migration would not be mapped, the TXNDD is not expected to contain an occurrence record of a migratory flyover or single confirmed stopover of the Whooping Crane. As indicated in previous correspondence, for federally-listed species it is important to contact the USFWS for additional data and information on these species.

Recommendation: TPWD recommends the NRC consult with the USFWS for possible additional information on the nearest and most current recorded stopover sites for the Whooping Crane in central and north Texas.

The DEIS should include additional detail on this species, including the potential on-site habitat and suitable stopover habitat in the vicinity of the proposed transmission lines and pipelines. Wetland habitat should not be limited to jurisdictional wetlands, as non-jurisdictional wetlands also provide habitat for the Whooping Crane. Further information on the Whooping Crane migration corridor and Whooping Crane migratory behaviors are available in the International Recovery Plan for the Whooping Crane (USFWS 2007) at http://ecos.fws.gov/docs/recovery_plan/070604_v4.pdf and in *Whooping Cranes and Wind Development: An Issue Paper* (USFWS 2009) at http://www.fws.gov/southwest/es/library/.

Page 2–50 mentions a record for the species of concern Glen Rose yucca (*Yucca necopina*) as possibly occurring within the discharge pipeline ROW. TPWD is including more detailed reports and maps for all records of rare and listed species within 1.5 miles of the project site, transmission lines and pipelines. Please note that three records for this species, EOID 8961, 7952 and 813, could occur in the ROW of the transmission line or water pipeline, depending on the final proposed alignments. As indicated through previous correspondence, the TXNDD does not include a representative inventory of rare resources in the state. Absence of information in the database does not imply that a species is absent from the area.

Recommendation: TPWD recommends updating the DEIS to indicate that Glen Rose yucca may occur where suitable habitat is present and suitable habitat for the species may occur within the project site including the proposed transmission line and pipeline ROWs.

Figure 2–13 shows the approximate 345-kV transmission line alignment to Whitney could cross through both Dinosaur Valley SP and Fossil Rim. Ecologically oriented recreational areas identified in the DEIS as wildlife protection areas include, among others, Dinosaur Valley SP and Fossil Rim, though Page 2-50 indicates that Dinosaur Valley SP is the only wildlife protection area that could potentially be affected by new transmission line construction.

Recommendation: The DEIS page 2-50 should be updated to reflect that Fossil Rim may also be affected by a transmission line crossing. Subsequent DEIS evaluation of impacts associated with the Whitney transmission line should also include Fossil Rim.

Section 2.4.2.1 Aquatic Resources – Site and Vicinity

The discussion of Lake Granbury aquatic community states that fish populations have been adversely affected since 2001 by golden alga (*Prymnesium parvum*) and that Lake Granbury has experienced relatively recent major fish kills, dated 2005, as a result of golden alga blooms. These findings were based on a 2009 reference to TPWD's website for golden alga. Please note that in 2009, golden algae did not create a large fish kill as in years prior to the fish studies conducted in 2007 and 2008 by Luminant's consultant, Bio-West. TPWD's data regarding the reduced impacts due to golden algae in recent years do not support the DEIS claim that the Lake Granbury fishery is declining due to the algae. TPWD previously commented on this during the scoping process. Additional links on TPWD's website provide status reports showing that from 2007-2009 Lake Granbury did not experience further fish kills of large magnitude.

Additionally, pages 2-54 and 2-66, and portions of Chapter 7, Section 7.3.2 continue to use older references and suggests that the fisheries in Lake Granbury have been severely impacted by golden algae. This conclusion is not warranted or scientifically documented. Current information is

available online to more appropriately describe the status of the Lake Granbury fisheries. Lake Granbury is still a very good fishery, though varies depending on the species.

> **Recommendation:** TPWD recommends the DEIS be modified to correctly characterize the historic and current condition of the fisheries in Lake Granbury using the best currently available information. The most recent survey is online at http://www.tpwd.state.tx.us/publications/pwdpubs/media/lake_survey/pwd_rp_t3200_1300_2009.pdf.

The status for the state-listed threatened Brazos Water Snake (*Nerodia harteri*) on page 2–74 and in Chapters 4 and 5 notes the species as having not been observed in 20 years. Recent thesis work has found populations of this snake above and below Lake Granbury in the Brazos River. These surveys were conducted in 2006–2008. This species was not found in Lake Granbury; the researcher noted that high lake levels and undesirable sampling period (July) combined to reduce the likelihood of finding this snake. Habitat for this species was found just below the Decordova dam and at the confluence of the Paluxy River and Brazos River (McBride 2009).

> **Recommendation:** TPWD recommends the DEIS include more current information on this species, its prey and habitat. A copy of the thesis is attached for your reference.

Page 2-54 indicates surveys of the lake bottom above the Lake Granbury dam identified a limited community of benthic macroinvertebrates. No mussels appear to have been found; however all sampling appears to have been conducted around the cooling water intake and discharge points. The methodology used to identify sample locations on the lake bottom was not described.

> **Recommendation:** The DEIS should clarify why sampling was restricted to the areas around the intake and discharge points. Since effects in an aquatic environment can spread to both upstream and downstream reaches of a waterbody, the methodology used to select the sampling locations should be described. To properly characterize the benthic fauna, sampling should include areas representative of the variations in habitat used by benthic macroinvertebrates.

On November 5, 2009, the Texas Parks and Wildlife Commission acted to place 15 native freshwater mussel species on the state threatened species list; therefore, previous TPWD correspondence regarding the proposed project did not fully address the newly-listed species. The DEIS correctly identifies the threatened listing status of the Texas Fawnsfoot (*Truncilla macrodon*), False Spike (*Quadrula mitchelli*), and Smooth Pimpleback (*Q. houstonensis*). However, the 2007 and 2008 Bio-West fish surveys, which occurred at the project footprint location within Lake Granbury and at limited survey locations downstream of Decordova Dam within the Brazos River do not appear to have utilized appropriate survey methodology to assess mussels in the Brazos River from Possum Kingdom Lake (PKL) to downstream reaches below Lake Granbury. These areas of the river would experience changes in flow rate due the project as discussed later in the DEIS.

The DEIS indicates that the Brazos River from Lake Granbury downstream to Lake Whitney could contain habitat supportive of rare and threatened mussels, though none were found during the Bio-West studies and none are known to occur in this river segment. Please note that the Brazos River from the dam at PKL in Palo Pinto County downstream to FM 2580 in Parker County, is designated by Texas Administrative Code (TAC Title 31, §57.157) as a mussel sanctuary. Surveys determined that some of the last remaining Texas Fawnsfoot mussels occur in this area. Texas Fawnsfoot only occurs in Central Texas and only about a dozen specimens have been found alive in recent decades

(Howells 2004). Additionally, TPWD survey records of Brazos River in the vicinity of the project, which are not currently included in the TXNDD, indicate Texas Fawnsfoot in the area. Live Texas Fawnsfoot were found in Palo Pinto and Parker counties, and dead Texas Fawnsfoot ranging from recently dead to very long dead were found in Somervell, McLennan, and Stephens counties (Howells 1994 and 1996). Texas Mussel Watch Program found dead shells or valves in the following counties and years: Hood 2005, 2006, 2007; Somervell 2007; and Palo Pinto 2000.

Recommendation: TPWD recommends the DEIS include a description of the mussels sampling methodology and its appropriateness for obtaining baseline data. The DEIS should include a summary of existing TPWD survey data for mussels from PKL to downstream of Lake Granbury. Because the data may be outdated, TPWD recommends Luminant conduct additional pre-operation mussels sampling from PKL to downstream reaches below Lake Granbury. Using survey methodology appropriate for mussels, sampling should assess the habitats that have suitable conditions to support mussels. For additional data regarding mussel survey records for the Brazos River in the project vicinity, please coordinate with Michael Warriner, TPWD Invertebrate Biologist, at (512) 389-8759.

Page 2-75 indicates that specific operational monitoring programs have not yet been established for CPNPP Units 3 and 4, though they are expected to be similar to or modifications of existing monitoring programs for Units 1 and 2. Monitoring of fish and other components of ecological communities of Lake Granbury, SCR, PKL, and Brazos River may also be required by state regulatory agencies.

Recommendation: TPWD recommends Luminant conduct long-term operational monitoring for mussels and Brazos Water Snake within the Brazos River system in the project vicinity.

Section 2.5.2.4 Aesthetics and Recreation

Page 2-91 indicates that Luminant installed low-sodium lighting at Units 1 and 2 as a result of local resident complaints of light pollution. The DEIS indicates the same type of low-sodium lighting for Units 3 and 4 would be installed.

Recommendation: TPWD recommends DEIS indicate the amount of light pollution that exists at Units 1 and 2 with the use of low-sodium lighting. Subsequent impact evaluations in the DEIS should include the magnitude of light pollution increase that would occur with Units 3 and 4.

The DEIS discusses the abundance of outdoor recreation offered at area lakes and parks. The area lakes and parks offering such recreation are listed on page 2-91, though Possum Kingdom SP is not included. Table 2-10 identifies ecological oriented public recreation areas within 50 miles of CPNPP. Although Possum Kingdom SP is not within 50 miles of CPNPP, the project will require water withdrawls from PKL and affect its water levels.

Recommendation: Because the project would require water withdrawls from PKL to supply Lake Granbury, Possum Kingdom SP should be included in the list of recreation areas within the project area. Subsequent evaluations in the DEIS should address potential impacts to Possum Kingdom SP.

3.0 Site Layout and Plant Description

Section 3.2.2.2 Blowdown Treatment Facility (BDTF) and Ponds

Page 3–12 discussed the BDTF as a conceptual design with design details not yet complete, though the parameters for the facility may change as Luminant pursues a permit from the state for discharging blowdown water to Lake Granbury. The 400-acre area would consist of reverse osmosis and ultrafiltration equipment buildings, a 47-acre storage pond, and a 128-acre evaporation pond. Approximately 83 percent of blowdown would pass through ultrafiltration followed by reverse osmosis to create a product stream with low total dissolved solids (TDS) and chloride concentrations, which will be mixed with the remaining 13 percent, untreated blowdown water from the cooling towers that is allowed to bypass the BDTF. This mixture will be discharged to Lake Granbury. Waste streams recovered from the reverse osmosis and ultrafiltration process would be combined in the storage pond. Storage pond water would be routed to the evaporation pond to evaporate wastewater to the point salts could be disposed of at a landfill. To accelerate evaporation, the evaporation pond would have 182 misters, each with a sound level of 95 decibels at a distance of 25 feet. Spray from the misters would be forced approximately 60 feet into the air, and the pond would be surrounded by a 16-foot tall fabric fence to capture salt drift falling out of the spray.

> **Recommendation:** When the final design for the BDTF has been completed, TPWD recommends the applicant provide the complete BDTF description and an environmental analysis for review as a supplemental report to the DEIS.

Section 3.2.2.3 Power Transmission System

The DEIS indicates that Oncor Electric Delivery Company (Oncor) is the transmission service provider for CPNPP and that it is a regulated electric distribution and transmission business that provides reliable electricity delivery to customers. They are responsible for operating, building, maintaining, dispatching, and marketing the electric transmission system from the generator bus bars through the distribution substations. Oncor is a member of Electric Reliability Council of Texas (ERCOT) which schedules the power on the electric grid. ERCOT is subject to oversight by Public Utility Commission of Texas (PUCT) and the Texas Legislature.

Off-site transmission circuits will be required to distribute the power that would be produced by Units 3 and 4. Of the five new transmission lines to be constructed, two would require new ROW including the line to Whitney and the line to DeCordova. At this time the approximate routes are provided on Figure 2-13, though the DEIS indicates that changes may be made during a routing study that will be conducted by Oncor and reviewed by the PUCT. The PUCT will review the application for a Certificate of Convenience and Necessity (CCN) to construct a transmission line. THE DEIS indicates that the study process calls for identifying areas where transmission lines are excluded or should be avoided.

> **Recommendation:** As stated in previous TPWD comments, this project is a federal action, and would therefore be subject to NEPA requirements. Although the CCN process is not always subject to NEPA, the transmission lines associated with the CPNPP would be associated with a federally-regulated project and would therefore have a federal nexus. As stated previously, to not fully address the direct impacts of the proposed transmission line corridors in the final EIS could appear to be "segmenting" by attempting to address the impacts of these transmission corridors

under the CCN process. An analysis of alternative routes and a preferred route for each proposed new transmission line should be identified for the EIS.

Section 3.3.1.10 Clearing, Grubbing and Grading

Twelve million dry pounds of wood fiber would be generated from clearing the main construction area, and would be used as hydraulic mulch for on-site erosion control. TPWD has concerns regarding the quality of the stormwater runoff. Depending on the binding agent used in the mulch, the stormwater runoff could potentially carry elevated levels of nutrients, or chemicals, such as nitrogen and ammonium, as a result of mulch decays. Luminant has not accounted for final disposition of 36 million pounds of biomass associated with BDTF clearing.

Recommendation: TPWD recommends Luminant consider the potential effects to water quality from stormwater runoff associated with decaying hydromulch material and include measures to monitor and/or treat such runoff water in the Stormwater Pollution Prevention Plan for the CPNPP site. TPWD recommends the applicant find a beneficial use for excess mulched vegetation that would not be needed for hydraulic mulching. Beneficial use could be in the form of materials donation to the Texas Department of Transportation Fort Worth and Waco Districts for erosion control on road construction projects or recycling at a composting facility.

Section 3.3.3.2 Clearing of Corridors

Page 3–28 discussed Oncor's full-cut clearing and selective-cut transmission line ROW clearing standards, but notes the standard does not contain a directive documenting the circumstances under which either method would be applied.

Recommendation: TPWD recommends NRC request clarification from the applicant or Oncor on the directives specifying the conditions under which each method is to be used. Given the 160-foot wide corridors required for the lines, the selective-cut method should be employed where safety precautions permit.

Page 3–28 also states the electrical lines would meet or exceed the design requirements set forth in the National Electrical Safety Code and American National Standards Institute. The Avian Power Line Interaction Committee (APLIC) has developed the following guidelines for minimizing adverse encounters with wildlife.

- APLIC. 1994. *Mitigating Bird Collisions with Power Lines: The State of the Art in 1994.* Edison Electric Institute, Washington, D.C., 78 pp.

- APLIC. 2006. *Suggested Practices for Avian Protection on Power Lines: The State of the Art in 2006.* Edison Electric Institute, APLIC, and the California Energy Commission, Washington, D.C. and Sacramento, CA, 140 pp.

Recommendation: TPWD recommends Luminant and Oncor incorporate these guidelines into the project to limit adverse impacts to wildlife, including migratory birds. These resources are available online at: www.aplic.org, www.eei.org, www.energy.ca.gov or at 1-800-334-5453.

Section 3.4.3 Radioactive Waste Management System

Liquid, gaseous, and solid radioactive waste would be produced as a byproduct of the facility operation. Each effluent will be processed to maintain releases within regulatory limits and as low as reasonably achievable before being released to the environment. The waste-processing systems are designed to meet objectives of federal guidelines discussed in the DEIS. Liquid radioactive waste is processed with radiation detection and sampling prior to release. The treated stream is discharged to SCR via CPNPP Units 1 and 2 circulating return line. The DEIS indicates that SCR tritium levels may approach allowable levels with all four units discharging to SCR at the same time, so Luminant plans to divert a portion the effluent to an evaporation pond, which would create an airborne dose pathway of tritium that is evaluated in Chapter 5 impacts. The DEIS does not indicate which evaporation pond and where liquid effluent from the evaporation pond discharges. Based on the discussion of the LRW handling processes, it is unclear if effluent other than to SCR may potentially contain tritium. Gaseous radioactive waste (GRW) containing radioactive isotopes, xenon, krypton, and iodine is processed to control and minimize release to the environment. The processed GRW is diluted with heating, ventilating and air conditioning (HVAC) flow and their release system is equipped with a discharge valve that closes if the radiation set point is exceeded. The temporary on-site storage of solid radioactive waste (SRW) is designed to store waste for up to 10 years. Approximately 30,000 cubic feet of SRW would be shipped from Units 3 and 4 annually. The DEIS does not indicate where the SRW would be shipped after leaving CPNPP.

Recommendation: TPWD recommends the DEIS indicate to which evaporation pond the LRW may be routed, if liquid effluent from this pond is discharged, and to which surface water the evaporation pond discharges. TPWD recommends the DEIS indicate where the SRW would be shipped after temporary on-site storage. Impacts associated with SRW transportation should be assessed in subsequent chapters of the DEIS.

4.0 Construction Impacts at the Proposed Site

The DEIS identifies NRC's authority related to building new nuclear units as being limited to construction activities that have a reasonable nexus to radiological health and safety and/or common defense and security. NRC regulations require impacts of preconstruction activities such as clearing, grading, excavating, erection of support buildings and transmission lines, and other associated activities be addressed in the cumulative impacts evaluation.

Because of the collaborative effort between NRC and USACE, the combined impacts of construction and preconstruction activities are presented in Chapter 4 relating to direct construction impacts. For each resource area, the DEIS describes the impacts of NRC-authorized construction activities as well as assesses the impacts of both construction and preconstruction activities.

Section 4.1.2 Land-Use Impacts: Transmission Line and Pipeline Right(s)-of-Way and Off-site Areas

Figure 2-13 shows the approximate corridors of the two proposed new location 345-kV transmission lines associated with the project, including the 17-mile route to DeCordova and the 45-mile route to Whitney. The DEIS indicates the routes would occupy approximately 148 acres and 954 acres, respectively, that consist of grassland, oak/juniper woodlands, and developed land. The figure shows the Whitney corridor potentially crosses Dinosaur Valley SP and Fossil Rim Wildlife Center. As

previously mentioned, the exact routes have not yet been decided, and the routes would be developed as required by ERCOT and PUCT.

The DEIS evaluation of direct impacts on land use indicates the proposed Whiney transmission line corridor, as currently shown, would pass very close to Dinosaur Valley SP, possibly encroaching on its western boundary, and would cross Fossil Rim. The DEIS indicates that land-use impacts of construction and preconstruction activities associated with transmission lines and pipelines would be MODERATE and impacts of NRC-authorized construction activities would be SMALL. Page 4–6 suggests mitigation measures for land use impacts of transmission line ROWs could include designating Dinosaur Valley State Park and Fossil Rim, and all areas visible from the park and Fossil Rim, as exclusion areas for the routing study.

Dinosaur Valley SP exhibits some of the world's best preserved fossil records of dinosaur tracks, provides endangered species habitat, and is a popular camping and hiking area. Fossil Rim is a nonprofit center specializing in breeding indigenous and exotic threatened and endangered species. Crossing through either area could adversely impact the wildlife, habitats and paleontological resources that have been protected to support their recovery and preservation for the benefit of the public. Part of the enjoyment of natural area recreation activities includes viewsheds devoid of man-made structures. Visibility of the transmission line would degrade the recreational experience for the park and wildlife center visitors.

Recommendation: TPWD supports the mitigation measures, presented in this section and summarized in NRC's conclusions and recommendations Table 10–1, to designate Dinosaur Valley SP and Fossil Rim and all areas visible from these properties as land use exclusion areas during the transmission line routing study. TPWD recommends every effort be made to avoid crossing these facilities.

If the final project design requires that transmission lines cross any state-owned or managed lands, such as Dinosaur Valley State Park, the NRC, Luminant, and Oncor should be aware of the requirements of Chapter 26 of TPW Code (Chapter 26). Chapter 26 is modeled on a federal statute, known as "section 4(f)" and codified at 49 U.S.C. §303. In fact, much of Chapter 26 is taken word for word from section 4(f). Chapter 26 requires that before any department, agency, political subdivision, county or municipality of this state can approve any project that will result in the use or taking of public land designated as a park, public recreation area, scientific area, wildlife refuge, or historic site, that entity must provide certain notice to the public, conduct a hearing, and render a finding that there is no reasonable or prudent alternative and that the project includes all reasonable planning to minimize harm to taking of such lands. If it appears the transmission lines may cross or come near a state park, please contact David Riskind of TPWD State Parks Division Natural Resources Program at (512) 389-4897.

Section 4.3.1.1 Ecological Impacts: Terrestrial Resources – Site and Vicinity

The DEIS indicates that the native grasses are the preferred cover for most disturbed areas and promote diversity. However, page 4–13 refers to buffalograss (*Bouteloua dactyloides*) as an improved grass that would be used in highly erosive areas.

Recommendation: Buffalograss is a native grass and TPWD recommends correcting the text. TPWD supports the use of this species in landscaped areas mixed with Blue grama (*Bouteloua*

gracilis) for a low maintenance turf grass. Buffalograss can be used elsewhere for erosion control in diverse native seed mixes with Blue grama, Green sprangletop (*Leptochloa dubia*), Curly mesquite (*Hilaria berlangeri*), Indiangrass (*Sorghum nutans*), Little bluestem (*Schizachyrium scoparium*), Prairie wildrye (*Elymus canadensis*), Texas cupgrass (*Eriochloa sericea*), Sand dropseed (*Sporobolus cryptandrus*), Sand Lovegrass (*Eragrostis trichodes*), Cane bluestem (*Bothriochloa barbinodis*) and Sideoats grama (*Bouteloua curtipendula*).

Section 4.3.1.3 Ecological Impacts: Important Terrestrial Species and Habitats

Page 4–21 states the map provided by TPWD showed no records of rare species occurrences at Fossil Rim. As previously discussed, occurrences for the BCV and GCW, EOID 7664 and 2870, respectively, have been recorded for Fossil Rim. The discussion of impacts indicates that, other than Dinosaur Valley SP, construction and preconstruction would have minimal impact on important habitat.

TPWD notes that Dinosaur Valley SP and Fossil Rim are not the only important terrestrial habitat in the area. Large acreages of grassland and forest occur within the affected counties. It is erroneous to assume that the managed preserves and areas with known TXNDD occurrences of rare resources are the only important sources of habitat. Not only are known locations of rare resources important, also important are undocumented locations of rare resources. The absence of data in the TXNDD is not to be interpreted as absence of rare and protected species or important habitats on the landscape.

Recommendation: TPWD recommends every effort be made to avoid crossing Dinosaur Valley SP and Fossil Rim and to avoid disturbance to wildlife habitat along the transmission line routes with potential to support rare species. Wildlife habitat contiguous with Dinosaur Valley SP and Fossil Rim should also be avoided. To protect large areas of habitat important to wildlife, TPWD also recommends that the transmission lines be sited in previously disturbed areas, along existing utility ROW, and away from areas of habitat to minimize the fragmentation that results from transmissions lines. Site surveys of the preferred and alternative routes should be conducted for the EIS to assess the habitat and determine potential impacts, including potential impacts to listed species and their habitat. Mitigation measures, of this section and NRC's conclusions and recommendations Table 10-1, should include avoidance of Fossil Rim as well as avoidance of areas of BCV and GCW suitable habitat.

The discussion of avoiding impacts to BCV and GCW, pages 4–21, 4–22 and 10–3, suggest that Oncor could adjust the timing of building and the location of the transmission lines within the corridors.

Recommendation: Adjustments to ROW clearing and construction timing to avoid impacts may not be an acceptable practice and should be discussed with USFWS prior to implementing the practice. TPWD supports the recommendation to adjusting the location of the transmission lines to avoid habitat of BCV and GCW habitat. TPWD recommends Luminant and Oncor avoid removal of BCV and GCW habitat, wherever feasible, and mitigate for the loss of habitat for both species when avoidance is not feasible. Avoiding removal of habitat should be practiced in the vicinity of Dinosaur Valley SP and Fossil Rim as well as other locations within the affected counties that exhibit habitat for these species. Surveys should be conducted along the proposed routes to identify suitable habitat. USFWS should be consulted regarding permits required for take of federal-listed species and plans to offset the loss of habitat for either of these species. If

recommended by the USFWS, Oncor and Luminant should manage for BCV habitat within transmission line ROW, where site characteristics are appropriate.

The DEIS page 4-23 discusses mitigation actions to be utilized if the Glen Rose yucca is encountered during pipeline placement. As previously commented, the Glen Rose yucca may occur where suitable habitat is present throughout the project area including the transmission line and pipeline ROWs.

Recommendation: TPWD supports our previous recommendation to survey for the Glen Rose yucca in areas of suitable habitat that would be disturbed by the project activities. TPWD recommends avoiding impact to the Glen Rose yucca during site planning and design. If the Glen Rose yucca is found in an area that must be disturbed, transplanting the specimens to a new location should be done under the guidance of a botanist familiar with this rare species and with the requirements specific to cultivating this species.

Page 4-22 states that monitoring for federally and state protected species would take place during pre-construction activities, and Luminant would stop work and contact state agency officials if workers encounter special status species, their habitat or vegetation.

Recommendation: TPWD appreciates that Luminant has made this commitment to help protect sensitive state resources. Luminant may contact the following staff if special status species are encountered at the site: TPWD regional diversity biologist Nathan Rains at (817) 641-3367 or Nathan.Rains@tpwd.state.tx.us, TPWD Headquarters Diversity Program at (512) 389-8111, or TPWD assessment biologist Celeste Brancel at (512) 389-8021 or Celeste.Brancel@tpwd.state.tx.us.

4.3.1.6 Ecological Impacts: Summary of Impacts to Terrestrial Resources during Construction and Preconstruction Activities

There is no reference to Fossil Rim regarding potential areas of important species impacts.

Recommendation: TPWD recommends including the potential for impacts to Fossil Rim as contributing to the potential for moderate impacts.

4.3.2.2 Aquatic Ecology and Wetland Impacts from Construction and Preconstruction: Aquatic Resources and Wetlands – Transmission Lines and Cooling Water Pipelines

The DEIS indicates that the entire proposed DeCordova transmission line, 27 miles of the Whitney transmission line, and the proposed intake and discharge pipelines would parallel existing ROW. Infrastructure currently present to allow vehicles to cross streams in the existing transmission line and pipeline ROW could be used during the construction and long-term maintenance of the new transmission lines and pipeline. To further minimize stream and riparian habitat impacts, the pipelines would bore under all streams. However, the initial 18-mile segment of the Whitney transmission line would be located on new-location ROW; thus installation of permanent culvert crossings at streams for construction and long-term maintenance access roads are proposed.

Recommendation: TPWD supports the plan to bore pipelines under stream crossings and their associated riparian corridors. TPWD recommends placing the bore entry/exit locations and equipment staging areas outside riparian habitat in previously disturbed sites.

To minimize unnecessary disturbance to stream and riparian habitat along the new location portions of the Whitney transmission line, all efforts should be made to locate construction and maintenance access roads so that placement of temporary and/or permanent culverts in streams can be avoided. Culverts can also disrupt stream morphology as well as migration of aquatic wildlife in the stream; thus existing roads and bridge crossings should be used.

4.3.2.3 Important Aquatic Species and Wetlands Species and Habitat

Page 4–33 discusses construction and preconstruction impacts to the state-listed threatened Brazos Water Snake. The potential for encounters with most rare species is low due to the rarity of the species. The Brazos Water Snake has a very restricted range but does occur in portions of the project area. Although there are specific habitat features along lake and river shoreline that attract the Brazos Water Snake, it may travel along the Brazos River and Lake Granbury outside of its preferred habitat. Potential construction impacts to this snake or its habitat may occur at the project footprint along Lake Granbury shoreline. The cooling water intake/discharge structures could impede access for this species to its shoreline habitat along Lake Granbury.

Recommendation: TPWD recommends Luminant restore all shoreline areas temporarily disturbed by project activities with habitat features appropriate for this species. If structures would be permanently placed at the shoreline, the structure-water interface should contain rocky habitat appropriate for this species. TPWD private lands biologist Dean Marquardt should be contacted at (817) 326-5373 or Dean.Marquardt@tpwd.state.tx.us, for assistance in design details that would benefit this species.

5.0 Operational Impacts at the Proposed Site

Section 5.2.2.1 Water-Related Impacts: Surface Water Use Impacts

The DEIS indicates that Luminant has been active in Region G and H Water Planning Groups and that water for Units 3 and 4 would be obtained primarily from the more efficient system-wide operations developed as part of the Brazos Water Authority (BRA) permit application on file TCEQ. The proposed system-wide operations are intended to achieve efficiency and additional water yield for its customers. The DEIS indicates stored or banked waters in BRA reservoirs under BRA current or future water rights would mitigate the risk of supplies being inadequate for Units 3 and 4 during extreme droughts. It is expected during extreme droughts that BRA would apportion the reductions in water availability to all of its contract customers.

The DEIS states that withdrawl and use of water from Lake Granbury for use by Units 3 and 4 would result in consumptive uses for Units 3 and 4 estimated at 61,617 acre-feet/year. These consumptive uses would result in lower water levels in Lake Granbury and decreased flows in the Brazos River downstream. Additionally, Brazos River system operations would be altered to accommodate the additional withdrawals including changes in timing of water releases from PKL, resulting in lowered water levels in that lake. Water levels would fall 2 feet or more below full pool for Lake Granbury, and 5 feet or more for PKL, 25 percent of the time. This would occur 15 percent more often than under current conditions which is 10 percent of the time.

The DEIS does not clearly convey 1) the effects on water levels during drought and drought-of-record conditions, and 2) definitions for drought and extreme drought. The DEIS should clearly identify

Lake Granbury and PKL water levels during drought conditions and drought-of-record, under current and proposed conditions.

It is TPWD's understanding that the BRA permit application has not yet been approved by TCEQ and, pending the outcome of the contested case hearing, could result in changes to the strategies that were evaluated in the DEIS.

Recommendation: The DEIS should include an evaluation of impacts the anticipated withdrawals would have on lake system water levels under various seasonal and climatic conditions including drought-of-record scenarios. TPWD is concerned the water withdrawal and consumptive use for Units 3 and 4 and the associated alterations in system-wide water management within the basin will have a significant impact on the lake system levels and overall hydrology of the Brazos River Basin.

5.2.5 Water-Related Impacts: Potential Mitigation Measures for Operation-Related Water Impacts

The DEIS indicates that the intake structure may alter flow patterns in the vicinity of the proposed diffuser during periods of low flow through the DeCordova Dam, which may diminish the effectiveness of the diffuser in mixing effluent from Units 3 and 4 while it is discharged to Lake Granbury. Locally elevated concentrations of effluent chemicals and temperature are possible under these conditions. Luminant has indicated that BRA controlled releases from PKL upstream would supply the flow required by the intake structure, thereby mitigating the potential for flow pattern alteration and any resultant local water quality perturbations. The DEIS states additional mitigation procedures that could be taken by Luminant and the BRA to support the effectiveness of their mitigation measures would include hourly or daily local flow monitoring, decision-support systems and processes, or water management policies.

Recommendation: TPWD supports these measures and recommends additional water quality monitoring in Lake Granbury and Brazos River downstream, particularly during low flow periods to confirm water quality criteria are being met.

5.3.1.1 Ecological Impacts: Terrestrial Resources – Site and Vicinity

The DEIS notes the vicinity of the proposed BDTF ponds under and adjacent to existing transmission lines and discusses the potential of the ponds to attract birds and cause collision-related deaths. The DEIS indicates that Luminant is prepared to monitor for potential impacts to birds, conduct bird deterrent procedures, and install bird deterrent equipment as needed including noise cannons, netting, artificial predators, periodic patrols, and minimizing periods of time in which standing water is present. Such bird deterrent procedures and devices would be selected during final design based on discussions with TPWD and USFWS.

Recommendation: Because the design of the BDTF is not yet finalized, TPWD recommends the applicant consider a proactive approach by locating the BDTF ponds away from existing or proposed transmission lines. This would eliminate the need for avoidable long-term, labor-intensive, or costly preventative measures. TPWD prefers locating the BDTF in areas of previous disturbance or low quality habitat, where feasible. An alternative consideration would be to re-locate the existing transmission lines away from the proposed ponds.

Page 5-17 indicates that fogging may occur within 0.25 mile north and south of the cooling towers including areas around SCR and small wetlands. The DEIS did not indicate if tall structures would be within 0.25 mile of the cooling towers and potentially within the fog plume.

Recommendation: The DEIS should address if fogging due to the cooling towers could increase potential bird collisions with existing or proposed tall structures within 0.25 mile of Units 3 and 4 cooling towers. Tall structures in the area may include Units 1 and 2 and existing or proposed transmission lines and towers.

The DEIS identifies many areas of uncertainty associated with the BDTF, including distance of salt deposition, concentration in the salt spray, effectiveness of the salt intercepting fence, level of wildlife safety hazard and exclusion controls.

Recommendation: TPWD recommends the uncertainty issues surrounding the BDTF operation be resolved prior to licensing. The uncertainties should be resolved in a manner that avoids and minimizes adverse impacts on wildlife and the surrounding habitat.

The DEIS indicates that additional nighttime artificial lighting would be minimal, and it would be lessened by using low sodium lighting as was previously done to lessen lighting impact from Units 1 and 2. Nighttime artificial lighting can induce fatal light attraction phenomenon on night migrating birds. Additional nighttime light may contribute to the effects on night-migrating birds when nighttime light combines with cooling tower fog.

Recommendation: As appropriate to Chapters 2, 3, and 5, TPWD recommends the DEIS include discussions on the amount of additional nighttime light created by the proposed project and the potential effect increased lighting combined with cooling tower fog may have on wildlife. In addition to lowering lighting levels, TPWD recommends down shielding lights to prevent light from being directed up into the night sky.

The shoreline habitat discussion on page 5–19 identified a reduction in water levels in PKL and Lake Granbury and a reduction in Brazos River flows between Lake Granbury and Lake Whitney. The DEIS indicates a maximum modeled change during periods of extreme drought in Lake Granbury is 2.5 feet and at PKL is 12.6 feet. The DEIS did not indicate the amount of reduction in Brazos River flows. Some shoreline areas contain steep, rocky terrain, while other portions, such as coves, contain shallower wetland habitat. The water level changes in the lakes will cause shoreline vegetation to migrate to a lower elevation. Drastic changes in water level can cause colonization of undesirable or invasive vegetation and affect shallow wetland habitat.

Recommendation: TPWD recommends the applicant mitigate for the ecosystem impacts resulting from drops in water levels. TPWD suggests Luminant delineate and quantify shoreline habitat from PKL to the Brazos River at Lake Whitney and utilize these data to develop a strategic monitoring and mitigation plan to account for impacts to the Brazos River ecosystem including impacts to shoreline habitat and wetlands. Habitats should be delineated pre-operation and at incremental periods once operation begins. Mitigation could include monitoring and controlling undesirable or invasive species and restoring diverse wetland habitats along the lakes and river shoreline. The anticipated amount of reduction in Brazos River flows should be provided in the DEIS.

5.3.1.3 Important Terrestrial Species and Habitat

The DEIS and the Biological Assessment of Appendix F (BA) do not assess operational impacts to the federal- and state-listed endangered Whooping Crane. The BA analysis relies on observations at the CPNPP site and known occurrences in the TXNDD and does not consider migration stopover. The BA indicates Whooping Crane are not likely to use the inland habitats found on the site for foraging, roosting, or nesting; thus they are not considered further in the BA.

As previously indicated, the project site is located within the Whooping Crane migratory corridor, which is based on all verified stopover and fatality sites recorded for the cranes. These records are estimated to only account for approximately 4 percent of stopovers. The entire alignment for the proposed transmission lines is within the 60-mile wide central pathway of the statistical corridor. Please note the only naturally occurring population of the Whooping Crane in the wild is currently estimated at less than 250 individuals, and collisions with power lines are a known cause of fledged Whooping Crane mortality. Whooping Cranes can choose stopover sites opportunistically and due to weather conditions. Project site features that can attract Whooping Cranes include wetlands, shoreline, lakes (as large distinct landmarks), rivers, rural setting, and distance from previous stopover site. The DEIS page 4–29 noted the DeCordova transmission line would cross several inlets of the SCR, Squaw Creek, the Brazos River, and Lake Granbury. The Whitney transmission line would cross the Paluxy River, Lake Whitney and tributaries of the Brazos River. Sixty to 80 percent of Whooping Crane deaths occur during migration, and electrical utility lines are a leading known cause of death in Whooping Cranes. The issue paper previously cited, *Whooping Cranes and Wind Development*, includes a discussion on the impacts from utility lines.

Two repeated-use Whooping Crane stopover sites, the Salt Plains National Wildlife Refuge (NWR), Oklahoma and the Quivira NWR, Kansas, are just over 300 and 400 miles from CPNPP, respectively. Whooping Cranes average between 200 and 400 miles between stopovers, possibly giving the project and surrounding area a higher probability for birds to stopover, if they have utilized these NWRs as their previous stops.

Recommendation: The DEIS should address potential operational impacts to the federal- and state- endangered Whooping Crane. Additional information regarding the Whooping Crane migration corridor and potential impacts to this species from transmission lines should be coordinated with the USFWS. The existing transmission lines and lattice towers and the project's proposed addition of new lines and towers could pose a threat to migrating cranes that may utilize stopover habitat in the vicinity of the project. The biological assessment of Appendix F and the DEIS should incorporate and assess potential impacts to the Whooping Crane and should identify all reasonable factors that may adversely impact this species.

Luminant and Oncor should develop, maintain, and operate the transmission line system under an Avian Protection Plan (APP). TPWD recommends the plan ensure all transmission lines on the CPNPP site and the five new 345-kV lines proposed beyond the CPNPP site provide the best available protection for BCV, GCW, and Whooping Crane as well as other avian species. TPWD recommends contacting the USFWS to discuss the most appropriate safety measures to incorporate on the powerlines and poles to protect Whooping Cranes and other large birds from collision hazards. TPWD recommends the plan be developed in accordance with the guidance provided by the Avian Power Line Interaction Committee, accessible online at http://www.aplic.org/ as referenced earlier in this letter, and with guidance from the USFWS.

Section 5.3.2 Ecological Impacts: Aquatic and Wetland Impacts

This section and its subsections of the DEIS assess potential operational impacts on aquatic and wetland ecosystems of Lake Granbury, SCR, Brazos River, PKL, WBR, Paluxy River, and waterbodies crossed by the proposed transmission line and pipeline ROWs. TPWD recommendations to minimize impacts described in these subsections are provided after Section 5.3.2.11 *Summary of Operational Impacts on Aquatic and Wetland Resources.*

Section 5.3.2.1 Impacts on the Lake Granbury Ecosystem and Section 5.3.2.4 Impacts on the PKL Ecosystem

The subsection addressing the impacts from hydrological changes for Lake Granbury and PKL states that the Water Availability Model (WAM) predicts similar magnitude fluctuations in water levels, though an increase in the frequency of lower water levels for operating Units 3 and 4. Operation of Units 3 and 4 would reduce average water levels in Lake Granbury by 0.6 foot and PKL by 1.5 feet. Water levels would fall 2 feet or more below full pool for Lake Granbury, and 5 feet or more for PKL, 25 percent of the time. This would occur 15 percent more often than under current conditions which is 10 percent of the time.

The DEIS indicates the increased frequency of lower water levels may reduce the spawning success of fish, if occurring during spawning seasons and desiccating shallow habitats where fish nest or deposit their eggs. The potential for populations of fish to be measurably affected by reductions in reproductive success would be dependent on the timing and duration of low water levels, the characteristics of the species, and the proportion of their spawning habitats affected. Thus, given these uncertainties, the DEIS indicates adverse effects on aquatic biota and habitat may range from negligible to noticeable for both Lake Granbury and PKL. No actions are proposed to mitigate for impacts from hydrological changes in Lake Granbury or PKL.

Section 5.3.2.3 Impacts on the Brazos River Ecosystem

Seasonal distribution of streamflow between PKL and Lake Granbury would be altered with lower flows during the wetter months of the year (typically May and June) and higher flows during the drier months, as BRA would release water from PKL to sustain water supply in Lake Granbury and Units 3 and 4 operations. This is likely to reduce the variability of flow regime in this stretch of the river.

Smaller releases from Lake Granbury and lower streamflow in Brazos River near Glen Rose would occur except during peak flood flows and periods of low flow when a minimum release would be maintained by BRA. However, the DEIS does not identify the expected lower flow rates. The DEIS page 3-9 indicates that the new units under normal operation would require a total 63,550 gallons per minute (gpm) of water withdrawal from Lake Granbury and a total discharge of 26,076 gpm back to Lake Granbury. The DEIS indicates streamflow reduction could reduce average extent and volume of aquatic habitat available for fish and invertebrates, increased predation, crowding and competition, affect reproduction, affect stream substrate characteristics, increase water temperatures, reduce turbulence, and reduce dissolved oxygen levels. The DEIS indicates such streamflow reduction could reduce the populations of some species of fish and invertebrates.

The DEIS indicates there is uncertainty about the magnitude of impacts on riverine biota that may result from the relatively limited alterations in river flow associated with operation of Units 3 and 4

and such impacts may range from negligible to substantial depending on the species and the degree to which its habitat is affected. No actions are proposed to mitigate for impacts from hydrological changes in the Brazos River ecosystem.

Section 5.2.3.8 Impacts on Important Aquatic Species and Habitat

Regarding impacts on recreational fishery species within PKL, Lake Granbury, and Brazos River below Lake Granbury as a result of changes in water levels and flow regime, the DEIS indicates that impacts may range from negligible to noticeable. The impacts are dependent on the species and degree to which their habitat is affected, as well as the uncertainties of project impacts to characteristics associated with reproductive success.

Regarding aquatic threatened and endangered species, the DEIS indicates no potential effects to the state-threatened Brazos Water Snake based on 1) no TXNDD reported observations of the snake in the vicinity of the project in more than 20 years, 2) the operation of submerged intake and discharge structures in Lake Granbury would not substantially alter the shallow, shoreline habitat potentially utilized by the snake nor reduce populations of small forage fish on which the snake would feed, and 3) there would be limited effects of water level changes on shoreline habitat along PKL and the Brazos River between PKL and Lake. However, as previously discussed in this letter, recent thesis work found populations of this snake above and below Lake Granbury in the Brazos River.

> **Recommendation:** Transmission lines across waterbodies can serve as perch sites for raptors that prey on aquatic species, including on the Brazos Water Snake. Long-term changes to the water levels proposed for the project could further modify the habitat of this species by moving the water level away from the current shoreline and leaving riffle areas dry. The sensitivity of this species and its prey base to changes in water quality, levels and temperatures are unknown. While juvenile snakes seem to adhere to the near shore areas, adults utilize deeper waters; therefore, the analysis should indicate whether this species could become impinged on the intake screens. The analysis provided in the DEIS should identify all reasonable factors that could come into play to adversely impact this species.

The DEIS indicates that although habitat of all five of the rare mussels discussed in the document may occur within the Brazos River between Lake Granbury and Lake Whitney, none are known to occur there and none were found during the recent Bio-West studies conducted for this project. The DEIS indicates minimal impacts would occur to rare mussels. As previously discussed in this letter, there is potential for occurrence of state-threatened and rare mussels within the Brazos River below Lake Granbury to Lake Whitney, and lack of occurrences in TXNDD cannot be used as absence data from that region. Additionally, the Bio-West studies conducted for the project did not appear to target mussels and were limited in scope, though detailed survey methodology was not presented in the DEIS. No actions are proposed to mitigate for potential impacts to recreational fishery species, state-threatened Brazos water snake, or state-threatened and rare mussels.

Section 5.2.3.9 Aquatic Monitoring during Operation

Luminant does not plan to perform formal monitoring of aquatic ecosystems or wetlands during operations because Luminant indicates operational impacts are expected to be minimal and states that no additional preoperational or operational monitoring is warranted or planned, with the possible exception of specific locations along the new transmission line ROWs, unless the need for monitoring

arises during the course of obtaining necessary regulatory permits or approvals required to construct and operate the proposed additional units at CPNPP. Thus, the USACE or TCEQ may require aquatic monitoring in conjunction with their permitting requirements.

Section 5.3.2.10 Potential Mitigation Measures for Operation-Related Aquatic and Wetland Impacts

Luminant does not plan to perform mitigation measures for operation-related impacts to aquatic resources beyond those discussed in the DEIS. No mitigation measures are discussed or presented by Luminant in the DEIS for the impacts identified in this letter under Section 5.3.2.

Section 5.3.2.11 Summary of Operational Impacts on Aquatic and Wetland Resources

The NRC review team summary of operational impacts on aquatic and wetland resources (Section 5.3.2.11) states substantial uncertainty associated with the magnitude of ecological effects that may result from hydrological changes in the Brazos River as well as Lake Granbury and PKL. The DEIS finds operational impacts on aquatic resources may range from SMALL to MODERATE and additional mitigation may be warranted to help reduce adverse effects of flow alterations on the Brazos River and suggest such mitigation measures could include managing water releases from PKL and Lake Granbury to maintain higher base flows and to periodically provide episodic high flows that would better simulate the natural instream flows regime of the river.

TPWD is concerned that the anticipated changes in water levels at PKL and Lake Granbury will cause reductions in the fish and benthic invertebrate habitat and both aquatic and terrestrial cover along the edges of the lakes, which can have cascading adverse effects on reproduction and reduce recreational fishing areas. TPWD is also concerned that reduced flows anticipated for the Brazos River downstream of Lake Granbury to Lake Whitney will affect native organisms that rely on variable flow and certain water levels, including the Brazos Water Snake and rare mussels.

> **Recommendation:** Because of the uncertainty of impacts to biota and habitat of PKL, Lake Granbury, and Brazos River both below and above Lake Granbury as a result of water level changes and flow regime changes, TPWD recommends the NRC and USACE conservatively assume the effects are noticeable and substantial until Luminant is able to prove otherwise. Given the findings addressed in *Section 5.3.2 Ecological Impacts: Aquatic and Wetland Impacts*, TPWD recommends operational monitoring of aquatic resources (biota and habitat) of PKL, Lake Granbury and Brazos River from PKL downstream to Lake Whitney. Operation procedures should be developed to detect levels of aquatic biota and habitat impact and to implement mitigation strategies as impacts above negligible levels are detected. An adaptive management strategy should be incorporated to mitigate the impacts revealed through monitoring. Additional pressures on biota and habitat as a result of the project should be reduced through mitigation to restore, enhance or create habitat to help offset anticipated impacts. As discussed in this section and in NRC's conclusions and recommendations Table 10-2, TPWD supports the NRC review team suggestion of manipulating base flows and episodic releases to simulate the natural instream flow regime of the river to aid in mitigating impacts.

5.4.4.2 Recreation

The DEIS states the operation of Units 3 and 4 could affect the recreational use of Lake Granbury and PKL by decreasing water level elevations, especially during summer months. With Units 3 and 4, the

average water level of Lake Granbury could decrease by a minimum of 0.6 foot and a maximum of 2.9 feet. The water level in PKL could decrease by a minimum of 1.5 feet and a maximum of 14.8 feet. The maximum reductions in water level provided in this section are different than those given in the discussion of shoreline habitat in Section 5.3.1.1, page 5–19. During the 2009 drought, Lake Granbury water level dropped 3.5 feet, the lowest level since 1984. During that time in 2009, half of the public boat ramps (3) and many of the private boat ramps and fixed boat docks were out of the water. The DEIS concludes that a 0.6-foot decrease would have a SMALL impact on recreational use, and a 2.9-foot decrease in water level during drought conditions would have a MODERATE impact on recreational use, particularly on the use of boat ramps and fixed boat docks. This would be especially noticeable given that most of the residential boat docks are fixed docks and cannot adjust to changes in water level.

In the 2009 drought PKL level dropped 5.2 feet below full pool elevation. The DEIS concluded that a 1.5-foot decrease at PKL would have a SMALL impact on recreational use; a 14.8-foot decrease during drought conditions would have a MODERATE impact on recreational use. The DEIS concludes that impact to recreation on PKL might be less noticeable than on Lake Granbury, due to the fact that most residential boat docks on PKL are floating docks that can adjust somewhat to changes in water level.

TPWD is concerned with the amount of boat docks and boat ramps that would be left dry during drought periods combined with water level reductions due to Units 3 and 4. It appears that water levels would be at their lowest during spring and summer when recreational use of boat docks and ramps is at its highest. Nighttime lighting is not addressed in this section on recreation, although Dinosaur Valley SP is located approximately 2.5 miles from the CPNPP site.

> **Recommendation:** TPWD recommends the applicant propose mitigation for loss of access to public and private boat ramps and docks. TPWD recommends Luminant provide financial assistance to both public and private entities for retrofitting existing ramps and docks to allow reasonable access to these surface waters. WAM models should include an assessment of the amount of time water levels would be reduced such that any of the existing public boat ramps would be dry and access from the boat ramps would be impacted. The values given for maximum water level reductions should be consistent throughout the document. Potential impacts associated with increased nighttime light pollution to park users at Dinosaur Valley SP should be addressed. Measures to minimize impacts to state parks should be developed in coordination with David Riskind of TPWD State Parks Division Natural Resources Program at (512) 389- 4897.

6.0 Fuel Cycle, Transportation, and Decommissioning

Section 6.1.6 Radiological Wastes

The DEIS indicates that Class A low-level radioactive water (LLW) would be acceptable for disposal at the Energy Solutions site in Clive, Utah, though Class B and C LLW would not be acceptable at the Energy Solutions site in Barnwell, South Carolina.

The DEIS indicates that Class A, B, and C LLW created from CPNPP Units 3 and 4 may likely be disposable at the Waste Control Specialists, LLC (WCS) newly licensed radioactive material low-level waste facility in Andrews County, Texas. WCS received its license from TCEQ in September 2009, though at the time of the DEIS, construction and operation of the facility had not yet been

approved. Approval of the WCS facility is expected in late 2010. The DEIS indicated it is likely alternate disposal pathways for Class B and C LLW would include compaction and storage at offsite vendor locations until disposal is secured and blending of waste types with subsequent disposal at available disposal sites. It is anticipated that Luminant could also temporarily store Class B and C LLW onsite in accordance with existing NRC regulations until offsite storage is available.

The DEIS indicates that high-level and transuranic wastes are to be buried at a repository such as the candidate repository at Yucca Mountain, Nevada. The NRC Waste Confidence Decision, 10 CFR 51.23, has made the generic determination that if necessary, spent fuel generated in any reactor can be stored safely and without significant environmental impacts for at least 30 years beyond the licensed life for operation of that reactor at its spent fuel storage basin or at either onsite or offsite independent spent fuel storage installations. Additionally, the NRC believes there is reasonable assurance that at least one mined geologic repository will be available within the first quarter of the 21st century and sufficient repository capacity will be available within 30 years beyond the licensed life for operation of any reactor to dispose of the commercial high-level waste and spent fuel originating in such reactor and generated up to that time. Thus the NRC concludes SMALL impact associated with LLW and high level waste generated by Units 3 and 4.

Recommendation: If the DEIS and EIS are not finalized until 2011, TPWD recommends the documents be updated to indicate the construction and operation status of the LLW WCS facility in Andrews County, Texas. Updates regarding the status of pending availability of high-level waste repositories should also be included as the EIS becomes finalized.

7.0 Cumulative Impacts

Section 7.2 Water Use and Quality

Page 7–7 indicates the U.S. Global Climate Research Program projects this region (Great Plains) may warm as much as 12 degrees Fahrenheit between 2000 and 2090 and tend to have less rainfall. Page 7–9 notes water management, under proposed changed strategies in this water planning region, would minimize adverse impacts on water availability for users with valid water rights. The decreased precipitation and increased temperatures associated with global climate change would reduce surface water runoff and increase evapotranspiration, contributing to cumulative impacts on water quantity of streamflows. The NRC review team identifies the cumulative impacts on surface water quantity as MODERATE with noticeable alterations in the Brazos River system. The surface-water quality impacts discussion in Section 7.2.2.1 (page 7–11) states these changes could reduce the ability of Lake Granbury and the Brazos River to dilute natural salt concentrations and waste heat and other constituents in the effluent from Units 3 and 4. The cumulative impacts to surface water quality is evaluated as SMALL to MODERATE with the MODERATE level based on the potential impacts to ambient water conditions and downstream users from increased dissolved solids, particularly during low flow conditions. The DEIS, however, does state that current and future potable water users would still be required to treat water to address salinity regardless of the increase in salt concentrations attributable to Units 3 and 4. Aquatic life in the Brazos River Basin does not presently qualify for a water right and under the current system, has been adversely impacted. It is unclear if the ecosystem could stabilize, under these future cumulative conditions.

Recommendation: The facility should plan to address adverse impacts imposed by global climate changes. To offset cumulative impacts, TPWD recommends that Luminant's discharge to

Lake Granbury during seasonal and drought low flow conditions be maintained at or below ambient lake concentrations. It would result in larger volumes of salt solids needing to be disposed off site, but would only occur during drought and summer periods. This mitigation measure would avoid the added stress of the lake and river needing to dilute Units 3 and 4 effluents.

Section 7.3 Ecology

The DEIS indicates that new transmission lines are not anticipated to cause any increase in bird collisions if proper mitigation were employed and would not be expect to increase and contribute to cumulative effects.

TPWD is concerned that the proposed project and future development in the area would increase the number of transmission lines in the area, and without guaranteed mitigation measures, may cause cumulative increases in bird collisions. At this time, mitigation measures to reduce bird collisions for this project have not been decided for the five proposed transmission lines associates with the project. Additionally, the BDTF site layout has not been finalized; thus strategic placement of the evaporation ponds away from existing transmission lines to minimize bird collisions has not been finalized or employed.

The DEIS indicates the proposed project and future development in the area would likely reduce habitat of the Limestone Cut Plain of the Western Cross Timbers ecoregion, and such impacts may be sufficient to noticeably alter the important attributes of wildlife habitat. Cumulative impacts to terrestrial ecological resources are assessed as MODERATE.

Recommendation: Strategic transmission line placement and guaranteed use of bird collision deterrent devices would be actions to reduce the cumulative impacts. To mitigate for cumulative losses to wildlife habitat, developers for this and future projects should employ site planning, design, and construction to limit disturbance footprints and to permanently set aside large contiguous areas and corridors to support wildlife habitat. Because the CPNPP site encompasses a large area of habitat that will remain undeveloped, management strategies to promote wildlife conservation and diversity will aid in mitigating the cumulative impact associated with habitat loss due to the project.

Withdrawals of water from the Brazos River system for Units 3 and 4 would be a major component of the increased withdrawals planned for under BRA water management policy. However, these increases are likely to occur even without Units 3 and 4 because the 2060 Brazos G Water Plan calls for full utilization of the yield from the Brazos River system between now and 2060. The DEIS indicates that future development of industries that compete for water along the Brazos River, as well as management of water budgets across the state, would likely affect aquatic resources in the Brazos River. The DEIS indicates noticeable SMALL to MODERATE cumulative effects on aquatic biota from the hydrological changes in the Brazos River, PKL, and Lake Granbury associated with increased water consumption by the proposed Units 3 and 4 in combination with other future users of BRA water allocations.

Recommendation: TPWD recommends a mitigation measure to minimize cumulative effects on aquatic resources through aquatic life water allocations within the Brazos River. Any future

innovations in cooling operating processes that reduce water consumption should be considered and employed, where feasible, at the CPNPP site.

9.0 Environmental Impacts of Alternatives

Section 9.1 No-Action Alternative

Under the no-action alternative, Luminant would not be given an NRC license or USACE permit to construct and operate Units 3 and 4. Unless other proposed power plants get built in lieu of the proposed project or other strategies are implemented in its place, the benefits of the additional electrical capacity and electricity generation to be provided by the project would not occur. If Luminant does nothing in response to license and permit denial, Luminant would not be able to meet its ability to maintain an adequate reserve margin and would fail to meet its public service obligations to provide sufficient power within its service territory. In such a case, ERCOT would need to pursue alternative options in power generation or demand reduction by implementing one or a combination of actions including more aggressive demand-side management programs, purchase insignificant amounts of power from other suppliers for short-term needs, and/or construct other baseload power options, such as nuclear power station construction at one of Luminant's alternative sites. These power alternatives could have environmental impacts themselves.

Section 9.3 Alternative Sites

The intention of alternative site analysis by the NRC is to determine if any obviously superior alternative exists to the site proposed. Within Luminant's region of interest for creating power, screening criteria were applied to evaluate sites and, after following different evaluation and selection refinement processes, led to the selection of the preferred and alternative sites. Eventually, four candidate sites were chosen, Coastal, Pineland, Tradinghouse, and Comanche Peak, and further evaluated to determine the preferred site, Comanche Peak. The NRC found Luminant's methodology of selecting the sites was reasonable and did not arbitrarily exclude locations that might be suitable choices. NRC's evaluation of the sites did not find differences that were sufficient to determine that any of the sites would be environmentally preferable, and no alternatives sites were identified as obviously superior. The USACE will conclude its analysis of both offsite and onsite alternatives in its Record of Decision.

Section 9.4 System Design Alternatives

The NRC considered three alternative closed-loop cooling tower systems (wet/dry, natural draft wet, and dry) and alternative intake, discharge, and water supply systems, concluding that none of the alternatives was environmentally preferable to the proposed CPNPP Units 3 and 4 systems. The proposed closed-loop cooling system utilizes less quantity of water by comparison to once-through (open) cooling systems; thus once-through systems were identified as inappropriate in the DEIS for the proposed project.

Dry cooling towers and combination mechanical wet/dry cooling towers utilize less water than wet cooling systems; however, dry cooling functions create inefficient power generation. Dry portions of these systems come with energy and efficiency penalties and are not as cost-effective as wet or evaporative systems. The project would need to be supplemented with power generated from an alternate source to meet the project's purpose. The inefficiencies and thermal energy losses translate

into increased fuel needs, increased fuel cycle impacts, displaced environmental impacts, air quality impacts, socioeconomic impacts, or a combination of these impacts.

Wet natural draft cooling towers induce circulation through 500-foot tall and 400-foot diameter towers by cascading warmed water downward through the tower. Rising heated air in the tower induces more air to enter the tower through its open base to replace exiting air at the top of the tower. This system requires a 20 degree Fahrenheit temperature difference between the warmed air and the ambient air temperature, which cannot be reliably achieved during warmer times of the year. The current thermal conditions and the size of Lake Granbury, which provides cool water for the process, cannot meet the required parameters, unless Lake Granbury would be expanded.

Regarding the circulating water system intake, the DEIS indicates that Lake Granbury is preferable location over SCR because using SCR has the disadvantage of further degrading the water supply situation in SCR. The various alternatives for intake structures at Lake Granbury all have similar minimal environmental impacts as the proposed structure.

Lake Granbury as the discharge location was identified as having the least environmental impacts over discharge to Brazos River, SCR, Squaw Creek, Paluxy River, and PKL. SCR cannot support the thermal load of Units 3 and 4 without affecting Units 1 and 2. Brazos River flow is not great enough to accept the thermal plume or dissipate/dilute receiving effluent. Discharging into Squaw Creek, which discharges to the Brazos River, would create the same impacts as directly discharging to the Brazos River. Discharges to Paluxy River could impact the natural heritage of Dinosaur Valley SP. Discharge to PKL would require many miles of pipeline. Zero liquid discharge means no outfall for CPNPP units and would create significant volume of salt solids during evaporation of cooling water to the point of dryness. Lake Granbury was identified as the only viable source of water for Units 3 and 4 because there are no reused water sources and no suitable groundwater sources.

Appendix D – Response to TPWD Comments on ER/Scoping

Page D–40, response to comment 0029–5, regarding TPWD's and the applicant's aquatic biota studies indicates that TPWD fisheries data would be considered, but did not indicate it would send the requested Bio-West studies to TPWD. Additionally, the NRC website shows an environmental Request for Additional Information (RAI) dated August 3, 2009, for which no response was received from Luminant (http://www.nrc.gov/reactors/new-reactors/col/comanche-peak/rai.html). The RAI requested copies of reference materials be placed on the NRC docket and reading room for citation and reference in the EIS. The Bio-West 2008a and 2008b studies were included in this request. TPWD was not able to locate these documents in the NRC reading room.

> **Recommendation:** TPWD has not received the studies, but is still interested in reviewing the documents. Please send Bio-West 2008a and 2008b reference materials to the attention of Gloria Garza, TPWD Wildlife Habitat Assessment Program, at TPWD headquarters or Gloria.Garza@tpwd.state.tx.us for proper receipt/internal tracking and distribution to appropriate review personnel.

Materials submitted with this document are provided in Appendix A and include:

1) TXNDD Occurrences within 1.5-miles of the CPNPP site, transmission lines, and pipelines
2) McBride thesis for the Brazos Water Snake

References:

Howells, R.G. 1994. Distributional Surveys of Freshwater Bivalves in Texas: Progress Report for 1994. TPWD, Austin.

Howells, R.G. 1996. Distributional Surveys of Freshwater Bivalves in Texas: Progress Report for 1996. TPWD, Austin.

Howells 2004. Texas Freshwater Mussels: Species of Concern. Wildlife Diversity meeting, San Marcos, Texas.

McBride, Dustin Lee. Distribution and Status of the Brazos Water Snake (*Nerodia harteri harteri*). M.S., Tarleton State University, 2009, 91 pp.

USFWS. 2007. International Recovery Plan Whooping Crane (*Grus americana).* Final Third Revision. March

USFWS. 2009. Whopping Cranes and Wind Development – An Issue Paper. USFWS Regions 2 and 6. April.

Appendix A

Texas Natural Diversity Database Records with in 1.5 miles of Proposed Comanche Peak Nuclear Power Plant Units 3 and 4, Including Transmission Line and Cooling Water Pipeline Planning Corridors

EO_ID	EO Number	Scientific Name	Common Name	Federal Status	State Status
4067	21	*Juniperus ashei-quercus spp. series*	Ashe Juniper-oak Series		
660	146	*Vireo atricapilla*	Black-capped Vireo	LE	E
1348	135	*Vireo atricapilla*	Black-capped Vireo	LE	E
4695	134	*Vireo atricapilla*	Black-capped Vireo	LE	E
6213	245	*Vireo atricapilla*	Black-capped Vireo	LE	E
7664	237	*Vireo atricapilla*	Black-capped Vireo	LE	E
8084	2	*Vireo atricapilla*	Black-capped Vireo	LE	E
2098	1	*Nerodia harteri*	Brazos Water Snake		T
896	30	*Ulmus crassifolia-celtis laevigata series*	Cedar Elm-sugarberry Series		
813	3	*Yucca necopina*	Glen Rose yucca		
2871	1	*Yucca necopina*	Glen Rose yucca		
5364	2	*Yucca necopina*	Glen Rose yucca		
7952	4	*Yucca necopina*	Glen Rose yucca		
8961	6	*Yucca necopina*	Glen Rose yucca		
130	66	*Dendroica chrysoparia*	Golden-cheeked Warbler	LE	E
1190	229	*Dendroica chrysoparia*	Golden-cheeked Warbler	LE	E
2696	64	*Dendroica chrysoparia*	Golden-cheeked Warbler	LE	E
2870	213	*Dendroica chrysoparia*	Golden-cheeked Warbler	LE	E
6205	228	*Dendroica chrysoparia*	Golden-cheeked Warbler	LE	E
6437	65	*Dendroica chrysoparia*	Golden-cheeked Warbler	LE	E
7708	67	*Dendroica chrysoparia*	Golden-cheeked Warbler	LE	E
6560	10	*Notropis buccula*	Smalleye Shiner	C	

Notes:
Federal Status: LE = Listed Endangered, C = Candidate for Federal Listing
State Status: E = Endangered, Blank = Species of Concern or Model Example of Natural Plant Community

Source:
Texas Natural Diversity Database, Revision Date June 7, 2010. TPWD Diversity Program, Wildlife Division.

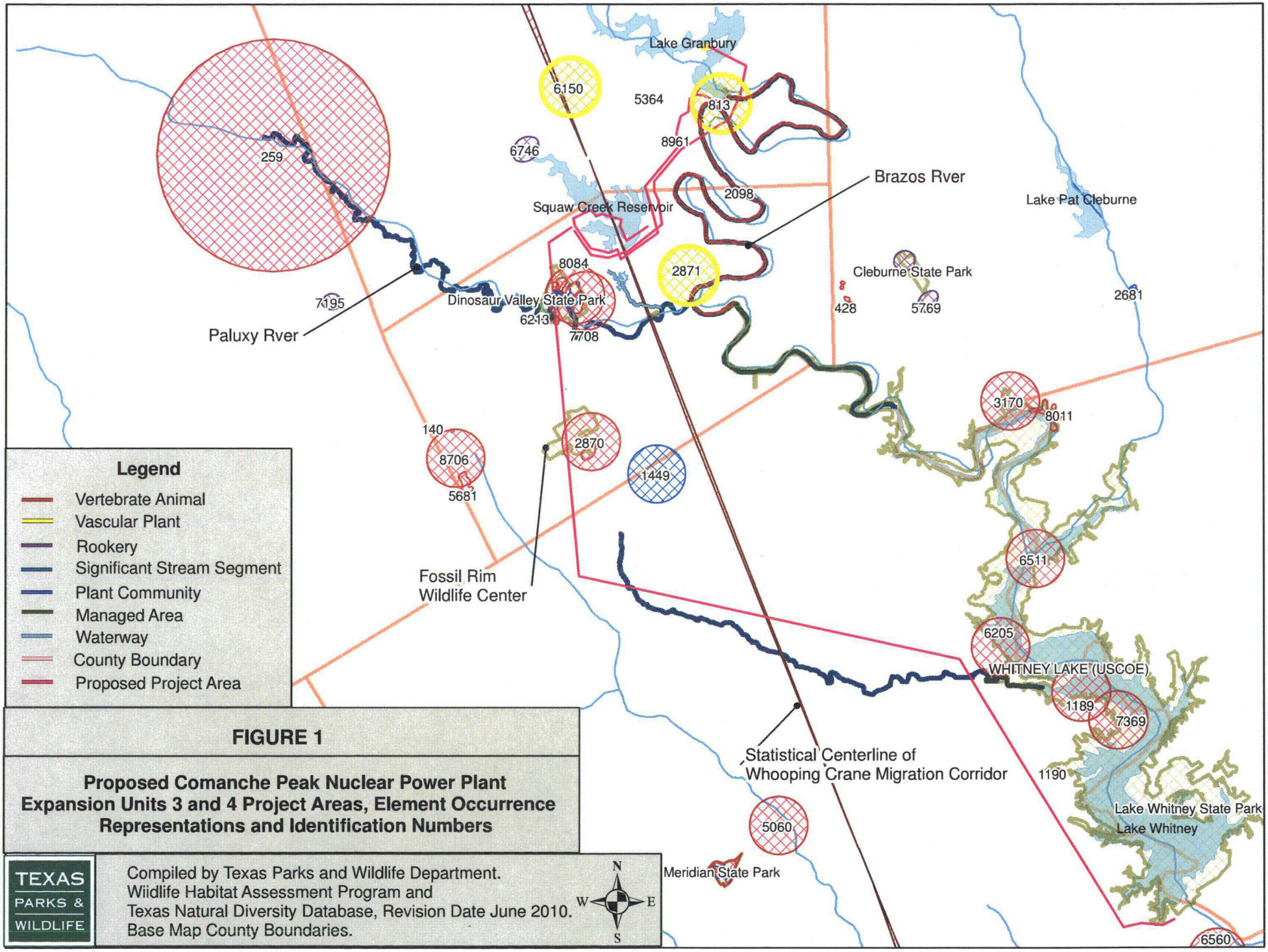


FIGURE 1

Proposed Comanche Peak Nuclear Power Plant Expansion Units 3 and 4 Project Areas, Element Occurrence Representations and Identification Numbers

TEXAS PARKS & WILDLIFE

Compiled by Texas Parks and Wildlife Department.
Wiidlife Habitat Assessment Program and
Texas Natural Diversity Database, Revision Date June 2010.
Base Map County Boundaries.

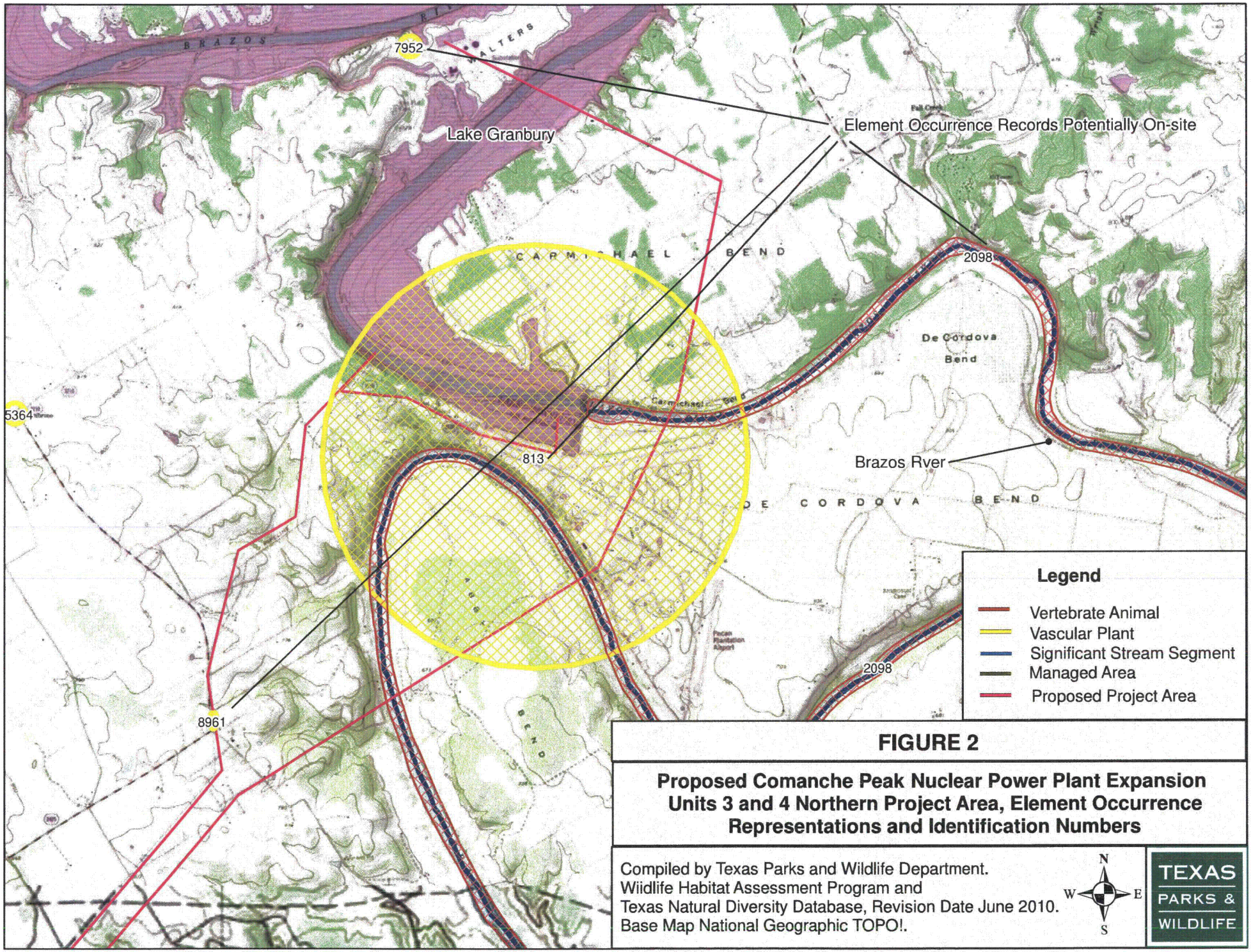


FIGURE 2

Proposed Comanche Peak Nuclear Power Plant Expansion Units 3 and 4 Northern Project Area, Element Occurrence Representations and Identification Numbers

Compiled by Texas Parks and Wildlife Department.
Wiidlife Habitat Assessment Program and
Texas Natural Diversity Database, Revision Date June 2010.
Base Map National Geographic TOPO!.

TPWD Recommendations for Electrical Transmission/Distribution Line Design and Construction

Construction of the line should be performed to avoid adverse impacts not only to the environment but the local bird populations and to restore or enhance environmental quality to the greatest extent practical. In order to minimize the possible project effects upon wildlife, the following measures are recommended.

TPWD recommends that each electrical company develop an Avian Protection Plan to minimize the risks to avian species that are protected by the Migratory Bird Treaty Act.

Avian Electrocution Risks

Birds can be electrocuted by simultaneously contacting energized and/or grounded structures, conductors, hardware, or equipment. Electrocutions may occur because of a combination of biological and electrical design. Biological factors are those that influence avian use of poles, such as habitat, prey and avian species. The electrical design factor is most crucial to avian electrocutions is the physical separation between energized and/or grounded structures, conductors, hardware, or equipment that can be bridges by birds to complete a circuit. As a general rule, electrocution can occur on structures with the following:

- Phase conductors separated by less than the wrist-to-wrist or head-to-foot (flesh-to-flesh) distance of a bird;
- Distance between grounded hardware (e.g. grounded wires, metal braces) and any energized phase conductor that is less than the wrist-to-wrist or head-to-foot (flesh-to-flesh) distance of a bird (Avian Power Line Interaction Committee 2006).

To protect raptors and eagles, procedures should be followed as outlined in:

> Suggested Practices for Raptor Protection on Power Lines: The State of the Art in 2006. by Avian Power Line Interaction Committee (APLIC). 2006. Distributed by the Avian Power Line Interaction Committee (APLIC).
>
> Mitigating Bird Collisions with Power Lines: the State of the Art in 1994. Avian Power Line Interaction Committee (APLIC). 1994. Edison Electric Institute. Washington D.C.

Line alterations to prevent bird electrocutions should not necessarily be implemented after such events occur, as all electrocutions may not be known or documented. Incorporation of preventative measures along portions of the routes that are most attractive to birds (as indicated by frequent sightings) prior to any electrocutions is much preferred.

Preventative measures include: phase covers, bushing cover, arrester covers, cutout covers, jumper wire hoses, and covered conductors. In addition, perch discouragers may be used to

deter birds from landing on hazardous (to birds) pole locations where isolate, covers, or other insulating techniques cannot be used (Avian Power Line Interaction Committee 2006).

Use wood or non-conducting cross arms, for distribution lines, to minimize the possibility of electrical contact with perching birds.

When possible, for distribution lines, install electrical equipment on the bottom cross arm to allow top cross arm for perching.

TPWD recommends using nest management strategies which include installing nesting platforms on or near power structures to provide nesting sites for several protected species while minimizing the risks of electrocution, equipment damage, or outages (Avian Power Line Interaction Committee 2006).

Avian Collision Risks

Birds typically establish flight corridors along and within river and creek drainages. Transmission lines that cross or are located very near these drainages should have line markers installed at the crossings or closest points to the drainages to reduce the potential of collisions by birds flying along or near the drainage corridors.

If transmission lines are located in an area with tall trees, the height of the transmission line should not be taller than the trees to reduce collision risks.

Transmission lines should be located to avoid separating feeding and nesting areas. If this cannot be avoided lines should be clearly marked to minimize avian collisions with the lines (Avian Power Line Interaction Committee 1994).

Transmission lines should be buried, when practical, to reduce the risks of avian collisions.

Habitat Impacts

Construction should avoid identified wetland areas. Coordination with appropriate agencies should be accomplished to ensure regulatory compliance. Construction should occur during dry periods.

Construction should attempt to minimize the amount of flora and fauna disturbed. Reclamation of construction sites should emphasize replanting with native grasses and leguminous forbs.

Existing rights-of-way should be used to upgrade facilities, where possible, in order to avoid additional clearing and prevent adverse impacts associated with habitat loss and fragmentation of existing blocks of wooded habitat.

Forest and woody areas provide food and cover for wildlife, these cover types should be

preserved. Mature trees, particularly those which produce nuts or acorns, should be retained. Shrubs and trees should be trimmed rather than cleared.

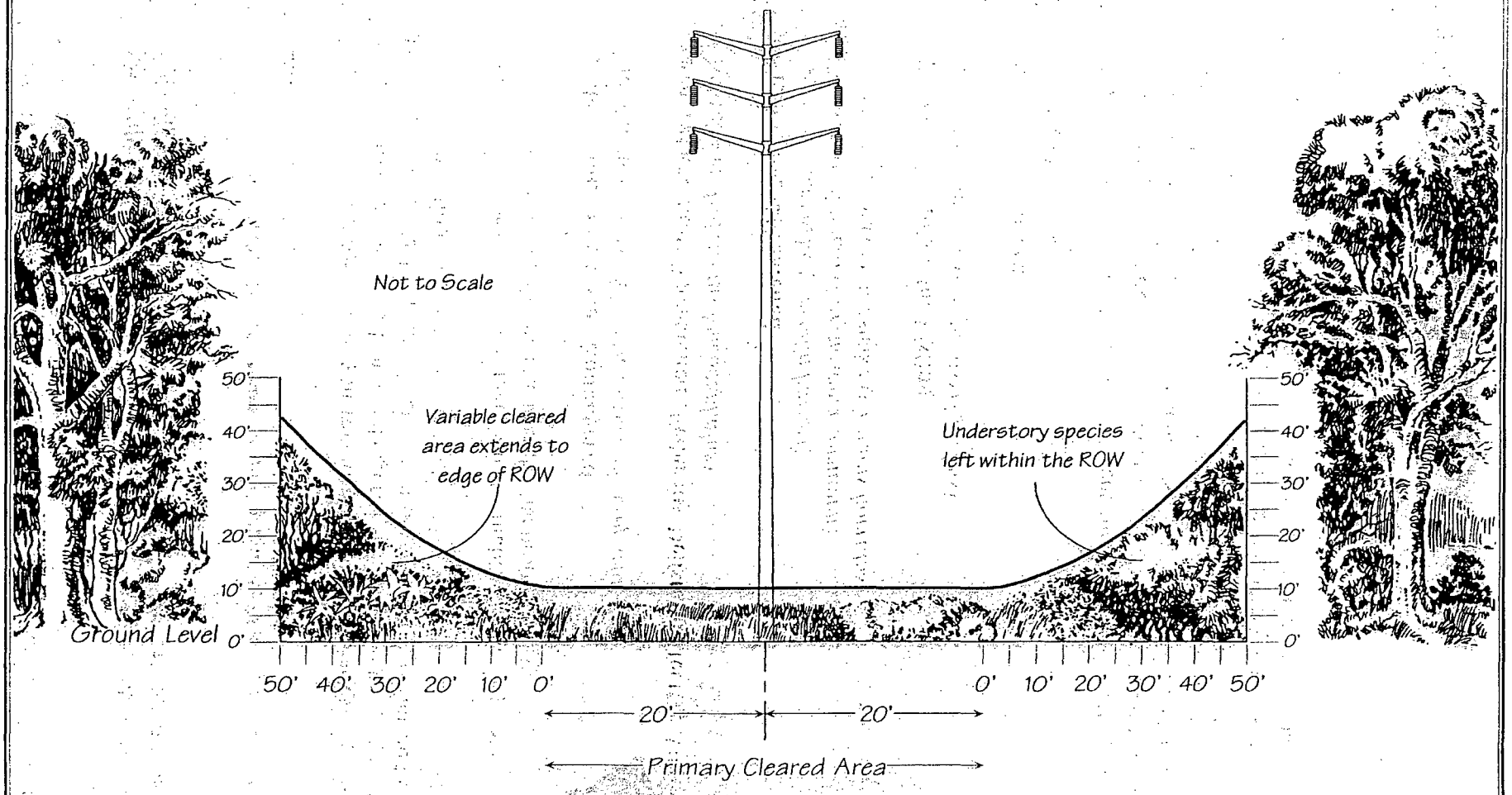
Transmission lines should be designed to cross streams at right angles, at points of narrowest width, and/or at the lowest banks whenever feasible to provide the least disturbance to stream corridor habitat.

Implementation of wildlife management plans along rights-of-way should be considered whenever feasible.

All pole design should be single phase (without arms), where possible, to preserve the aesthetics of the area.

AN ALTERNATIVE TO EDGE-TO-EDGE ELECTRIC TRANSMISSION LINE ROW CLEARING

MAXIMUM HEIGHT OF TIMBER LINE FOR RIGHT-OF-WAY CLEARING IN SELECTIVE CUT CLEARING AREAS



source: TU Electric Engineering

Habitat Assessment Branch, Jan'95

August 3, 2007

TEXAS PARKS & WILDLIFE

Mr. William Wenstrom, PhD
Enercon Services, Inc.
33020 Conifer Drive
Trinidad, CO 81082

Dear Mr. Wenstrom:

This letter is in response to your review request, dated June 5, 2007, for potential impacts to rare, threatened, and endangered species from the proposed addition to the Comanche Peak Steam Electric Station consisting of an additional nuclear power generation facility in Somervell County.

Based on the project as presented, when suitable habitat is present, the following species could potentially be impacted by the proposed project:

Federal and State Listed Endangered
Golden-cheeked Warbler (*Dendroïca chrysoparia*)

Federal and State Threatened (Federally Delisted Effective August 8, 2007)
Bald Eagle (*Halaieetus leucocephalus*)

State Listed Threatened
Brazos water snake (*Nerodia harteri*)
Texas horned lizard (*Phrynosoma cornutum*)
Timber/Canebrake rattlesnake (*Crotalus horridus*)

Federal Candidate for Listing
Sharpnose shiner (*Notropis oxyrhynchus*)

Species of Concern
Pistolgrip (*Tritogonia verrucosa*)

The Golden-cheeked Warbler is present in Texas only during breeding season, from about mid-March to mid-August. The warbler usually occurs in mature Ashe juniper-deciduous tree woodlands. Based on the habitat shown the aerial imagery included with your request, this species may occur on the project site and could be adversely impacted by your project activities. Additional information for the management and conservation needs for this species can be obtained at http://www.tpwd.state.tx.us/huntwild/wild/species/endang/animals/birds/index.phtml.

Replacement of habitat for this species takes many years. Harassment and disturbance of this species are prohibited, except by a permit issued under the Endangered Species Act and Migratory Bird Treaty Act (MBTA) through the US Fish and Wildlife Service (USFWS).

Recommendations: The siting and thus the probable required removal of mature woody vegetation in the proposed cooling tower area and its access road should be re-evaluated closely. TPWD recommends alternative siting be proposed for the cooling tower. Compensatory mitigation for preserving high quality habitat should be considered also, if avoidance is not possible. If proposed, any planned removal of woody vegetation should be scheduled during the non-breeding season to minimize impacts to this species.

Currently, TPWD has no specific information for the immediate project area regarding rare species. However, the general area is known to support numerous rare species. TPWD maintains information on rare resources in the Texas Natural Diversity Database (TXNDD) to assist users in avoiding harm to rare species or significant ecological features. However, absence of information in an area does not imply that a species is absent from that area. Given the small proportion of public versus private land in Texas, the TXNDD does not include a representative inventory of rare resources in the state. Although it is based on the best data available to TPWD regarding rare species, the data from the TXNDD do not provide a definitive statement as to the presence, absence or condition of special species, natural communities, or other significant features within your project area. These data are not inclusive and **cannot be used as presence/absence data**. They represent species that could potentially be in your project area. This information cannot be substituted for on-the-ground surveys by your qualified biologists. The TXNDD is updated continuously, based on new, updated, and previously undigitized information. For future projects, please contact Stephanie.Shelton@tpwd.state.tx.us for the most current TXNDD information.

Recommendations: TPWD recommends that your qualified biologist conduct on-site habitat assessments for the species listed above. Also, please review the most current TPWD county list, as other rare species could be present depending upon habitat availability. These lists are updated on an adhoc basis and are now available on-line at http://www.tpwd.state.tx.us/landwater/land/maps/gis/ris/endangered_species.phtml. If habitat is found, it is recommended that measures be incorporated into the site plans to avoid impacting rare resources. If avoiding potential habitat is not an option, then TPWD recommends surveying for the rare resources listed above and developing minimization and compensatory measures to reduce the potential impacts to rare species.

The USFWS has specific minimum procedural protocols for assessing presence/absence of the Golden-cheeked Warbler. For USFWS county lists of rare species access http://www.fws.gov/southwest/es/EndangeredSpecies/lists/ListSpecies.cfm. Determining the actual presence of a species in a given area depends on many variables including daily and seasonal activity cycles, environmental activity cues, preferred habitat, transiency and population density (both wildlife and human). The absence of a species can be demonstrated only with great difficulty and then only with repeated negative observations, taking into account all the variable factors contributing to the lack of detectable presence.

Recommendations: The US Fish and Wildlife Service (USFWS) should be contacted for permitting, survey protocols, and mitigation for federally listed species. Please provide this office with copies of survey results and any additional written consultation you may conduct with the USFWS regarding rare resources.

Most native bird species may not be disturbed and must be dealt with in a manner consistent with the Migratory Bird Treaty Act (MBTA). The MBTA implicitly prohibits intentional and unintentional take of nearly all native birds, except when authorized under a USFWS permit. Additional information regarding the MBTA may be obtained through the USFWS Region 2 Migratory Bird Permit Office at (505) 248-7882.

Recommendations: TPWD recommends excluding all clearing activities during the general bird nesting season, March through August, to avoid adverse impacts to this group, including ground nesting species.

Long term and cumulative impacts should also be addressed.

Recommendations: In addition to analyzing the direct construction related impacts, the environmental documentation should discuss long term impacts. For example, the discussion should include changes resulting from operation of the new units, if any, such as changes in the water temperature near the discharge outlet in the cooling reservoir, changes in water intake and discharge quantity and quality. Such changes could have direct impacts on aquatic fauna, which could potentially have adverse impacts further up the foodchain, for instance potential for loss of an adequate supply of crustaceans and fish for the birds known to utilize the site, such as sandpipers, terns, and gulls. If there are no changes planned for these operational items, this should be clarified. If changes are planned, further analysis should be attempted to assess the potential for impacts.

Thank you for the opportunity to comment on this project. Please contact me if you have any questions or need additional assistance (512) 912-7021.

Sincerely,

Celeste Brancel, Environmental Review Coordinator
Wildlife Habitat Assessment Program
Threatened and Endangered Species

TEXAS PARKS & WILDLIFE

Life's better outside.™

April 24, 2009

Michael Lesar, Chief
Rules and Directives Branch
Division of Administrative Services
Mail Stop T-6D59
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

RE: Dockets 52-034 and 52-035
Luminant Generation Company LLC
Comanche Peak Nuclear Power Plant Units 3 & 4
Combined License Application (Hood and Somervell Counties, Texas)

Dear Chief Lesar:

In response to the Nuclear Regulatory Commission's (NRC) request for participation in the scoping process in preparation of an Environmental Impact Statement (EIS) for the project referenced above, the Texas Parks and Wildlife Department (TPWD) provided a response letter February 16, 2009. Since that time, TPWD participated in a portion of the Environmental Review Site Audit and the applicant, Luminant Generation Company LLC (Luminant), submitted additional information to the NRC regarding specific locations of the alternative sites. This letter is intended to provide the NRC with 1) a summary of the findings regarding identification of specific yucca species during the Site Audit and 2) refined data regarding known occurrences of rare resources in the vicinity of the specific alternative sites.

Environmental Review Site Audit - Yucca Species

During the February 2, 2009, site visit of the proposed Comanche Peak Nuclear Power Plant (CPNPP) site, *Yucca* species were observed by TPWD personnel in the peninsula area proposed for the construction of the cooling towers for units 3 and 4. Because occurrences of Glen Rose Yucca (*Yucca necopina*), a state rare species, occurs within the vicinity of the project area, TPWD requested to see the plants again during the Environmental Review Site Audit to record their location and obtain photographs for proper identification of the species.

Evaluation of the photographs indicate that the *Yucca* plants observed on the slopes of the peninsula for the proposed cooling towers of units 3 and 4 are

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www.tpwd.state.tx.us

Yucca pallida and not Glen Rose Yucca. The *Yucca pallida* were observed at approximately NAD83 Zone 14N UTM 0613235 Easting, 3574724 Northing.

> **Comment.** *Yucca pallida* are endemic to the area and TPWD recommends transplanting them somewhere else on the CPNPP property to maintain the population, such as native landscaping areas or grassland areas that would not be mowed. They are very easy to transplant, since they have small root systems and are not hard to dig up and move. They can be planted in shallow ground.

> **Comment.** Because Glen Rose Yucca occur within the vicinity of the project area, TPWD recommends that *Yucca* species found in other areas proposed for clearing be identified to the species level. Glen Rose Yucca identified should be relocated to maintain the population. TPWD can assist with species identification and development of relocation plans.

The Texas Natural Diversity Database (TXNDD)

At the time of TPWD's February 16, 2009 response letter, Luminant had not revealed the alternative site locations because they held the locations as proprietary information. Therefore, TPWD presented data regarding known occurrences of rare resources based on countywide sets of data for two counties per site including a 10 mile radius buffer. Submitting occurrence data across such a large area resulted in data sets that may not have been representative of the project area, though were based on the best data available.

Since that time, Luminant provided the NRC with specific alternative site locations; therefore, TPWD has conducted a new search of the TXNDD for known occurrences of rare resources within 10 miles of the coordinate point of the CPNPP and alternative sites. This data should replace the data provided for the county-wide alternatives analysis and allow the NRC to evaluate the alternative sites more effectively.

Please refer to the attachment regarding the new TXNDD search results for the CPNPP and Alternative Sites.

TPWD appreciates the opportunity to comment on this project. Please do not hesitate to contact me at (512) 917-4155 if you have any questions.

Sincerely,

Kathy Boydston for

Karen Hardin
Wildlife Habitat Assessment Program
Wildlife Division

KH:gg.13698B

Attachment

TEXAS PARKS & WILDLIFE

Life's better outside.™

February 16, 2009

Mr. Michael Lesar, Chief
Rules and Directives Branch
Division of Administrative Services
Mail Stop T-6D59
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

RE: Dockets 52-034 and 52-035
Comanche Peak Nuclear Power Plant Units 3 and 4
Combined License Application (Hood and Somervell Counties, Texas)

Dear Mr. Lesar:

Texas Parks and Wildlife Department (TPWD) received the Nuclear Regulatory Commission (NRC) request for participation in the scoping process in preparation of an Environmental Impact Statement (EIS) for the project referenced above. Luminant Generation Company LLC (Luminant) has applied for two combined licenses for construction and operation of two new nuclear power plants at its Comanche Peak Nuclear Power Plant (CPNPP). The NRC seeks information relevant to state-listed, proposed, and candidate species and protected habitat in the vicinity of the proposed CPNPP site, the alternative sites, and the transmission line right-of-ways (ROW). The NRC also invited any information, comments, or concerns that TPWD feels appropriate on the scope of the proposed action by the end of the comment period, February 17, 2009.

Under section 12.0011 of the Texas Parks and Wildlife Code, TPWD is charged with "providing recommendations that will protect fish and wildlife resources to local, state, and federal agencies that approve, permit, license, or construct developmental projects" and "providing information on fish and wildlife resources to any local, state, and federal agencies or private organizations that make decisions affecting those resources."

TPWD provides the following comments and concerns regarding the proposed project: the comments have been organized to coincide with Luminant's Environmental Report (ER):

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Chapter 2 - Existing Environment

Section 2.4 of the ER references a List of Somervell County Threatened and Endangered Species to address state-listed threatened or endangered species that may occur at the proposed CPNPP site. The ER failed to include the TPWD Annotated List of Rare Species for Hood County, though it appears that components of the project would occur within Hood County. Additionally, the ER only addressed state-listed threatened or endangered species, but did not address all species included on the Annotated County List of Rare Species. Those species on the list with a blank under federal or state status are tracked by TPWD and considered rare. Rare species are of conservation concern by TPWD within Texas, and efforts to minimize impact to such species are encouraged to help prevent future listing of the species.

The most up-to-date TPWD Annotated County Lists of Rare Species are available at http://gis.tpwd.state.tx.us/TpwEndangeredSpecies/DesktopDefault.aspx. The lists provide information regarding rare species that have potential to occur within each county. Rare species could potentially be impacted if suitable habitat is present at or near the project site.

> **Comment**: The EIS should address all species on the Hood and Somervell County Lists including rare, threatened, and endangered species. The project site should be assessed to determine if suitable habitat for any of these species occurs within or near the proposed area and to determine if construction and operation of the project would impact the species or habitats.

Section 2.4.2.2 of the ER provides basic details about the fish studies conducted for Squaw Creek Reservoir and Lake Granbury. Fish avoidance of gill nets is a known problem in reservoirs with high water clarity, such as Squaw Creek Reservoir and near the dam on Lake Granbury.

> **Comment:** Further information is needed about the monofilament nets used to sample the fish population, the depth at which gill nets were placed, and the gill net mesh size used. Mesh sizes too large to capture smaller fish would produce inaccurate results. Electrofishing, even with high total dissolved solids, would likely provide important additional information on fish populations in both reservoirs. Seining in littoral areas could provide information about smaller species that are unlikely to be captured by gill nets.

Section – 2.3.3.1.9 Golden Algae – see comments under Chapter 5

Chapter 3 - Plant Description

The ER does not provide details of the site plan for the blowdown treatment facility (BDTF) other than large blocks showing the proposed location. The February 2, 2009 site visit indicated that several ponds of unknown size, shape or location would be constructed within this area. Power transmission lines were observed in the area.

> **Comment:** The size, shape, and location of the BDTF ponds relative to the transmission lines need to be revealed in a site plan drawing.

Chapter 4 - Construction Impacts

Aquatic Impacts

During the February 2, 2009 site visit, and in Section 4.3.2.4 of the ER, it was mentioned that fish populations are struggling in Lake Granbury. The consultant's sampling at four sites near the dam claims to support this opinion. The TPWD Inland Fisheries staff conducts full fishery studies on the lake every four years as well as ongoing fish sampling. These studies show that only a few fish species have declined post-golden algae kills, many have remained at the same population levels, and some have increased in numbers (Baird and Tibbs 2006). The opinion that the fishery is "dead" by the dam due to golden algae is not supported by the information provided.

> **Request:** TPWD requests a copy of the fish studies conducted by Luminant's consultant, specifically the studies referenced in Chapter 2.4 of the ER, Bio-West 2008a and 2008b. TPWD staff may have additional comments following review of the consultant's report.

Vegetation Impacts

Wooded riparian corridors along streams generally provide nesting habitat for birds, soil stabilization for enhanced water quality, and food, cover, and travel corridors for wildlife. Riparian habitat is a high priority habitat type for conservation by TPWD across the state.

> **Comment:** The project should be designed and constructed to avoid disturbance to stream and riparian areas.

The proposed project is situated in the Cross Timbers and Prairies Ecoregion of Texas which has generally supported native grassland valley communities with higher wooded divides. Native grassland communities have become increasingly rare in Texas due to historical conversion to row crop agriculture, overgrazing,

invasion by woody species from a lack of fire on the landscape, conversion to non-native pastures and hayland, and other development associated with humans. Native grasslands are an important resource for wildlife adapted to grassland environments. Population declines of many grassland birds are attributed to this loss of habitat.

> **Comment:** The location of facilities should be sited to avoid native grassland communities and placed in areas of previous disturbance or in areas previously converted to non-native pasture.

Because native vegetation is adapted to the soil and climate of the area, it usually requires less maintenance and watering than introduced species. Water conservation is warranted for the relatively dry climate of the project area. The disease tolerance of native vegetation provides longevity to the landscape without high cost. Mature trees and shrubs provide nesting, loafing, and forage habitat for birds and other wildlife.

> **Comment:** The project site should be carefully planned and constructed to avoid and preserve existing native vegetation. To eliminate or reduce the need for permanent irrigation, native trees, shrubs, grasses, and forbs should be incorporated into the landscape plan. The following websites describe appropriate native vegetation for the project area, http://www.tpwd.state.tx.us/huntwild/wild/wildscapes/ and http://tpid.tpwd.state.tx.us/.

> **Comment:** The revegetation and maintenance plan for temporary disturbed areas should focus on re-establishing native cover through natural regeneration and/or planting and should be developed in coordination with TPWD. Plans for natural regeneration and/or revegetation of disturbed areas should include measures to treat and control undesirable and/or invasive species and should include management practices to benefit wildlife.

The ER did not address the potential for the project site to contain rare plant species or sensitive plant communities that are tracked by TPWD and/or included on our annotated county lists of rare species; therefore impacts to those species or communities were not addressed.

> **Comment:** Sites should be surveyed to identify potential impacts to rare plant species and natural communities identified by TPWD.

Protecting vegetated buffers is discussed in Section 4.3.1.1, though no vegetated buffer areas are specifically identified in the ER.

Comment: The vegetated buffer areas that would receive protection need to be identified and mapped.

Figure 4.2-1 indicates that the area immediately adjacent to the wetland identified along SCR on the cooling tower peninsula is slated as a construction area. During the February 2, 2009 site visit, Luminant noted that a buffer area would be placed around the wetland. It is unclear the amount of wooded area on the slopes of the draw that would be excluded from construction activities to serve as the buffer area to the wetland.

Comment: A buffer area developed in coordination with TPWD should be established along the slopes to protect water quality, provide wildlife habitat, and shelter the wetland located down slope at this location.

Section 4.3.1 of the ER indicates that the disturbed area is equivalent to 275 acres and 384 acres, for the CPNPP and the BDTF, respectively. The ER does not distinguish between permanent and temporary disturbance areas per the CPNPP site and the BDTF. The 275-acre CPNPP site is the only area showing impacts by cover type, but the amount of each cover type lost to permanent construction is not provided. No impact assessment per cover type is provided for the 384-acre BDTF, the pipelines, the power transmission lines, or the intake and return structure areas.

Comment: The permanent and temporary disturbances should be revealed per cover type (grassland, scrub brush, disturbed, juniper woodland, wetland, hardwood forest, etc.) per facility (CPNPP, BDTF, power transmission lines, pipelines, and intake and return structure areas). Total temporary and permanent impacts per cover type should be provided for the proposed project, inclusive of the CPNPP, the BDTF, the pipelines, the transmission lines, and the intake and discharge structure areas. This type data can easily be presented in table form.

Wildlife Impacts

Comment: Construction crews should be informed of the rare species in the project counties and should avoid disturbance to sensitive species if encountered during construction. Only personnel with a TPWD scientific collection permit are allowed to handle and move state listed species. For further information on the required permit please contact Chris Maldonado at (512) 389-4647.

The ER did not address the potential for the project site to contain rare species that are tracked by TPWD and included on our annotated county lists of rare

species; therefore impacts to those species were not addressed. The ER does not include a detailed evaluation of impacts associated with the BDTF construction.

> **Comment**: Site surveys of the CPNPP and BDTF sites for rare species with potential to occur within the area should be conducted prior to construction. Occurrences should be avoided or a mitigation plan developed in coordination with TPWD.

Chapter 5 - Operation Impacts

Section 5.2 discusses water-related impacts associated with water withdrawal from Lake Granbury, water loss, and return discharge to Lake Granbury. The ER claims that there is currently minimal use of water in the Brazos River from Possum Kingdom Lake to Lake Whitney; and due to the minimal water use and other users returning water to the Brazos River Basin, the project impacts are not expected to affect the available water for other water users nor for the aquatic ecological communities of the Brazos River. The ER considers the impacts from the CPNPP water withdrawal and discharge rates as small. The ER presents the reported mean monthly discharges at DeCordova Bend Dam at 1,031 cubic feet per second (cfs) and indicates that anticipated normal discharge would be 55.43 cfs during operation of CPNPP Units 3 and 4.

The operational impacts associated with water use do not specifically address potential impacts to aquatic resources such as potential impacts to the state-threatened Brazos Water Snake (*Nerodia harteri*), various rare species of mollusks listed on the county lists, and other aquatic resources occurring or potentially occurring downstream of Lake Granbury.

> **Comment:** Potential impacts associated with CPNPP water losses need to be specifically addressed for aquatic resources within the Brazos River Basin.

Chapter 2 Section – 2.3.3.1.9 and Chapter 5 Sections – 5.2.1.7 and 5.2.3.4

Golden algae, specifically *Prymnesium parvum*, are microscopic plants present in Possum Kingdom Reservoir, Lake Granbury, and Lake Whitney, as well as other areas in the state. The alga prefers saltier water for growth as it is a marine species. Lower water levels in Possum Kingdom Reservoir would likely make the lake more susceptible to golden alga. Like most other reservoirs, when the water level in Possum Kingdom Reservoir is low, conditions become more saline and nutrients become more concentrated. Historically, both conditions have been associated with increased occurrence and severity of golden algal blooms in Possum Kingdom Reservoir and other Texas reservoirs. An increase in salinity (conductivity) within Lake Granbury would likely also cause enhanced golden

algal blooms. With the return water entering by the dam, the potential for increased conductivity by the dam and immediately downstream is a concern as well.

> **Comment:** If golden alga occurrences increase in severity after periods of water loss, then Luminant may be required through TPWD's civil restitution process to mitigate for fish mortalities from these golden alga kills and may be asked to contribute to annual restocking efforts or golden alga treatment and research.

Section 5.2.1.2

The typical golden algal bloom within a Brazos River Basin reservoir starts in the shallow areas where the river enters the reservoir. These shallow areas cool faster than the deeper parts of the lake found at the dams, allowing for temperatures to drop to levels where golden algal blooms are found. The sediments in these shallow areas are easily resuspended into the water column, supporting the golden alga cysts within these sediments to hatch. The increased releases from Possum Kingdom Reservoir to provide makeup water in Lake Granbury may increase resuspension rates and lead to increased golden algal blooms. In the typical progression, the area of the reservoir closest to the dam is affected by golden alga once flow or current has moved the algal bloom downstream. The new intake for the proposed units will increase circulation within Lake Granbury and has the potential to spread the golden algal blooms throughout the lake at a faster rate. Although the relationship between golden algal blooms and toxicity, which kills the fish, is not yet well understood, it is likely that increased golden algal blooms could lead to larger, lake-wide fish kills once the golden algae become toxic.

TPWD has concerns about increased selenium levels in Lake Granbury and downstream portions of the Brazos River resulting from the discharge. As stated in Section 5.2.3.4, "When half the detection limit was used to estimate concentrations that would result from CPNPP Units 3 and 4 2.4-cycle cooling tower operation, selenium was estimated to exceed the Texas Commission on Environmental Quality (TCEQ) Criteria for Specific Metals in Water for Protection of Aquatic Life and also for both the mean and maximum concentrations when mixed with Lake Granbury at low flow. However, selenium is expected to be reduced to concentrations less than the TCEQ standards for Specific Metals in Water for Protection of Aquatic Life at the edge of the mixing zone in Lake Granbury during the annual mean flow for both mean and maximum concentrations." The acute freshwater criteria for selenium is 0.020 mg/L and freshwater chronic criteria is 0.005 mg/L (TCEQ 2008). Exceeding the set criteria can be harmful to aquatic life within and downstream of the reservoir.

Section 5.2.2.3.1

The consumptive demands from the project are a concern for the Brazos River Basin. Chapter 3 Section 4 indicates that Luminant will use up to 103,000 acre-feet per year (ac-ft/yr) of water from Lake Granbury for the cooling process with an estimated evaporative loss of 61,000 ac-ft/yr. The loss of 61,000 ac-ft/yr from Possum Kingdom Reservoir, Lake Granbury and the Brazos River will lead to declines in lake levels, a reduction of streamflow downstream of Lake Granbury, and a resultant wide range of impacts on fish and wildlife resources and recreation.

Potential recreational effects span from Possum Kingdom Reservoir, to below the Lake Granbury dam, to the Brazos River below the city of Waco. Possum Kingdom Reservoir receives heavy recreational use, Lake Granbury supports recreational use, water skiers frequently use the Brazos River between Lake Granbury and Lake Whitney, and Lake Whitney has been rated the top destination by the citizens in the Dallas/Fort Worth area. Downstream of Lake Whitney, the Brazos River has been recognized as a canoeing and kayaking destination and Lake Brazos within the city of Waco is currently being developed into a major greenbelt.

Fisheries may be impacted; reduced flows in the Brazos River below Waco may impact several imperiled fish species, as well as a vulnerable alligator gar fishery. Water levels are also anticipated to drop in Possum Kingdom Reservoir since the water for Units 3 and 4 will be taken from Lake Granbury but supplied by releases from Possum Kingdom Reservoir. Currently, Possum Kingdom Reservoir struggles with having enough water to inundate littoral vegetation during spawning times for a variety of sport fish. The proposed water loss would exacerbate an already less than desirable condition. In addition, lowering the water level in Possum Kingdom Reservoir will expose fish habitat used for sheltering and feeding, as well as for breeding. This loss of habitat, especially during spawning season, is likely to impact fish populations.

It is not apparent that Chapter 5 of the ER addresses impacts to wildlife associated with operation of the BDTF. The proposed site for the BDTF would include a large area of ponds that may be placed near and/or under existing power transmission lines. The BDTF area is also in close proximity to a large reservoir. Therefore, there is increased potential for use of the area near the transmission lines by migratory and resident waterfowl and shorebirds once the BDTF ponds are installed. The attractiveness of the BDTF ponds to birds would increase the potential for bird collision with the transmission lines.

> **Comment:** Potential collision impacts to migratory and resident birds as a result of constructing large ponds near and/or under transmission lines

should be addressed. Measures to avoid or mitigate potential impacts should be developed in coordination with TPWD, such as transmission line marking, relocation of the proposed BDTF ponds, and pre- and post-construction monitoring.

Comment: Any potential dangers to wildlife as a result of exposure to the BDTF ponds should also be made apparent. Significant impacts should be mitigated.

Comment: TPWD is concerned that high salinity reject water (brine) from any desalination process be disposed of in a manner that does not impact fish and wildlife resources. TPWD may offer additional comment when Luminant provides greater detail of proposed operations of the BDTF.

Because the CPNPP boundary encompasses approximately 7,950 acres inclusive of Squaw Creek Reservoir and large areas of undeveloped property, there is opportunity for Luminant to develop a working plan for conservation, protection, and management of fish and wildlife resources within the CPNPP boundary.

Comment: An adaptive wildlife management plan should be developed in coordination with TPWD. Suggestions for activities to address in the management plan include, but are not limited to:

- Opening Squaw Creek Reservoir or portions of the reservoir for public fishing
- Creating and maintaining native grassland communities within transmission line ROWs and areas of non-native grasslands
- Creating and protecting riparian corridor habitat
- Developing a grazing management plan for areas leased to livestock
- Developing livestock exclusion areas or rotation plans near ponds to help improve water quality and increase wildlife diversity
- Conducting deer management in areas that are overpopulated
- Monitoring and treatment of invasive or undesirable species

Rare Resource Occurrences

To support preparation of the EIS, the NRC has requested information regarding state-listed, proposed, and candidate species and protected habitat that may be in the vicinity of the proposed site, the alternative sites, and the transmission line ROWs.

The ER indicates that three alternative sites and a preferred site were considered for the proposed nuclear power plants. The applicant has not revealed the alternative site locations because they hold the locations as proprietary information. The three alternative sites have been described as occurring A) near the border of Victoria and Calhoun counties, B) near the border of San Augustine and Sabine counties, and C) near the border of McLennan and Limestone counties. Therefore, TPWD must present the data regarding known occurrences of rare resources based on countywide sets of data for two counties per site. TPWD has included a 10-mile radius buffer beyond the two counties because including a buffer to a project site is typical practice for Texas Natural Diversity Database (TXNDD) searches. This buffer also encompasses area that may be in a different county, but still within 10 miles of the border of the two given counties. To eliminate bias in the evaluation of site alternatives by the NRC, TPWD is submitting data for the proposed site in the same manner encompassing Hood and Somervell counties and a 10-mile radius buffer area.

If the actual locations of the alternative sites are provided to TPWD, then we will provide a less intensive list of TXNDD occurrences to the NRC by site location rather than countywide.

TPWD is also submitting a set of data specific to the proposed site location including occurrences within a 10-mile buffer area. This data should be considered when assessing the potential impacts to rare resources if the alternatives analysis of the EIS indicates that the proposed site is adequate as the preferred site. Thus, an appropriate evaluation of impacts to rare resources specific to the preferred site can be conducted.

The ER identifies two new proposed 345-kV transmission line routes requiring new ROW, one extending 45 miles to a substation near Lake Whitney in Bosque County and one extending 17 miles to a switching station near Lake Granbury. There are also two new proposed circuits that will be added to vacant positions on two separate existing 345-kV double lattice steel tower structures, one extending 44.8 miles to a switching station in Tarrant County and one extending 41.6 miles to a switching station in Parker County. TPWD understands that the proposed transmission line ROW routes are preliminary and not final. Therefore, the information provided regarding resources within the vicinity of the two new proposed 345-kV transmission line ROWs will need to be updated and an assessment of potential impacts to rare resources will need to be reevaluated once specific routes are identified.

Determining the actual presence of a species in a given area depends on many variables including daily and seasonal activity cycles, environmental activity cues, preferred habitat, transiency and population density (both wildlife and human). The absence of a species can be demonstrated only with great difficulty

and then only with repeated negative observations, taking into account all the variable factors contributing to the lack of detectable presence.

The TXNDD is intended to assist users in avoiding harm to rare species or significant ecological features. Given the small proportion of public versus private land in Texas, the TXNDD does not include a representative inventory of rare resources in the state. Absence of information in the database does not imply that a species is absent from that area. Although it is based on the best data available to TPWD regarding rare species, the data from the TXNDD do not provide a definitive statement as to the presences, absence or condition of special species, natural communities, or other significant features within your project area. These data are not inclusive and **cannot be used as presence/absence data**. They represent species that could potentially be in your project area. This information cannot be substituted for on-the-ground surveys. The TXNDD is updated continuously based on new, updated and undigitized records. For questions regarding a record, please contact txndd@tpwd.state.tx.us.

Please refer to the attachment regarding TXNDD search results for the countywide alternatives analysis, for the proposed site, and for the preliminary transmission line ROWs.

Comment: If rare plant or animal species or natural communities are identified within the project vicinity, then site surveys for those species or communities should be conducted within the project area to assess potential impacts. An example includes verifying the species of yucca found on the project site because occurrences of Glen Rose Yucca (*Yucca necopina*), a state rare species, occurs within the vicinity of the project area.

Comment: Additionally, potential impacts to specific occurrences of species or natural communities within or near the project area should be assessed. An example includes the project's potential to impact the state-threatened Brazos Water Snake, which occurs within the Brazos River below Lake Granbury Dam.

Comment: If rare resources would be impacted by the proposed project, TPWD should be contacted to determine avoidance, minimization, and mitigation strategies. Further consultation with TPWD would be warranted upon detection of a Texas-listed rare, threatened, or endangered species or tracked vegetative community within or near the ROW at any time prior to or during construction and operation of the facilities.

TPWD appreciates the opportunity to comment on this important project and participate in the scoping process. Please direct any questions to Kathy Boydston of the Wildlife Division Wildlife Habitat Assessment Program at (512) 389-4638.

Sincerely,

Carter Smith
Executive Director

CS:KB:KH:gg

Attachments

References:

Baird, M. S., and J. Tibbs. 2006. 2005 Survey Report Granbury Reservoir. Texas Parks and Wildlife Department, Austin, TX.

Texas Commission on Environmental Quality. 2008. 2008 Guidance for Assessing and Reporting Surface Water Quality in Texas, March 2008. Texas Commission on Environmental Quality, Austin, TX.

Element Occurrence Record

Scientific Name: *Juniperus ashei-quercus spp. series* **Occurrence #:** 21 **Eo Id:** 4067

Common Name: Ashe Juniper-oak Series **TX Protection Status:** **ID Confirmed:** Y

Global Rank: G4 **State Rank:** S4 **Federal Status:**

Location Information:

Watershed Code:	Watershed Description:
12060202	Middle Brazos-Lake Whitney

County Code:	County Name:	Mapsheet Code:	Mapsheet Name:	State:
TXSOME	Somervell	32097-C7	Hill City	TX
		32097-B7	Glen Rose West	TX

Directions:

STEEP SLOPES AND ROLLING UPLANDS BETWEEN DENIO BRANCH AND BUCKEYE CREEK, DINOSAUR VALLEY SP

Survey Information:

First Observation: **Survey Date:** 1990-07-02 **Last Observation:** 1990

Eo Type: **EO Rank:** BC - Good or fair estimated viability **EO Rank Date:** 1990-07-02

Observed Area (acres): **Estimated Representation Accuracy:**

Comments:

General Description: EVERGREEN/DECIDUOUS SHRUBLAND ON GLEN ROSE LIMESTONE

Comments:

Protection Comments:

Management Comments:

Data:

EO Data: DESCRIPTION AND PLANT LIST IN DLI REPORT, SITE 2

Managed Area:

Managed Area Name:	Managed Area Type:
DINOSAUR VALLEY STATE PARK	SPWPK

Reference:

Full Citation:

TEXAS PARKS & WILDLIFE DEPARTMENT. 1990. DINOSAUR VALLEY STATE PARK. SUMMARY OF REPRESENTATIVE PLANT COMMUNITIES.

Element Occurrence Record

Specimen:

Associated Species:

Species Name	Type	Comments

Element Occurrence Record

Scientific Name: *Vireo atricapilla* **Occurrence #:** 146 **Eo Id:** 660

Common Name: Black-capped Vireo **TX Protection Status:** E **ID Confirmed:** Y

Global Rank: G2G3 **State Rank:** S2B **Federal Status:** LE

Location Information:

Watershed Code:	Watershed Description:
12060202	Middle Brazos-Lake Whitney

County Code:	County Name:	Mapsheet Code:	Mapsheet Name:	State:
TXSOME	Somervell	32097-C7	Hill City	TX

Directions:

FROM HEAD OF WILDCAT HOLLOW TO PALUXY RIVER INCLUDING UNNAMED EAST DRAINAGE ENTERING WILDCAT HOLLOW; SLOPES ON BOTH SIDES OF WILDCAT HOLLOW AND INCLUDING HILLTOP BETWEEN FORKS OF DRAINAGES TO EAST-FACING SLOPES OF DRAINAGE INTO DENIO BRANCH AND PARK BOUNDARY ON NORTHEAST; DINOSAUR VALLEY SP

Survey Information:

First Observation: **Survey Date:** 1991 **Last Observation:** 1991

Eo Type: **EO Rank:** **EO Rank Date:**

Observed Area (acres): **Estimated Representation Accuracy:**

Comments:

General Description:

Comments:

Protection Comments:

Management Comments:

Data:

EO Data: 3 MALES OBSERVED

Managed Area:

Managed Area Name:	Managed Area Type:
DINOSAUR VALLEY STATE PARK	SPWPK

Reference:

Element Occurrence Record

Full Citation:

SCOTT, P. 1991. SURVEYS FOR BLACK-CAPPED VIREOS AND GOLDEN-CHEEKED WARBLERS IN CENTRAL TEXAS STATE PARKS AND NATURAL AREAS, MAY-JUNE 1991.

Specimen:

Associated Species:

Species Name	Type	Comments

Element Occurrence Record

Scientific Name: *Yucca necopina* **Occurrence #:** 3 **Eo Id:** 813

Common Name: Glen Rose yucca **TX Protection Status:** **ID Confirmed:** Y

Global Rank: G1G2 **State Rank:** S1S2 **Federal Status:**

Location Information:

Watershed Code:	Watershed Description:
12060201	Middle Brazos-Palo Pinto

County Code:	County Name:	Mapsheet Code:	Mapsheet Name:	State:
TXHOOD	Hood	32097-C6	Nemo	TX

Directions:

ON FM 3210/2425 IN VICINITY OF CORDOVA DAM, GRANBURY LAKE

Survey Information:

First Observation: 1992-08-02 **Survey Date:** **Last Observation:** 1992-08-02

Eo Type: **EO Rank:** **EO Rank Date:**

Observed Area (acres): **Estimated Representation Accuracy:**

Comments:

General Description: ON THIN SOILS ABOVE LIMESTONE OUTCROP [NOTE: QUATERNARY TERRACE DEPOSITS ARE MAPPED SOUTHEAST OF DAM]

Comments: COUNTY GIVEN BY K. CLARY AS SOMERVELL COUNTY, LOCATION IS IN HOOD COUNTY

Protection Comments:

Management Comments:

Data:

EO Data: 1992-08-02, INFREQUENT, PLANTS WITH PANICULATE SCAPE, COLLECTED CAPSULES WITH SEEDS

Managed Area:

Managed Area Name: **Managed Area Type:**

Reference:

Full Citation:

Element Occurrence Record

Specimen:

UNIVERSITY OF TEXAS AT AUSTIN HERBARIUM. 1992. K.H. CLARY #320, SPECIMEN # ? TEX. 2 AUGUST 1992.

Associated Species:

Species Name	Type	Comments

Element Occurrence Record

Scientific Name: *Ulmus crassifolia-celtis laevigata series* **Occurrence #:** 30 **Eo Id:** 896

Common Name: Cedar Elm-sugarberry Series **TX Protection Status:** **ID Confirmed:** Y

Global Rank: G4 **State Rank:** S4 **Federal Status:**

Location Information:

Watershed Code:	Watershed Description:
12060202	Middle Brazos-Lake Whitney

County Code:	County Name:	Mapsheet Code:	Mapsheet Name:	State:
TXSOME	Somervell	32097-B7	Glen Rose West	TX
		32097-C7	Hill City	TX

Directions:

SOUTH BANK OF PALUXY RIVER, DINOSAUR VALLEY SP

Survey Information:

First Observation: **Survey Date:** 1990-04-24 **Last Observation:** 1990

Eo Type: **EO Rank:** C - Fair estimated viability **EO Rank Date:** 1990-04-24

Observed Area (acres); **Estimated Representation Accuracy:**

Comments:

General Description: SOME TALL TREES, SOME YOUNGER SECOND GROWTH, ABSENT FROM SOME STEEP SLOPES

Comments:

Protection Comments:

Management Comments:

Data:

EO Data: DESCRIPTION AND PLANT LIST IN DLI REPORT, SITE 1

Managed Area:

Managed Area Name:	Managed Area Type:
DINOSAUR VALLEY STATE PARK	SPWPK

Reference:

Full Citation:

TEXAS PARKS & WILDLIFE DEPARTMENT. 1990. DINOSAUR VALLEY STATE PARK. SUMMARY OF REPRESENTATIVE PLANT COMMUNITIES.

Element Occurrence Record

Specimen:

Associated Species:

Species Name	Type	Comments

Element Occurrence Record

Scientific Name: *Dendroica chrysoparia* **Occurrence #:** 229 **Eo Id:** 1190

Common Name: Golden-cheeked Warbler **TX Protection Status:** E **ID Confirmed:** Y

Global Rank: G2 **State Rank:** S2B **Federal Status:** LE

Location Information:

Watershed Code:	Watershed Description:
12060202	Middle Brazos-Lake Whitney

County Code:	County Name:	Mapsheet Code:	Mapsheet Name:	State:
TXBOSQ	Bosque	31097-H4	Allen Bend	TX

Directions:

WEST OF LAKE WHITNEY/BRAZOS RIVER, SOUTH SIDE OF CEDRON CREEK AND WEST OF FM 56

Survey Information:

First Observation: 1996-04-13 **Survey Date:** **Last Observation:** 1996-05-03

Eo Type: **EO Rank:** **EO Rank Date:**

Observed Area (acres): **Estimated Representation Accuracy:**

Comments:

General Description: MATURE JUNIPER/OAK WOODLAND CA. 30 FEET IN HEIGHT WITH OVER 70% CANOPY COVER

Comments:

Protection Comments:

Management Comments:

Data:

EO Data: 3 TERRITORIES

Managed Area:

Managed Area Name: **Managed Area Type:**

Reference:

Full Citation:

DLS ASSOCIATES. 1996. ENDANGERED SPECIES INVESTIGATION MID-BRAZOS PROJECT - LAKE WHITNEY, HILL AND BOSQUE COUNTIES, TEXAS. JULY 1996.

Element Occurrence Record

Specimen:

Associated Species:

Species Name	Type	Comments

Element Occurrence Record

Scientific Name: *Vireo atricapilla* **Occurrence #:** 135 **Eo Id:** 1348

Common Name: Black-capped Vireo **TX Protection Status:** E **ID Confirmed:** Y

Global Rank: G2G3 **State Rank:** S2B **Federal Status:** LE

Location Information:

Watershed Code:	Watershed Description:
12060202	Middle Brazos-Lake Whitney

County Code:	County Name:	Mapsheet Code:	Mapsheet Name:	State:
TXSOME	Somervell	32097-C7	Hill City	TX

Directions:

WEST OF WILDCAT HOLLOW, NORTH OF PALUXY RIVER; CA. 2.6 AIR MILES SOUTH OF STATE ROUTE 201 INTERSECTION WITH HOOD-SOMERVELL COUNTYLINE; HILLTOP AND EAST-FACING SLOPES DOWN TO WILDCAT HOLLOW; DINOSAUR VALLEY SP

Survey Information:

First Observation: **Survey Date:** 1993 **Last Observation:** 1993

Eo Type: **EO Rank:** **EO Rank Date:**

Observed Area (acres): **Estimated Representation Accuracy:**

Comments:

General Description: VERY SMALL PATCH OF OAK SHINNERY SURROUNDING THE 850 TO 800 CONTOURS OF KNOB TO THE WEST OF WILDCAT HOLLOW; BIRDS USING JUNIPER ALSO

Comments:

Protection Comments:

Management Comments:

Data:

EO Data: 2 MALES - VISUAL CONTACT

Managed Area:

Managed Area Name:	Managed Area Type:
DINOSAUR VALLEY STATE PARK	SPWPK

Reference:

Element Occurrence Record

Full Citation:

CONNALLY, W.A.S. 1993. SURVEY OF PUBLIC LANDS - TEXAS PARKS AND WILDLIFE DEPARTMENT - FOR BLACK-CAPPED VIREO AND GOLDEN-CHEEKED WARBLER. INVESTIGATIONS FROM 17 APRIL TO 1 JULY 1993.

Specimen:

Associated Species:

Species Name	Type	Comments

Element Occurrence Record

Scientific Name: *Nerodia harteri* **Occurrence #:** 1 **Eo Id:** 2098

Common Name: Brazos Water Snake **TX Protection Status:** T **ID Confirmed:** Y

Global Rank: G2 **State Rank:** S2 **Federal Status:**

Location Information:

Watershed Code:	Watershed Description:
12060202	Middle Brazos-Lake Whitney
12060201	Middle Brazos-Palo Pinto

County Code:	County Name:	Mapsheet Code:	Mapsheet Name:	State:
TXSOME	Somervell	32097-C6	Nemo	TX
TXJOHN	Johnson	32097-B6	Glen Rose East	TX
TXHOOD	Hood	32097-D6	Acton	TX
		32097-C5	Bono	TX

Directions:

BRAZOS RIVER DOWNSTREAM FROM LAKE GRANBURY TO A FEW KM BELOW GLEN ROSE, PATCHY DISTRIBUTION ALONG RIVER.

Survey Information:

First Observation: 1984 **Survey Date:** 1985-05,06 **Last Observation:** 1984

Eo Type: **EO Rank:** B - Good estimated viability **EO Rank Date:**

Observed Area (acres): **Estimated Representation Accuracy:**

Comments:

General Description: MEDIUM SIZE RIVER, LIMESTONE BEDROCK; RIFFLES WITH SMALL TO LARGE ROCKS AND BOULDERS. SWIFT CLEAR WATER.

Comments: RECENTLY CONFIRMED ON RIVER AND FOUND TO BE IN FAIR NUMBERS.

Protection Comments: SUPPORT FEDERAL LISTING AS THREATENED.

Management Comments: PRESERVE RIFFLE HABITAT STRETCH OF RIVER.

Data:

EO Data: A LOCALLY COMMON WATERSNAKE FOUND IN MAIN RIVER BED, USUALLY ASSOCIATED WITH RIFFLES AND BOULDER STREWN BANKS.

Managed Area:

Managed Area Name: **Managed Area Type:**

Element Occurrence Record

Reference:

Full Citation:

MAXWELL, T.C. 1982. STATUS AND DISTRIBUTION OF NERODIA HARTERI HARTERI, FINAL REPORT. USF& WS, ALBQ., NM. 40 PP.

SCOTT, DR. NORMAN J. 1984. USF& W SERVICE, REGION 2, ALBUQUERQUE, NEW MEXICO. PH-505/766-3903.

U84SCO01TXUS - Created by EO conversion

SCOTT, NORM. 1985. USF& W SERVICE REGION 2 ALBUQUERQUE, N.M. PH-505/766-3903. JANUARY 1985.

Specimen:

Associated Species:

Species Name	Type	Comments

Element Occurrence Record

Scientific Name: *Dendroica chrysoparia* **Occurrence #:** 64 **Eo Id:** 2696

Common Name: Golden-cheeked Warbler **TX Protection Status:** E **ID Confirmed:** Y

Global Rank: G2 **State Rank:** S2B **Federal Status:** LE

Location Information:

Watershed Code:	Watershed Description:
12060202	Middle Brazos-Lake Whitney

County Code:	County Name:	Mapsheet Code:	Mapsheet Name:	State:
TXSOME	Somervell	32097-C7	Hill City	TX

Directions:

FROM CA. 0.3 RIVER MILE UP DENIO BRANCH FROM CONFLUENCE WITH PALUXY RIVER TO PARK BOUNDARY; SLOPES OF BOTH SIDES OF DRAINAGE TO HILLTOPS ON SOUTH AND EAST EXTENDING TO PARK BOUNDARY; DINOSAUR VALLEY SP

Survey Information:

First Observation: **Survey Date:** 1993 **Last Observation:** 2000

Eo Type: **EO Rank:** **EO Rank Date:**

Observed Area (acres): **Estimated Representation Accuracy:**

Comments:

General Description:

Comments:

Protection Comments:

Management Comments:

Data:

EO Data: ONE GOLDEN-CHEEKED WARBLER; IN 1991, THIS ENSCRIBED AREA HAD 3 SINGLE MALES AND ONE PAIR; BLACK-CAPPED VIREOS ALSO FOUND HERE; IN 2000, NUMEROUS GOLDEN-CHEEKED WARBLERS HEARD DURING BRIEF BLACK-CAPPED VIREO SURVEY

Managed Area:

Managed Area Name:	Managed Area Type:
DINOSAUR VALLEY STATE PARK	SPWPK

Reference:

Element Occurrence Record

Full Citation:

CONNALLY, W.A.S. 1993. SURVEY OF PUBLIC LANDS - TEXAS PARKS AND WILDLIFE DEPARTMENT - FOR BLACK-CAPPED VIREO AND GOLDEN-CHEEKED WARBLER. INVESTIGATIONS FROM 17 APRIL TO 1 JULY 1993.

SCOTT, P. 1991. SURVEYS FOR BLACK-CAPPED VIREOS AND GOLDEN-CHEEKED WARBLERS IN CENTRAL TEXAS STATE PARKS AND NATURAL AREAS, MAY-JUNE 1991.

HORIZON ENVIRONMENTAL SERVICES, INC. 1999. LETTER TO USFWS RE: ENDANGERED SPECIES PERMIT PRT-798998 FOR 1999 YEAR DATA. 7 FEBRUARY 2000.

MARESH, JOHN. 2000. BLACK-CAPPED VIREO CENSUS AND MONITORING PROJECT FIELD NOTES.

Specimen:

Associated Species:

Species Name	Type	Comments

Element Occurrence Record

Scientific Name: *Dendroica chrysoparia* **Occurrence #:** 66 **Eo Id:** 130

Common Name: Golden-cheeked Warbler **TX Protection Status:** E **ID Confirmed:** Y

Global Rank: G2 **State Rank:** S2B **Federal Status:** LE

Location Information:

Watershed Code:	Watershed Description:
12060202	Middle Brazos-Lake Whitney

County Code:	County Name:	Mapsheet Code:	Mapsheet Name:	State:
TXSOME	Somervell	32097-B7	Glen Rose West	TX
		32097-C7	Hill City	TX

Directions:

ON EAST SIDE OF PALUXY RIVER; MAJORITY OF SLOPES, HILLTOPS, AND DRAINAGES IN EASTERN PORTION OF PARK EAST OF DENIO BRANCH WATERSHED; DINOSAUR VALLEY SP

Survey Information:

First Observation: **Survey Date:** 1993 **Last Observation:** 1999

Eo Type: **EO Rank:** **EO Rank Date:**

Observed Area (acres): **Estimated Representation Accuracy:**

Comments:

General Description: SOME JUNIPER APPEARED OVER ONE FOOT IN DIAMETER; BLACK-CAPPED VIREO PRESENT ALSO

Comments:

Protection Comments:

Management Comments:

Data:

EO Data: AT LEAST 4 TERRITORIES; ONE FEMALE OBSERVED; IN 1991, SCOTT OBSERVED 6 MALES PLUS ONE WITH 2 JUVENILE GOLDEN-CHEEKED WARBERS

Managed Area:

Managed Area Name:	Managed Area Type:
DINOSAUR VALLEY STATE PARK	SPWPK

Reference:

Element Occurrence Record

Full Citation:

CONNALLY, W.A.S. 1993. SURVEY OF PUBLIC LANDS - TEXAS PARKS AND WILDLIFE DEPARTMENT - FOR BLACK-CAPPED VIREO AND GOLDEN-CHEEKED WARBLER. INVESTIGATIONS FROM 17 APRIL TO 1 JULY 1993.

SCOTT, P. 1991. SURVEYS FOR BLACK-CAPPED VIREOS AND GOLDEN-CHEEKED WARBLERS IN CENTRAL TEXAS STATE PARKS AND NATURAL AREAS, MAY-JUNE 1991.

HORIZON ENVIRONMENTAL SERVICES, INC. 1999. LETTER TO USFWS RE: ENDANGERED SPECIES PERMIT PRT-798998 FOR 1999 YEAR DATA. 7 FEBRUARY 2000.

Specimen:

Associated Species:

Species Name	Type	Comments

Element Occurrence Record

Scientific Name: *Yucca necopina* **Occurrence #:** 1 **Eo Id:** 2871

Common Name: Glen Rose yucca **TX Protection Status:** **ID Confirmed:** Y

Global Rank: G1G2 **State Rank:** S1S2 **Federal Status:**

Location Information:

Watershed Code:	Watershed Description:
12060202	Middle Brazos-Lake Whitney
12060201	Middle Brazos-Palo Pinto

County Code:	County Name:	Mapsheet Code:	Mapsheet Name:	State:
TXSOME	Somervell	32097-C6	Nemo	TX
		32097-B6	Glen Rose East	TX

Directions:

THREE MILES NORTHEAST OF GLEN ROSE ON OLD ROAD

Survey Information:

First Observation: 1955 **Survey Date:** **Last Observation:** 1955-05-06

Eo Type: **EO Rank:** **EO Rank Date:**

Observed Area (acres): **Estimated Representation Accuracy:**

Comments:

General Description: FENCEROW BY SANDY FIELD

Comments: TYPE LOCALITY; ONLY OCCURRENCE; MAY BE OF HYBRID ORIGIN

Protection Comments:

Management Comments:

Data:

EO Data: IN FLOWER; ABUNDANT

Managed Area:

Managed Area Name: **Managed Area Type:**

Reference:

Element Occurrence Record

Full Citation:

Specimen:

Southern Methodist University Herbarium. 1955. L.H. Shinners #20102, Specimen # none SMU. 6 May 1955. Type Locality.

Associated Species:

Species Name	Type	Comments

Element Occurrence Record

Scientific Name: *Yucca necopina* **Occurrence #:** 6 **Eo Id:** 8961

Common Name: Glen Rose yucca **TX Protection Status:** **ID Confirmed:** Y

Global Rank: G1G2 **State Rank:** S1S2 **Federal Status:**

Location Information:

Watershed Code:	Watershed Description:
12060201	Middle Brazos-Palo Pinto

County Code:	County Name:	Mapsheet Code:	Mapsheet Name:	State:
TXHOOD	Hood	32097-C6	Nemo	TX

Directions:

2.2 miles south of the intersection of F.M. 2425 (Hayworth Highway) and F.M. 3210. Located between River View Trail and County Road 313. On the east side of F.M. 2425.

Survey Information:

First Observation: 2008-07-02 **Survey Date:** 2008-07-02 **Last Observation:** 2008-07-02

Eo Type: **EO Rank:** E - Verified extant (viability not assessed) **EO Rank Date:** 2008-07-02

Observed Area (acres): 0 **Estimated Representation Accuracy:** High

Comments:

General Description: Plants were in a highway ROW that was 95 percent grass. The soil was clay with limestone rocks.

Comments: A specimen from this population was collected on 2 July, 2008, and will be submitted to the Plant Resources Center at the University of Texas, Austin.

Protection Comments:

Management Comments:

Data:

EO Data: 64 plants were observed. Plants were in a highway ROW that was 95 percent grass. The soil was clay with limestone rocks.

Managed Area:

Managed Area Name: **Managed Area Type:**

Reference:

Element Occurrence Record

Full Citation:

Sawey, Jamye and Alvin D Meyer, 2008. Texas Natural Diversity Database Reporting Form regarding a population of Yucca necopina along F.M. 2425 in Tarrant County.

Specimen:

Associated Species:

Species Name	Type	Comments

Element Occurrence Record

Scientific Name: *Vireo atricapilla* **Occurrence #:** 134 **Eo Id:** 4695

Common Name: Black-capped Vireo **TX Protection Status:** E **ID Confirmed:** Y

Global Rank: G2G3 **State Rank:** S2B **Federal Status:** LE

Location Information:

Watershed Code:	Watershed Description:
12060202	Middle Brazos-Lake Whitney

County Code:	County Name:	Mapsheet Code:	Mapsheet Name:	State:
TXSOME	Somervell	32097-C7	Hill City	TX

Directions:

CA. 2.7 AIR MILES SOUTH-SOUTHEAST OF STATE ROUTE 201 INTERSECTION WITH HOOD-SOMERVELL COUNTYLINE; CA. 0.8 AIR MILE NORTHEAST OF DENIO BRANCH/PALUXY RIVER CONFLUENCE; NORTH-FACING SLOPE JUST OUTSIDE DINOSAUR VALLEY STATE PARK BOUNDARY; ALSO OBSERVED IN DINOSAUR VALLEY STATE PARK; FROM CONFLUENCE OF DENIO BRANCH WITH PALUXY RIVER, GO CA. 0.3 RIVER MILE UP DENIO BRANCH TO JUST BEYOND PARK BOUNDARY; SLOPES ON BOTH SIDES OF DRAINAGE TO HILLTOPS ON SOUTH AND EAST

Survey Information:

First Observation: 1991-05-19 **Survey Date:** 1993 **Last Observation:** 1999

Eo Type: **EO Rank:** **EO Rank Date:**

Observed Area (acres): **Estimated Representation Accuracy:**

Comments:

General Description:

Comments:

Protection Comments:

Management Comments:

Data:

EO Data: 1993, ONE MALE VOCALIZED CA. 15 MINUTES, DID NOT COME ONTO PARK PROPERTY; 1991, ONE SINGLE MALE AND TWO PAIR, ONE WITH NEST, ON PARK PROPERTY

Managed Area:

Managed Area Name:	Managed Area Type:
DINOSAUR VALLEY STATE PARK	SPWPK

Element Occurrence Record

Reference:

Full Citation:

CONNALLY, W.A.S. 1993. SURVEY OF PUBLIC LANDS - TEXAS PARKS AND WILDLIFE DEPARTMENT - FOR BLACK-CAPPED VIREO AND GOLDEN-CHEEKED WARBLER. INVESTIGATIONS FROM 17 APRIL TO 1 JULY 1993.

HORIZON ENVIRONMENTAL SERVICES, INC. 1999. LETTER TO USFWS RE: ENDANGERED SPECIES PERMIT PRT-798998 FOR 1999 YEAR DATA. 7 FEBRUARY 2000.

SCOTT, P. 1991. SURVEYS FOR BLACK-CAPPED VIREOS AND GOLDEN-CHEEKED WARBLERS IN CENTRAL TEXAS STATE PARKS AND NATURAL AREAS, MAY-JUNE 1991.

Specimen:

Associated Species:

Species Name	Type	Comments

Element Occurrence Record

Scientific Name: *Dendroica chrysoparia* **Occurrence #:** 228 **Eo Id:** 6205

Common Name: Golden-cheeked Warbler **TX Protection Status:** E **ID Confirmed:** Y

Global Rank: G2 **State Rank:** S2B **Federal Status:** LE

Location Information:

Watershed Code:	Watershed Description:
12060202	Middle Brazos-Lake Whitney

County Code:	County Name:	Mapsheet Code:	Mapsheet Name:	State:
TXBOSQ	Bosque	32097-A4	Lakeside Village	TX
TXHILL	Hill	32097-A5	Morgan	TX

Directions:

WEST OF LAKE WHITNEY/BRAZOS RIVER, JUST NORTH OF LAKESIDE VILLAGE COMMUNITY ON "POWELLDALE MOUNTAINS"

Survey Information:

First Observation: 1998-04-22 **Survey Date:** **Last Observation:** 1998-04-22

Eo Type: **EO Rank:** **EO Rank Date:**

Observed Area (acres); **Estimated Representation Accuracy:**

Comments:

General Description: MATURE JUNIPER/OAK WOODLAND ON EAST SIDE OF HILL JUST WEST (?) OF RADIO TOWER, ABUNDANCE OF TEXAS OAK NEAR TOP OF THE HILL

Comments:

Protection Comments:

Management Comments:

Data:

EO Data: TWO SINGING MALES

Managed Area:

Managed Area Name: **Managed Area Type:**

Reference:

Element Occurrence Record

Full Citation:

ESPEY, HUSTON & ASSOCIATES, INC. 1998. FINAL REPORT. MID-BRAZOS PROJECT - LAKE WHITNEY 1998 ENDANGERED SPECIES INVESTIGATIONS. AUGUST 1998.

DLS ASSOCIATES. 1996. ENDANGERED SPECIES INVESTIGATION MID-BRAZOS PROJECT - LAKE WHITNEY, HILL AND BOSQUE COUNTIES, TEXAS. JULY 1996.

Specimen:

Associated Species:

Species Name	Type	Comments

Element Occurrence Record

Scientific Name: *Vireo atricapilla* **Occurrence #:** 245 **Eo Id:** 6213

Common Name: Black-capped Vireo **TX Protection Status:** E **ID Confirmed:** Y

Global Rank: G2G3 **State Rank:** S2B **Federal Status:** LE

Location Information:

Watershed Code:	Watershed Description:
12060202	Middle Brazos-Lake Whitney

County Code:	County Name:	Mapsheet Code:	Mapsheet Name:	State:
TXSOME	Somervell	32097-B7	Glen Rose West	TX

Directions:

NORTH AND SOUTH OF FM 205, CA. 3 MILES WEST OF US 67/FM 205 INTERSECTION; SOUTH OF DINOSAUR VALLEY STATE PARK

Survey Information:

First Observation: 2000-05-27 **Survey Date:** 2000-05-27 **Last Observation:** 2002-04-23

Eo Type: **EO Rank:** **EO Rank Date:**

Observed Area (acres): **Estimated Representation Accuracy:**

Comments:

General Description: IN 2000, GOOD HABITAT ON RIDGETOP THAT HAD BEEN BURNED WITHIN PAST 10 YEARS

Comments:

Protection Comments:

Management Comments:

Data:

EO Data: IN 2000, 2 TERRITORIES, PAIR WITH TWO NESTS SOUTH OF FM 205, BOTH NESTS PARASITIZED BY BROWN-HEADED COWBIRDS AND ABANDONED; IN 2001, 2 MALES HEARD ON EITHER SIDE OF FM 205 (SAME TERRITORIES AS IN 2000); 2002, 2 MALES HEARD ON EITHER SIDE OF FM 205 (SAME TERRITORIES)

Managed Area:

Managed Area Name: **Managed Area Type:**

Reference:

Element Occurrence Record

Full Citation:

MARESH, JOHN. 2000. BLACK-CAPPED VIREO CENSUS AND MONITORING PROJECT FIELD NOTES.

PINKSTON, JANE, NED WRIGHT, AND JOHN MARESH. 2002. POPULATION MONITORING FOR BLACK-CAPPED VIREO (VIREO ATRICAPILLUS) AT FOSSIL RIM WILDLIFE CENTER, DINOSAUR VALLEY STATE PARK, AND ADJACENT PRIVATE PROPERTY IN SOMERVELL COUNTY, TEXAS. 2001 FIELD SEASON.

MARESH, JOHN. 2002. FIELD NOTES FROM SPRING/SUMMER 2002 FIELD SEASON.

Specimen:

Associated Species:

Species Name	Type	Comments

Element Occurrence Record

Scientific Name: *Notropis buccula* **Occurrence #:** 10 **Eo Id:** 6560

Common Name: Smalleye Shiner **TX Protection Status:** **ID Confirmed:** Y

Global Rank: G2Q **State Rank:** S2 **Federal Status:** C

Location Information:

Watershed Code:	Watershed Description:
12060202	Middle Brazos-Lake Whitney

County Code:	County Name:	Mapsheet Code:	Mapsheet Name:	State:
TXBOSQ	Bosque	31097-G3	Smiths Bend	TX
TXHILL	Hill			

Directions:

TRIBUTARY TO BRAZOS RIVER 4 MILES SOUTH OF WHITNEY DAM, BOSQUE COUNTY; [MAPPED 1.5 MILES EAST AND 2.4 MILES SOUTH OF WHITNEY DAM]

Survey Information:

First Observation: **Survey Date:** **Last Observation:** 1952-04-08

Eo Type: **EO Rank:** D - Poor estimated viability **EO Rank Date:**

Observed Area (acres): **Estimated Representation Accuracy:**

Comments:

General Description: A MEDIUM SIZED CREEK

Comments: SURVEY IN BRAZOS RIVER BY HUBBS NEAR HERE IN 1986, THEY DID NOT FIND SPECIES

Protection Comments:

Management Comments:

Data:

EO Data: 16 FISH COLLECTED HERE BY SUTTKUS AND ANDERSON (RDS2277). TULANE COLLECTION NO. 4993.

Managed Area:

Managed Area Name: **Managed Area Type:**

Reference:

Full Citation:

Element Occurrence Record

Specimen:

Tulane University, Museum of Natural History. 1952. R.D. Suttkus #RDS2277 and P.K. Anderson, Catalog # 4993 TUMNH. 8 April 1952.

Associated Species:

Species Name	Type	Comments

Element Occurrence Record

Scientific Name: *Dendroica chrysoparia* **Occurrence #:** 65 **Eo Id:** 6437

Common Name: Golden-cheeked Warbler **TX Protection Status:** E **ID Confirmed:** Y

Global Rank: G2 **State Rank:** S2B **Federal Status:** LE

Location Information:

Watershed Code:	Watershed Description:
12060202	Middle Brazos-Lake Whitney

County Code:	County Name:	Mapsheet Code:	Mapsheet Name:	State:
TXSOME	Somervell	32097-C7	Hill City	TX

Directions:

FROM HEAD OF WILDCAT HOLLOW TO PALUXY RIVER INCLUDING UNNAMED EAST DRAINAGE ENTERING WILDCAT HOLLOW, SLOPES ON BOTH SIDES OF WILDCAT HOLLOW AND INCLUDING HILLTOP BETWEEN FORKS OF DRAINAGES TO EAST-FACING SLOPES OF DRAINAGE INTO DENIO BRANCH AND PARK BOUNDARY ON NORTHEAST; DINOSAUR VALLEY SP

Survey Information:

First Observation: **Survey Date:** 1993 **Last Observation:** 2000

Eo Type: **EO Rank:** **EO Rank Date:**

Observed Area (acres): **Estimated Representation Accuracy:**

Comments:

General Description:

Comments:

Protection Comments:

Management Comments:

Data:

EO Data: IN 1991, 3 GOLDEN-CHEEKED WARBLER MALES OBSERVED; ONE GOLDEN-CHEEKED WARBLER MALE IN 1993; IN 2000, NUMEROUS GCW HEARD DURING BRIEF BCV SURVEY

Managed Area:

Managed Area Name:	Managed Area Type:
DINOSAUR VALLEY STATE PARK	SPWPK

Reference:

Element Occurrence Record

Full Citation:

CONNALLY, W.A.S. 1993. SURVEY OF PUBLIC LANDS - TEXAS PARKS AND WILDLIFE DEPARTMENT - FOR BLACK-CAPPED VIREO AND GOLDEN-CHEEKED WARBLER. INVESTIGATIONS FROM 17 APRIL TO 1 JULY 1993.

SCOTT, P. 1991. SURVEYS FOR BLACK-CAPPED VIREOS AND GOLDEN-CHEEKED WARBLERS IN CENTRAL TEXAS STATE PARKS AND NATURAL AREAS, MAY-JUNE 1991.

MARESH, JOHN. 2000. BLACK-CAPPED VIREO CENSUS AND MONITORING PROJECT FIELD NOTES.

Specimen:

Associated Species:

Species Name	Type	Comments

Element Occurrence Record

Scientific Name: *Dendroica chrysoparia* **Occurrence #:** 67 **Eo Id:** 7708

Common Name: Golden-cheeked Warbler **TX Protection Status:** E **ID Confirmed:** Y

Global Rank: G2 **State Rank:** S2B **Federal Status:** LE

Location Information:

Watershed Code:	Watershed Description:
12060202	Middle Brazos-Lake Whitney

County Code:	County Name:	Mapsheet Code:	Mapsheet Name:	State:
TXSOME	Somervell	32097-B7	Glen Rose West	TX
		32097-C7	Hill City	TX

Directions:

CA. 1.7 AIR MILES NORTHWEST OF HIGHWAY 67 AND STATE ROUTE 205 INTERSECTION; CA. 1.1 AIR MILES NORTHEAST OF PARK ENTRANCE; SOUTHEAST-FACING SLOPE ALONG EAST PARK BOUNDARY; DINOSAUR VALLEY SP

Survey Information:

First Observation: **Survey Date:** 1993 **Last Observation:** 1993

Eo Type: **EO Rank:** **EO Rank Date:**

Observed Area (acres): **Estimated Representation Accuracy:**

Comments:

General Description: JUNIPER - MATURE WOODLAND

Comments:

Protection Comments:

Management Comments:

Data:

EO Data: ONE MALE - NO VISUAL CONTACT, ONLY VOCAL; IN 1991, SCOTT HAD 2 TERRITORIES IN THIS LOCATION

Managed Area:

Managed Area Name:	Managed Area Type:
DINOSAUR VALLEY STATE PARK	SPWPK

Reference:

Element Occurrence Record

Full Citation:

CONNALLY, W.A.S. 1993. SURVEY OF PUBLIC LANDS - TEXAS PARKS AND WILDLIFE DEPARTMENT - FOR BLACK-CAPPED VIREO AND GOLDEN-CHEEKED WARBLER. INVESTIGATIONS FROM 17 APRIL TO 1 JULY 1993.

SCOTT, P. 1991. SURVEYS FOR BLACK-CAPPED VIREOS AND GOLDEN-CHEEKED WARBLERS IN CENTRAL TEXAS STATE PARKS AND NATURAL AREAS, MAY-JUNE 1991.

Specimen:

Associated Species:

Species Name	Type	Comments

Element Occurrence Record

Scientific Name: *Vireo atricapilla* **Occurrence #:** 237 **Eo Id:** 7664

Common Name: Black-capped Vireo **TX Protection Status:** E **ID Confirmed:** Y

Global Rank: G2G3 **State Rank:** S2B **Federal Status:** LE

Location Information:

Watershed Code:	Watershed Description:
12060202	Middle Brazos-Lake Whitney

County Code:	County Name:	Mapsheet Code:	Mapsheet Name:	State:
TXSOME	Somervell	32097-B7	Glen Rose West	TX

Directions:

FOSSIL RIM WILDLIFE CENTER, CA. 2.5 MILES SOUTH OF US 67 OFF CR 2009

Survey Information:

First Observation: 1998-05-29 **Survey Date:** 1998-05-29 **Last Observation:** 2001-05

Eo Type: **EO Rank:** **EO Rank Date:**

Observed Area (acres): **Estimated Representation Accuracy:**

Comments:

General Description: SHIN OAK/SUMAC HABITAT

Comments:

Protection Comments:

Management Comments:

Data:

EO Data: ONE BCV HEARD/SEEN IN 1998; IN 2001, THREE MALE AND TWO FEMALE BCV OBSERVED ON TWO TERRITORIES, ONE NEST FOUND, NO PRODUCTION OBSERVED

Managed Area:

Managed Area Name: **Managed Area Type:**

Reference:

Element Occurrence Record

Full Citation:

PINKSTON, JANE, NED WRIGHT, AND JOHN MARESH. 2002. POPULATION MONITORING FOR BLACK-CAPPED VIREO (VIREO ATRICAPILLUS) AT FOSSIL RIM WILDLIFE CENTER, DINOSAUR VALLEY STATE PARK, AND ADJACENT PRIVATE PROPERTY IN SOMERVELL COUNTY, TEXAS. 2001 FIELD SEASON.

MARESH, J.P. AND G.A. ROWELL. 2000. PROJECT 89: EXTENSION OF BLACK-CAPPED VIREO ROADSIDE SURVEY AND DEVELOPMENT OF SATELLITE HABITAT MAPS IN TEXAS. SECTION 6 - FINAL REPORT.

Specimen:

Associated Species:

Species Name	Type	Comments

Element Occurrence Record

Scientific Name: *Vireo atricapilla* **Occurrence #:** 2 **Eo Id:** 8084

Common Name: Black-capped Vireo **TX Protection Status:** E **ID Confirmed:** Y

Global Rank: G2G3 **State Rank:** S2B **Federal Status:** LE

Location Information:

Watershed Code:	Watershed Description:
12060202	Middle Brazos-Lake Whitney

County Code:	County Name:	Mapsheet Code:	Mapsheet Name:	State:
TXSOME	Somervell	32097-C7	Hill City	TX
		32097-B7	Glen Rose West	TX

Directions:

DINOSAUR VALLEY STATE PARK, ABOUT 25 MILES SOUTH OF GLEN ROSE

Survey Information:

First Observation: 1984 **Survey Date:** 1993 **Last Observation:** 1991

Eo Type: **EO Rank:** C - Fair estimated viability **EO Rank Date:** 1986-04-29

Observed Area (acres): **Estimated Representation Accuracy:**

Comments:

General Description: OAK-JUNIPER WOODLAND; DWARF OAK, JUNIPER AND SUMAC WITH WELL VEGETATED STRATA; MANY JUNIPERS WITH CANOPY CLOSING IN

Comments: THREATS INCLUDE HABITAT MODIFICATION AND COWBIRD PARASITISM

Protection Comments:

Management Comments: COWBIRD TRAP PLACED AT SITE APRIL 29, 1986

Data:

EO Data: 2 OR 3 INDIVIDUALS SEEN ON SEVERAL DAYS (1984); 3 SINGING MALES HEARD (1985); NO SINGING MALES HEARD BY WAHL IN 1986; HABITAT APPEARS MARGINAL; IN 1993, NO BLACK-CAPPED VIREOS LOCATED IN THIS AREA OF THE PARK; HABITAT APPEARS OVERGROWN AND INVADED BY MUCH JUNIPER; IN 1991, AT LEAST 4 BLACK-CAPPED VIREO TERRITORIES; NO VIREOS OBSERVED IN 2001

Managed Area:

Managed Area Name:	Managed Area Type:
DINOSAUR VALLEY STATE PARK	SPWPK

Reference:

Element Occurrence Record

Full Citation:

CONNALLY, W.A.S. 1993. SURVEY OF PUBLIC LANDS - TEXAS PARKS AND WILDLIFE DEPARTMENT - FOR BLACK-CAPPED VIREO AND GOLDEN-CHEEKED WARBLER. INVESTIGATIONS FROM 17 APRIL TO 1 JULY 1993.

PINKSTON, JANE, NED WRIGHT, AND JOHN MARESH. 2002. POPULATION MONITORING FOR BLACK-CAPPED VIREO (VIREO ATRICAPILLUS) AT FOSSIL RIM WILDLIFE CENTER, DINOSAUR VALLEY STATE PARK, AND ADJACENT PRIVATE PROPERTY IN SOMERVELL COUNTY, TEXAS. 2001 FIELD SEASON.

SCOTT, P. 1991. SURVEYS FOR BLACK-CAPPED VIREOS AND GOLDEN-CHEEKED WARBLERS IN CENTRAL TEXAS STATE PARKS AND NATURAL AREAS, MAY-JUNE 1991.

MARSHALL, J. T., R. B. CLAPP AND J. A. GRZYBOWSKI. 1984. INTERIM STATUS REPORT: VIREO ATRICAPILLUS WOODHOUSE, BLACK-CAPPED VIREO. USF& WS, ALBUQUERQUE, NM.

RISKIND, DAVID, PH.D. TEXAS PARKS AND WILDLIFE DEPARTMENT 4200 SMITH SCHOOL ROAD AUSTIN, TEXAS 78744 PH-512/479-4897 (WORK)

MARSHALL, J. T., R. B. CLAPP AND J. A. GRZYBOWSKI. 1985. STATUS REPORT: VIREO ATRICAPILLUS WOODHOUSE (BLACK-CAPPED VIREO). REPORT TO USF& WS, ALBUQUERQUE, NEW MEXICO. 48pp.

WAHL, C. R. , 1986. FIELD TRIP TO MERIDIAN AND DINOSAUR VALLEY STATE PARKS (TO INSTALL COWBIRD TRAPS) OF APR. 28-29, 1986.

Specimen:

Associated Species:

Species Name	Type	Comments

Element Occurrence Record

Scientific Name: *Dendroica chrysoparia* **Occurrence #:** 213 **Eo Id:** 2870

Common Name: Golden-cheeked Warbler **TX Protection Status:** E **ID Confirmed:** Y

Global Rank: G2 **State Rank:** S2B **Federal Status:** LE

Location Information:

Watershed Code:	Watershed Description:
12060202	Middle Brazos-Lake Whitney

County Code:	County Name:	Mapsheet Code:	Mapsheet Name:	State:
TXSOME	Somervell	32097-B7	Glen Rose West	TX

Directions:

FOSSIL RIM WILDLIFE CENTER (CONSERVATION CAMP AREA), COUNTY ROAD 2009, CA. 0.7 MILE FROM INTERSECTION WITH CR 2008

Survey Information:

First Observation: 2000-04-25 **Survey Date:** **Last Observation:** 2000-04-25

Eo Type: **EO Rank:** **EO Rank Date:**

Observed Area (acres): **Estimated Representation Accuracy:**

Comments:

General Description:

Comments:

Protection Comments:

Management Comments:

Data:

EO Data: AT LEAST 5 GCW'S HEARD

Managed Area:

Managed Area Name: **Managed Area Type:**

Reference:

Full Citation:

MARESH, JOHN. 2000. BLACK-CAPPED VIREO CENSUS AND MONITORING PROJECT FIELD NOTES.

Element Occurrence Record

Specimen:

Associated Species:

Species Name	Type	Comments

Code Key for Printouts from
Texas Parks and Wildlife Department
Texas Natural Diversity Database (TXNDD)

This information is for your assistance only; due to continuing data updates, vulnerability of private land to trespass and of species to disturbance or collection, **please refer all requesters to our office to obtain the most current information available.** Also, please note, identification of a species in a given area does not necessarily mean the species currently exists at the point or area indicated.

LEGAL STATUS AND CONSERVATION RANKS

FEDERAL STATUS (as determined by the US Fish and Wildlife Service)

LE	Listed Endangered
LT	Listed Threatened
PE	Proposed to be listed Endangered
PT	Proposed to be listed Threatened
PDL	Proposed to be Delisted (Note: Listing status retained while proposed)
SAE, SAT	Listed Endangered on basis of Similarity of Appearance, Listed Threatened on basis of Similarity of Appearance
DL	Delisted Endangered/Threatened
C	Candidate. USFWS has substantial information on biological vulnerability and threats to support proposing to list as threatened or endangered. Data are being gathered on habitat needs and/or critical habitat designations.
C*	C, but lacking known occurrences
C**	C, but lacking known occurrences, except in captivity/cultivation
XE	Essential Experimental Population
XN	Non-essential Experimental Population
Blank	Species is not federally listed

TX PROTECTION (as determined by the Texas Parks and Wildlife Department)

E	Listed Endangered
T	Listed Threatened
Blank	Species not state-listed

GLOBAL RANK (as determined by NatureServe)

G1	Critically imperiled globally, extremely rare, typically 5 or fewer viable occurrences
G2	Imperiled globally, very rare, typically 6 to 20 viable occurrences
G3	Very rare and local throughout range or found locally in restricted range, typically 21 to 100 viable occurrences
G4	Apparently secure globally
G5	Demonstrably secure globally
GH	Of historical occurrence through its range
GU	Possibly in peril range-wide, but status uncertain
G#G#	Ranked within a range as status uncertain
GX	Apparently extinct throughout range
Q	Rank qualifier denoting taxonomic assignment is questionable
#?	Rank qualifier denoting uncertain rank
C	In captivity or cultivation only
G#T#	"G" refers to species rank; "T" refers to variety or subspecies rank

STATE (SUBNATIONAL) RANK (as determined by the Texas Parks and Wildlife Department)

S1	Critically imperiled in state, extremely rare, vulnerable to extirpation, typically 5 or fewer viable occurrences
S2	Imperiled in state, very rare, vulnerable to extirpation, typically 6 to 20 viable occurrences
S3	Rare or uncommon in state, typically 21 to 100 viable occurrences
S4	Apparently secure in State
S5	Demonstrably secure in State
S#S#	Ranked within a range as status uncertain
SH	Of historical occurrence in state and may be rediscovered
SU	Unrankable – due to lack of information or substantially conflicting information
SX	Apparently extirpated from State
SNR	Unranked – State status not yet assessed
SNA	Not applicable – species id not a suitable target for conservation activities
?	Rank qualifier denoting uncertain rank in State

ELEMENT OCCURRENCE RECORD

Element Occurrence Record (EOR) Spatial and tabular record of an area of land and/or water in which a species, natural community, or other significant feature of natural diversity is, or was, present and associated information; may be a single contiguous area or may be comprised of discrete patches or subpopulations

Occurrence # Unique number assigned to each occurrence of each element when added to the NDD

LOCATION INFORMATION

Watershed Code Eight digit numerical code determined by US Geological Survey (USGS)

Watershed Name of watershed as determined by USGS

Quadrangle Name of USGS topographical map

Directions Directions to geographic location where occurrence was observed, as described by observer or in source

SURVEY INFORMATION

First/Last Observation Date a particular occurrence was first/last observed; refers only to species occurrence as noted in source and does not imply the first/last date the species was present

Survey Date If conducted, date of survey

EO Type State rank qualifiers:

- **M** Migrant – species occurring regularly on migration at staging areas, or concentration along particular corridors; status refers to the transient population in the State
- **B** Qualifier indicating basic rank refers to the breeding population in State
- **N** Qualifier indicating basic rank refers to the non-breeding population in State

EO Rank

A	Excellent	**AI**	Excellent, Introduced
B	Good	**BI**	Good, Introduced
C	Marginal	**CI**	Marginal, Introduced
D	Poor	**DI**	Poor, Introduced
E	Extant/Present	**EI**	Extant, Introduced
H	Historical/No Field Information	**HI**	Historical, Introduced
X	Destroyed/Extirpated	**XI**	Destroyed, Introduced
O	Obscure	**OI**	Obscure, Introduced

EO Rank Date Latest date EO rank was determined or revised

Observed Area Acres, unless indicated otherwise

COMMENTS

Description General physical description of area and habitat where occurrence is located, including associated species, soils, geology, and surrounding land use

Comments Comments concerning the quality or condition of the element occurrence at time of survey

Protection Comments Observer comments concerning legal protection of the occurrence

Management Comments Observer comments concerning management recommendations appropriate for occurrence conservation

DATA

EO Data Biological data; may include number of individuals, vigor, flowering/fruiting data, nest success, behaviors observed, or unusual characteristic, etc.

SITE

Site Name Title given to site by surveyor

MANAGED AREA INFORMATION

Managed Area Name Place name or (on EOR printout) name of area when the EO is located within or partially within an area identified for conservation, such as State or Federal lands, nature preserves, parks, etc.

Alias Additional names the property is known by

Acres Total acreage of property, including non-contiguous tracts

Manager Contact name, address, and telephone number for area or nearest area land steward

Please use one of the following citations to credit the source for the printout information:

Texas Natural Diversity Database. [year of printouts]. Wildlife Diversity Program of Texas Parks & Wildlife Department. [day month year of printouts].

Texas Natural Diversity Database. [year of printouts]. Element occurrence printouts for [scientific name] *records # [occurrence number(s)]. Wildlife Diversity Program of Texas Parks & Wildlife Department. [day month year of printouts]. *Use of record #'s is optional.

DISTRIBUTION AND STATUS OF THE BRAZOS WATER SNAKE

(NERODIA HARTERI HARTERI)

THESIS

Presented to the College of Graduate Studies
Tarleton State University
In Partial Fulfillment of the Requirements
For the Degree of

MASTER OF SCIENCE

By

DUSTIN LEE MCBRIDE

Stephenville, Texas
May 2009

TEXAS PARKS & WILDLIFE

Life's better outside.™

February 20, 2009

Texas Parks and Wildlife Dept.
Attn: Rosie Roegner
Wildlife Division
4200 Smith School Rd.
Austin, TX 78744

Dear Rosie,

I have enclosed paper and cd copies of Dustin McBride's thesis titled "Distribution and Status of the Brazos Water Snake." The thesis should serve as the project's final report and meet the T-39 reporting requirements. Additional data files and maps will be forthcoming after Mr. McBride's thesis defense scheduled for March 17, 2009.

Sincerely,

Michael Miller
Technical Guidance Biologist
Texas Parks and Wildlife Dept.
Box T-0070
Stephenville, TX 76402
254-968-9879

ACKNOWLEDGEMENTS

The completion of this thesis required contributions from numerous individuals. Foremost, I would like to express my gratitude to my advisor, Dr. James M. Mueller. I will be forever grateful for Dr. Mueller's support, advice, and patience as both a mentor and friend throughout this entire project. Members of my committee, Dr. James M. Mueller, Dr. Jeff B. Breeden, Dr. Christopher L. Higgins, and Michael S. Miller (Texas Parks and Wildlife Department), provided much needed support and encouragement during this study, and constructive criticisms of this thesis.

I am especially thankful for the logistic and field support provided by the Texas Parks and Wildlife Department (TPWD) and TPWD biologists Nathan Rains and Dean Marquardt during this project. I also owe many thanks for the help of several field assistants who gave their time and energy to this project: Kyle Salzmann, Pat Kostecka, Cory and Carly Chesnut, Kim Littlefield, James Arno, Daniel Taylor, and Elizabeth Reidlinger. I am indebted to the many landowners who granted me access to their property and to Mitch Baird (Texas Historical Commission) and the personnel at Fort Griffin State Historic Site for providing campsites and additional logistical support.

My gratitude is extended to Dr. Michael R. J. Forstner (Texas State University – San Marcos) for the opportunity to assist with genetic research of the Brazos Water Snake, and to Dr. Lou D. Densmore (Texas Tech University) and Dr. David Rodriguez

(Texas Tech University) for their hospitality and assistance in the lab. Dr. Russell S. Pfau generously donated supplies for collection of blood and tissue samples.

Funding for this study was provided by the Texas Parks and Wildlife Department and Tarleton State University.

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McBride, Dustin L., Distribution and Status of the Brazos Water Snake (*Nerodia harteri harteri*), Master of Science (Agriculture), May, 2009, 89 pp., 5 tables, 23 figures, references cited, 72 titles.

Nerodia h. harteri (Brazos Water Snake) is a state threatened endemic Texas snake found along the upper Brazos River drainage in north-central Texas. A range-wide survey was conducted from 2006-2008 to determine the current distribution and relative abundance of *N. h. harteri*, identify potential habitat, and investigate habitat relationships of the snake. While the range of *N. h. harteri* and suitable habitat remain intact, the snake is now rare. Logistic regression analysis indicated the likelihood of finding the snake was positively related to both the amount of rock (>10 cm) at a site and surrounding a site. Reasons for the population decline remain unclear; however, results illustrate the importance of riffle habitat for the future conservation of this Texas snake.

INTRODUCTION

Nerodia h. harteri (Brazos Water Snake) is a relatively small natricine snake endemic to the upper Brazos River drainage in north-central Texas (Scott et al., 1989; Werler and Dixon, 2000). Initially discovered in the late 1930s along rocky stretches of the Brazos River in Palo Pinto County, *N. harteri* was formally described in 1941 (Trapido, 1941). In 1961, an allopatric population from the Concho and Colorado rivers in central Texas was described (Tinkle and Conant, 1961), thereby dividing *N. harteri* into two subspecies – *Nerodia h. harteri* from the upper Brazos River drainage, and *N. h. paucimaculata* (Concho Water Snake) from the upper Concho-Colorado River drainage. The taxonomy and systematics of these two populations is a source of contention, with some authors proposing an elevation of *N. h. paucimaculata* to specific status (Rose and Selcer, 1989; Densmore et al., 1992); however, recent biologists have retained the subspecific status for these two taxa (e.g., Werler and Dixon, 2000; Gibbons and Dorcas, 2004; Whiting et al., 2008). In accordance with recent literature and just completed population genetics results (M. R. J. Forstner, Texas State University – San Marcos, personal communication), the more conservative subspecific assignment of these taxa is retained herein.

Collectively, *N. harteri* is the only species of *Nerodia* endemic to a single state (Gibbons and Dorcas, 2004), and is one of just two snake species endemic to Texas (the

other being the Trans-Pecos Black-headed Snake, *Tantilla cucullata*; Werler and Dixon, 2000). *Nerodia harteri* inhabits a limited portion of stream corridor and reservoir shoreline within the upper reaches of two river drainages (Scott et al., 1989), giving it one of the most restricted geographic ranges of any North American snake species. Despite being locally abundant in areas with suitable habitat (Trapido, 1941; Scott et al., 1989), the state of Texas placed both subspecies on the state list of endangered species in 1977 due to their limited distribution, specific habitat requirements, and perceived threats from future water development projects (Scott and Fitzgerald, 1985). In 1986, *N. h. paucimaculata* was listed as Threatened by the U.S. Fish and Wildlife Service (Stefferud, 1986), and was subsequently the focus of several in-depth ecological studies (e.g., Greene et al., 1994; Whiting et al., 1997; Greene et al., 1999; Whiting et al., 2008), while *N. h. harteri* has received little attention from the scientific community.

Knowledge specific to *N. h. harteri* is limited and has accumulated slowly since its formal description. Detailed bibliographies, species accounts, and literature reviews have been compiled by several authors (Dixon, 2000; Werler and Dixon, 2000; Ernst and Ernst, 2003; Gibbons and Dorcas, 2004). A concise literature review is provided here to highlight the available information pertaining to this subspecies. Following the original species description, brief distributional records (Tinkle and Knopf, 1964; Wade, 1968; Smith, 1983) and notes pertaining to reproduction and young (Conant, 1942; McCallion, 1944; Carl, 1981) were published. Worley (1970) described a single survey, Mecham (1983) reviewed current knowledge, and Seigel and Fitch (1984) summarized relative clutch mass data for over 100 populations of snakes, including *N. h. harteri*. The

phylogenetic relationships of *N. h. harteri* have been discussed by several authors (Eberle, 1972; Kilpatrick and Zimmerman, 1973; Lawson, 1987; Rose and Selcer, 1989; Densmore et al., 1992), and two clearly defined taxa have been described. Scott et al. (1989) conducted the most comprehensive investigation of the ecology of *N. h. harteri* to date. Other authors have reported further on the status and distribution of the snake (Dorcas and Mendelson, 1991; Rossi and Rossi, 1999; Forstner et al., 2006), its parasites (McAllister and Upton, 1989; Upton et al., 1989; McAllister and Bursey, 2008), and captive maintenance (Rossi and Rossi, 2000).

Between 1979 and 1987, Scott et al. (1989) conducted extensive surveys for both *N. h. harteri* and *N. h. paucimaculata*. They found that the range of *N. h. harteri* encompassed approximately 700 km of the upper Brazos River drainage, and within this range the snake was found only to inhabit approximately 300 km of river corridor and portions of two reservoirs, Possum Kingdom Lake and Lake Granbury (Scott et al., 1989). The patchy distribution of *N. h. harteri* within even this very limited range is likely linked to the availability of suitable juvenile habitat (Scott et al., 1989). Scott et al. (1989) found that the most important habitat features for juveniles were the presence of medium (>10 cm) to large flat rocks on unshaded shoreline for cover and adjacent rocky shallows for foraging. Along the Brazos River and its tributaries these features are typically associated with riffles, and within Possum Kingdom Lake and Lake Granbury *N. h. harteri* is known to occupy shoreline with similar features (Scott et al., 1989). Adults utilize a much wider range of habitats than juveniles, such as deeper waters, and their distribution is believed to be limited by the distance they can travel from suitable

juvenile habitat and their need for deeper, more secure rocky cover (Scott et al., 1989). Scott et al. (1989) conceded that *N. h. harteri* might lose some habitat due to future dams and development projects, but concluded that it was not likely to experience any threat that would jeopardize its long-term persistence. This conclusion was based on the assumption that no threat could likely affect the entire population because it was divided into at least five isolated segments (Scott et al., 1989). However, they believed that the barriers which isolate these populations also would inhibit recolonization should the population of any segment be extirpated (Scott et al., 1989).

Several herpetologists have recently noted the apparent extirpation of *N. h. harteri* from parts of its historic range (Rossi and Rossi, 1999; Forstner et al., 2006; C. T. McAllister, Hot Springs National Park, AR, personal communication). The causes of these declines are unknown, although potential threats include direct killing by humans, drought, habitat degradation, and reductions in prey availability (Maxwell, 1982; Rossi and Rossi, 1999; Bender et al., 2005; Forstner et al., 2006). At present *N. h. harteri* is classified as Threatened by the Texas Parks and Wildlife Department (Texas Parks and Wildlife Department, 2007a) and has a G2 (Imperiled) global status (i.e., at high risk of extinction; NatureServe, 2008). The IUCN lists *N. h. harteri* as Near Threatened due to its limited range, and states that it is close to qualifying as Vulnerable (Hammerson, 2007). The Texas Wildlife Action Plan identified research and monitoring for species of concern as a high priority for the Brazos River Basin, and identified *N. h. harteri* as a medium priority conservation need (Bender et al., 2005). Furthermore, surveying current

populations and defining the extent of potential habitat were identified as priority conservation actions for *N. h. harteri* (Bender et al., 2005).

Given the apparent recent population declines, a systematic survey was needed to assess the current distribution and relative abundance of the snake. In addition, a better understanding was needed of the habitat characteristics of sites occupied by *N. h. harteri* as compared to unoccupied sites. The objectives of this study were to 1) determine the current distribution and relative abundance of *N. h. harteri*, 2) identify potential habitat, and 3) investigate the relationship between *N. h. harteri* and habitat quality and density.

MATERIALS AND METHODS

Study Area.—Surveys for *N. h. harteri* were conducted throughout the range of the snake, including stretches listed as uninhabited by Scott et al. (1989). The upstream limits were Deadman Creek (32°37.05′N, 99°37.60′W) in Jones County, and Paint Creek below Lake Stamford Dam (33°04.58′N, 99°33.40′W) in Haskell County, both tributaries to the Clear Fork of the Brazos River. Downstream, surveys extended along the Clear Fork from the mouth of Deadman Creek to the confluence with the Brazos River in Young County, and down the Brazos River to the FM (Farm-to-Market) 1118 bridge crossing (32°12.25′N, 97°36.33′W) near Brazos Point, Bosque County. Searches of tributaries adjacent to this range and not known to be occupied by *N. h. harteri* were also conducted opportunistically. Counties included within the study area were Jones, Shackelford, Haskell, Throckmorton, Stephens, Young, Palo Pinto, Parker, Hood, Somervell, Johnson, Bosque, and Hill.

The climate of north-central Texas is Subtropical-Subhumid and characterized by hot summers and relatively mild, dry winters (Larkin and Bomar, 1983). The average annual temperature of the region is 18.2°C, with a low monthly mean temperature of 6.8°C in January and a high of 28.7°C in July (National Oceanic and Atmospheric Administration, 2002). Precipitation is highly variable across the region and drought conditions are common and sometimes persistent (Stahle and Cleveland, 1988;

Woodhouse and Overpeck, 1998). Precipitation falls in a seasonally bimodal pattern, with the greatest amounts typically falling in the month of May, followed by September and October (National Oceanic and Atmospheric Administration, 2002). Mean annual precipitation within the study area ranges from 88.4 cm in the east (Glen Rose, Texas) to 72.3 cm in the west (Albany, Texas; National Oceanic and Atmospheric Administration, 2004).

The study area lies primarily within the Cross Timbers and Prairies ecoregion of Texas and extends westward into the Rolling Plains (Gould et al., 1960). The upland vegetation adjacent to the riparian corridor varies considerably throughout the study area. Beginning at the upstream limits in Jones County, the river corridor bisects the following vegetative and cover associations described by McMahan et al. (1984): Mesquite (*Prosopis glandulosa*)-Lotebush (*Ziziphus obtusifolia*) Shrub, Mesquite Brush, Post Oak (*Quercus stellata*) Parks/Woods, Live Oak (*Q. virginiana*)-Ashe Juniper (*Juniperus ashei*) Parks, Ashe Juniper Parks/Woods, Oak-Mesquite-Juniper Parks/Woods, and Silver Bluestem (*Bothriochloa saccharoides*)-Texas Wintergrass (*Nassella leucotricha*) Grassland. The riparian vegetation is dominated by pecan (*Carya illinoinensis*), cottonwood (*Populus deltoides*), black willow (*Salix nigra*), elm (*Ulmus* spp.), hackberry (*Celtis* spp.), ash (*Fraxinus* spp.), western soapberry (*Sapindus drummondii*), and bur oak (*Q. macrocarpa*). Mesquite and saltcedar (*Tamarix* spp.) become increasingly common riparian trees toward the west, particularly along the Clear Fork of the Brazos River and the Brazos River above Possum Kingdom Lake. Throughout most of the study area tall grasses line the low banks and islands within the stream channel, of which the most

prominent species is switchgrass (*Panicum virgatum*). In some areas bermudagrass (*Cynodon dactylon*) has become established.

Field Surveys.—Surveys for *N. h. harteri* and potential juvenile habitat were conducted between September 2006 and October 2008. From September 2006 to September 2007, surveys were conducted along the lower half of the range of *N. h. harteri*, from Morris Sheppard Dam (Possum Kingdom Lake), Palo Pinto County, to the upper reaches of Lake Whitney, Johnson County. From October 2007 to October 2008 surveys were conducted along the upper half of the range, from Deadman Creek, Jones County, to Possum Kingdom Lake, Palo Pinto County, in addition to surveys along the lower portion of the range. Field work was concentrated during the spring (April-May) and fall (September-October), periods when *N. harteri* activity is highest and densities are greatest (Mueller, 1990; Greene, 1993). Flooding events during the spring of 2007 prevented surveys throughout most of April and May that year. During this period, smaller tributaries were searched opportunistically between flood pulses. Surveys along the Brazos River resumed when high flows receded in July 2007. Additionally, heavy rain events hampered survey efforts along most of the Clear Fork upstream from the confluence of Paint Creek in 2008.

A team of at least two people conducted surveys along the Brazos River and its tributaries using canoes. The shoreline, overhanging vegetation, and water were carefully searched for snakes, and the habitat was subjectively assessed for juvenile *N. h. harteri* suitability. Upon encountering potential habitat (i.e., shallow riffle areas), intensive timed searches were conducted on foot. This consisted of searching all cover that could harbor a

snake within 3 m of the water's edge, including searching under all rocks (>10 cm), crevices, debris piles, and vegetation. Deadman Creek could not be surveyed by canoe due to lack of access and its small size; however, several road crossings of the creek were examined and extended searches were made at two of these.

Snakes were captured by hand, measured (snout-vent length [SVL], tail length, and mass), sexed, and released. Snout-vent and tail lengths were measured (±1.0 mm) by holding the snake along a metal tape until the body was fully relaxed but not over-stretched, and mass was measured (±0.5 g) by clipping a spring scale to the tail of the snake and holding it vertically in the air. Sex was determined by manually extruding the hemipenes, if present, or by visual inspection of the tail region; beginning in April 2008, blunt sexing probes were used to determine sex. The accuracy of sex determination in the field, particularly during the period before sexing probes were used, was examined by calculating the ratio of tail length to total length for all *N. h. harteri* with complete tails. Results were compared to ratios previously reported for *N. h. harteri* by Trapido (1941), Tinkle and Conant (1961), and Carl (1981), where they ranged from 0.244-0.291 for males and 0.220-0.258 for females. If the tail length to total length ratio fell within the overlap between the sexes (0.244-0.258), snakes ($N = 7$) were assumed to be sexed correctly. Four snakes (3 males and 1 female) were identified as being sexed incorrectly in the field. The sex ratio was tested against a null hypothesis of 1:1 using chi-square analysis. Relative age (juvenile or adult) of captured *N. h. harteri* was determined by the minimum SVL at sexual maturity (adult male: ≥380 mm, adult female: ≥460 mm) reported for *N. h. paucimaculata* (Greene et al., 1999). When snakes were found under

rocks, the dimensions (thickness × longest axis × shortest axis; ±1.0 cm) of the rock were recorded. Comparisons were made between the sizes of rock utilized by adults and juveniles using a Student's *t*-test. Additional data collected included the coordinates where snakes were found, time of observation, air temperature at ground level, water temperature, a written description of the habitat, and any additional observations regarding the condition of the snake or the nature in which it was observed. Captured snakes were not marked during this study due to the unlikely nature of recapture given the large study area, and no snakes were collected. Photographs of captured snakes were taken in most cases.

Beginning in April 2008, blood or tissue samples were collected from 25 *N. h. harteri*. Blood was drawn (≤0.1 ml) from the ventral coccygeal vein of the tail (Willette-Frahm, 1995) using a 25-gauge tuberculin syringe, and was stored in 1.5 ml polypropylene tubes containing 0.5 ml of lysis buffer (Longmire et al., 1988). When blood collection was unsuccessful, a small (≤1.5 cm) portion of the tip of the tail was clipped and stored in 1.5 ml polypropylene tubes containing 0.5 ml of lysis buffer. All samples were accessioned into the MF Tissue Catalog at Texas State University – San Marcos, Department of Biology (Michael Forstner, Curator). Photographs were taken of each snake to document the morphological traits reported by Tinkle and Conant (1961), and consisted of the following images: dorsal head, ventral head, right and left side of head, ventral pre-cloaca, and ventral post-cloaca.

In addition to intensive searches at riffle areas, visual searches while traveling between sites in the canoe were used to document *N. h. harteri* presence. An attempt was

made to capture or positively identify all snakes observed to species, and the total time spent on the entire trip was recorded. Commercial minnow traps were used opportunistically to sample for snakes along the river. Traps were set partially submerged along the shoreline and parallel to objects (e.g., rock piles) within shallow riffle habitat. Traps were checked approximately every 2-3 h, or in the morning if set overnight. The coordinates of traps, total time traps were set, and air and water temperatures were recorded.

The shorelines of Lake Granbury and Possum Kingdom Lake were surveyed by at least 2 people in a small motorized boat. Surveys consisted of subjectively assessing the shoreline for *N. h. harteri* suitability (e.g., a shallow, gently sloping lake bottom adjacent to rocky shoreline) and then slowly floating along suitable shorelines while looking for snakes. Areas were searched on foot when possible. Prior to conducting surveys along Lake Granbury and Possum Kingdom Lake, historic locations of *N. h. harteri* from Scott et al. (1989) were plotted on lake maps to ensure sampling at those sites. The entire shoreline of Lake Granbury was surveyed on 10-11 July 2007 and the locations of all potential habitat were plotted on a lake map. One canoe trip was made on 8 May 2007 to survey Strouds Creek, a small tributary to Lake Granbury at Thorp Spring, Texas, and adjacent lake habitat. To supplement visual searches, commercial minnow traps were placed along the shoreline of Lake Granbury in areas deemed potentially suitable on 8 May 2007, and 16-19 July 2007. Minnow traps were fitted with foam floats to prevent drowning of captured snakes, placed parallel to the shoreline, and tied to nearby vegetation, rocks, or debris. Engine failure on 17 July 2007 precluded traps from being

checked until 19 July 2007 (2 nights) and halted trapping efforts in Lake Granbury. Surveys of Possum Kingdom Lake on 15-16 May 2008 were concentrated along the upper portion of the lake in areas where Scott et al. (1989) documented *N. h. harteri*, and minnow traps were not used.

Habitat Quantification and Delineation.—After searches for snakes were completed at each site along the river, the linear extent of the habitat (i.e., the riffle) was measured using a GPS unit, and the available rocky cover along both banks and any islands, if present, was quantified using a point intercept technique. This consisted of walking along the shoreline at its interface with the water and categorizing the rocky substrate located at the tip of the foot into one of three size classes (0: ≤99 mm; 1: 100-256 mm; 2: >256 mm) at an interval of every other step. This method provided an index of the amount of rocky habitat available to *N. h. harteri* at each site. These data were not collected when water levels were above normal because the majority of rock at a site became inundated.

The amount of rock in each of the three size classes was calculated for each site after field surveys were completed, and the linear extent of the habitat was plotted on a map of the river system. The amount of rock in size classes 1 and 2 (i.e., ≥10 cm) was summed to provide a measure of the abundance of rocky cover available to *N. h. harteri* at each site. Sites with shoreline composed entirely of substrate ≤99 mm (i.e., size class 0) were omitted since they lacked suitable juvenile cover. To provide a measure of the density of potential habitat surrounding a site, the number of riffles within 5 km of each site was summed. In addition, the amount of rock ≥10 cm was summed for all riffles

within 5 km of each site. To identify the most important stretches of river for *N. h. harteri*, (i.e., those that contain the greatest amount of rocky habitat), the amount of rock ≥10 cm within each 5 km segment and the corresponding central riffle was summed. This created segments of river approximately 10 km in length that were centered on each site. The values of available habitat within each 10 km segment were divided into quartiles, ranked, and plotted on a map of the river system.

The efficacy of using aerial photography to remotely delimit potentially suitable juvenile *N. h. harteri* habitat (i.e., shallow riffles) was investigated using digital imagery with a 1-m resolution. Imagery of the entire study area was obtained from the Texas Natural Resources Information System (2008) and consisted of color-infrared digital orthophoto quarter quadrangles with imagery from 2004 provided by the National Agricultural Imagery Program (NAIP). The river corridor and lakeshore within the study area was examined for the presence of rock within 3 m of the water's edge at a spatial scale of 1:3,500. Viewing the imagery at a spatial scale beyond this point (i.e., at a finer scale), caused the image to become pixilated and increasingly difficult to interpret. All mapping and imagery analysis was completed with ArcView 9.2 software (Environmental Systems Research Institute, Redlands, CA, 2006).

Modeling.—Logistic regression analysis can be used to assess the relationship between a dependent binary response variable (e.g., presence or absence) and one or more explanatory independent variables (i.e., covariates) by applying maximum likelihood estimation after transforming the dependent variable into a logit variable (Hosmer and Lemeshow, 2000). In doing so, logistic regression estimates the odds of a

certain event occurring. The logistic regression model has the form: $\pi(x) = e^{g(x)}/(1 + e^{g(x)})$, where $\pi(x)$ is the probability of a successful event (e.g., finding *N. h. harteri* at a site), and $g(x)$, the logit transformation function, is given by: $g(x) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_n x_n$, where β_0 is a constant and $\beta_1 \ldots \beta_n$ are the coefficients of the $x_1 \ldots x_n$ variables (Hosmer and Lemeshow, 2000). No assumptions are made about the distributions of the independent variables in logistic regression, and a linear relationship between the dependent and the independent variables is not assumed. Rather, logistic regression assumes a linear relationship between the independent variables and the logit of the dependent variable. Additional assumptions of the logistic regression model include absence of multicollinearity between independent variables, inclusion of all relevant variables and exclusion of all irrelevant variables, independent observations, independent variables measured without error, no outliers, and large sample size.

Logistic regression was used to test for a significant relationship between the logit of finding *N. h. harteri* at a site (i.e., a riffle) and the combination of habitat quality and density. Habitat quality was quantified using the abundance of rocky cover available to *N. h. harteri* at a site (i.e., the sum of rock in size classes 1 and 2). The density of potential habitat surrounding a site was measured by summing the amount of rocky cover available to *N. h. harteri* within 5 km up- and downstream of a site. Significance of the model was assessed using a full-reduced model likelihood ratio chi-square test. All statistical analyses were conducted using SPSS 16.0 software (Statistical Package for the Social Sciences, Inc., Chicago, IL, 2007), with $\alpha = 0.05$.

RESULTS

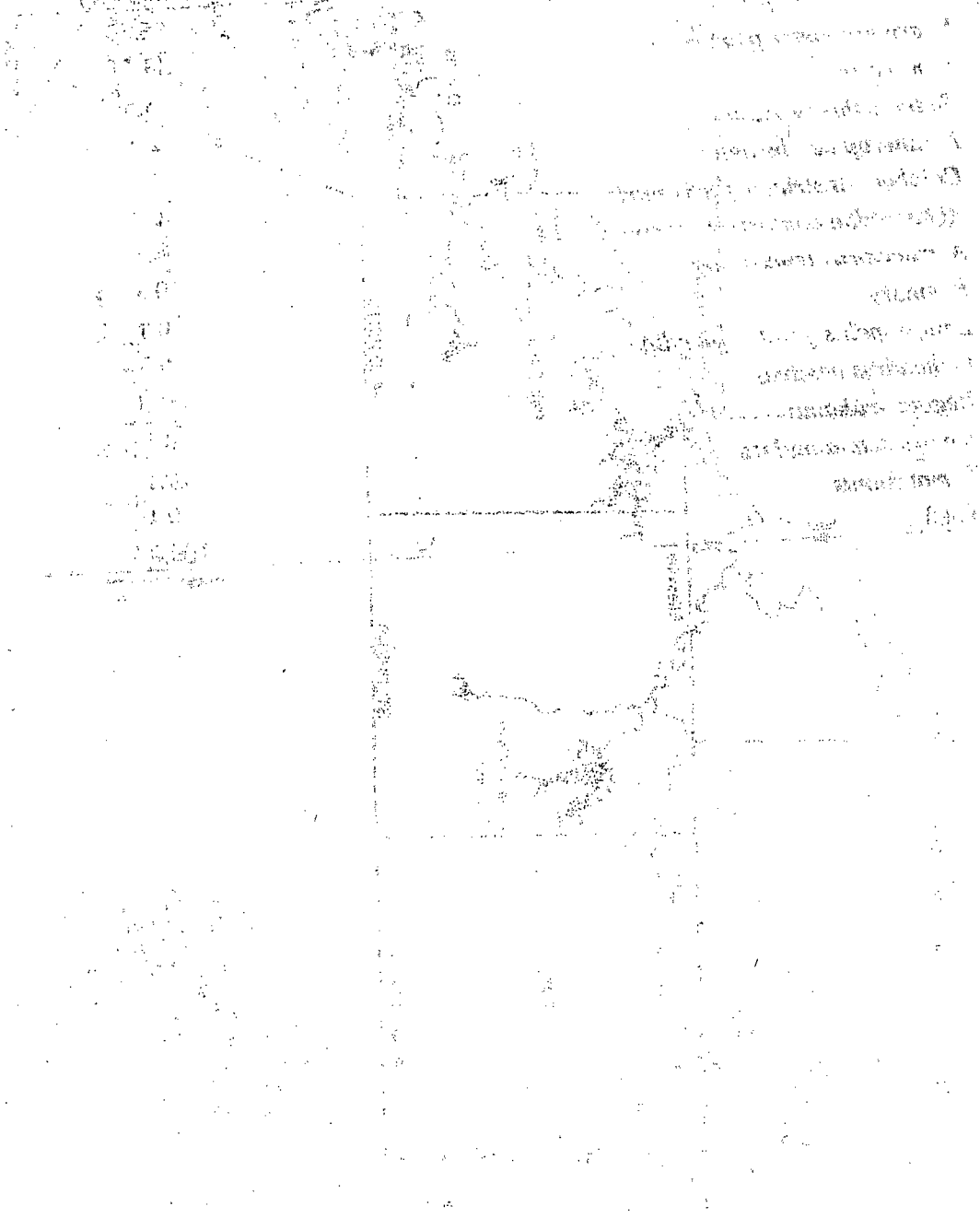
Field Surveys.—A total of 574 km (94%) of river corridor within the range of *N. h. harteri* was surveyed by canoe. Including resampling of river sections, 985 km were floated during 25 trips that spanned 57 days. Trips ranged from 4.13 h to 8 days in length. A total of 350.35 h (733.92 man-h) were spent searching for snakes while floating in a canoe, and 112.12 h (232.40 man-h) were spent intensively searching for snakes during 330 searches.

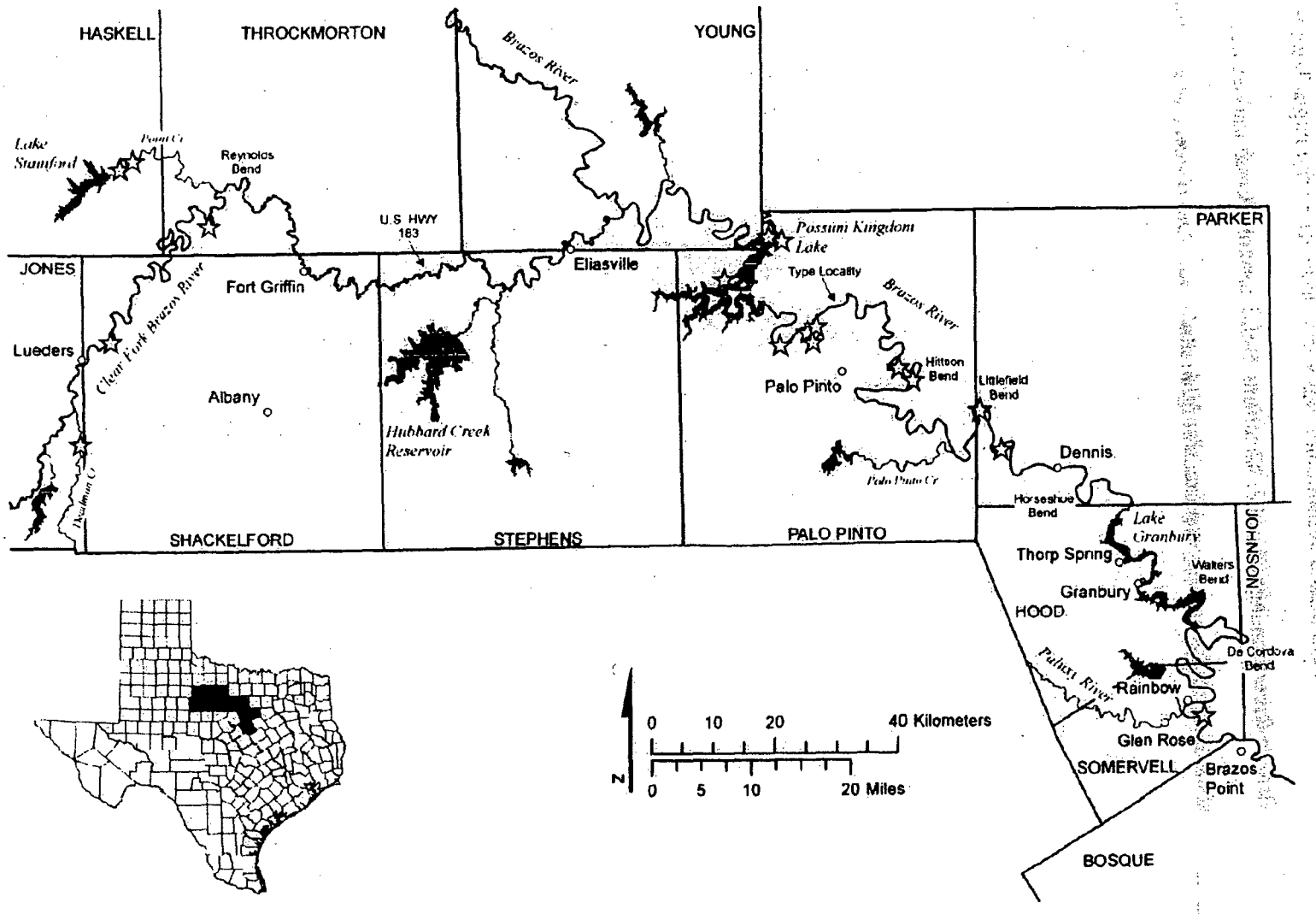
During this study 816 snakes and one Slender Glass Lizard (*Ophisaurus attenuatus*) were observed. Positively identified snakes (N = 755) comprised 14 different species (Table 1). The most common species encountered were *N. rhombifer* (Diamondback Water Snake; N = 421) and *N. erythrogaster transversa* (Blotched Water Snake; N = 253), which comprised 55.8% and 33.5% of all positively identified snakes, respectively. Forty-two (5.6%) *N. h. harteri* were observed (Fig. 1), and 38 were captured. Two were recaptures (determined by obvious scarring of the individuals and examination of photographs) and one individual escaped before measurements could be recorded; therefore, data were collected from 35 snakes. Of these, 11 (31%) were adult males, 6 (17%) were juvenile males, 9 (26%) were adult females, and 9 (26%) were juvenile females (Fig. 2). The overall sex ratio (χ^2_1 = 0.03, P = 0.87), and the sex ratio of juveniles (χ^2_1 = 0.60, P = 0.44) and adults (χ^2_1 = 0.20, P = 0.66) were not significantly

TABLE 1. Species and number of snakes observed along the upper Brazos River drainage, Texas, 2006-2008.

Species	No. observed	Percent (%)
Nerodia rhombifer	421	55.8
N. erythrogaster transversa	253	33.5
N. h. harteri	42	5.6
Thamnophis proximus	17	2.3
Pantherophis obsoletus	9	1.2
Coluber constrictor flaviventris	3	0.4
Agkistrodon contortrix laticinctus	2	0.3
A. piscivorus leucostoma	2	0.3
P. emoryi	1	0.1
Lampropeltis getula splendida	1	0.1
Opheodrys aestivus	1	0.1
Regina grahamii	1	0.1
Sonora semiannulata	1	0.1
T. marcianus	1	0.1
Total	755	100.0

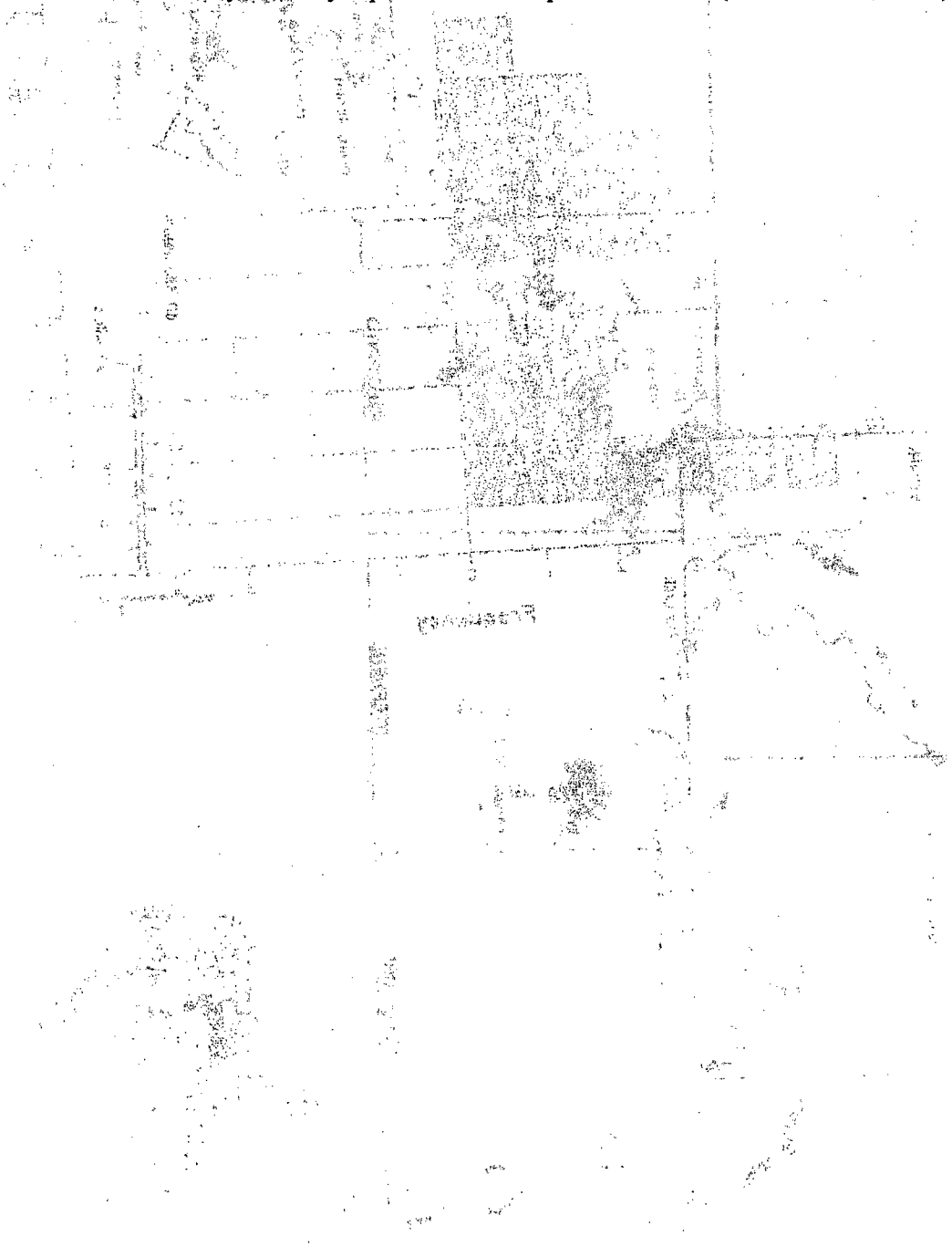
FIGURE 1. Map of locations along the upper Brazos River drainage, Texas, where *N. h. harteri* were found, 2006-2008. Locations where snakes were found are indicated by stars. Some stars cover more than a single site.

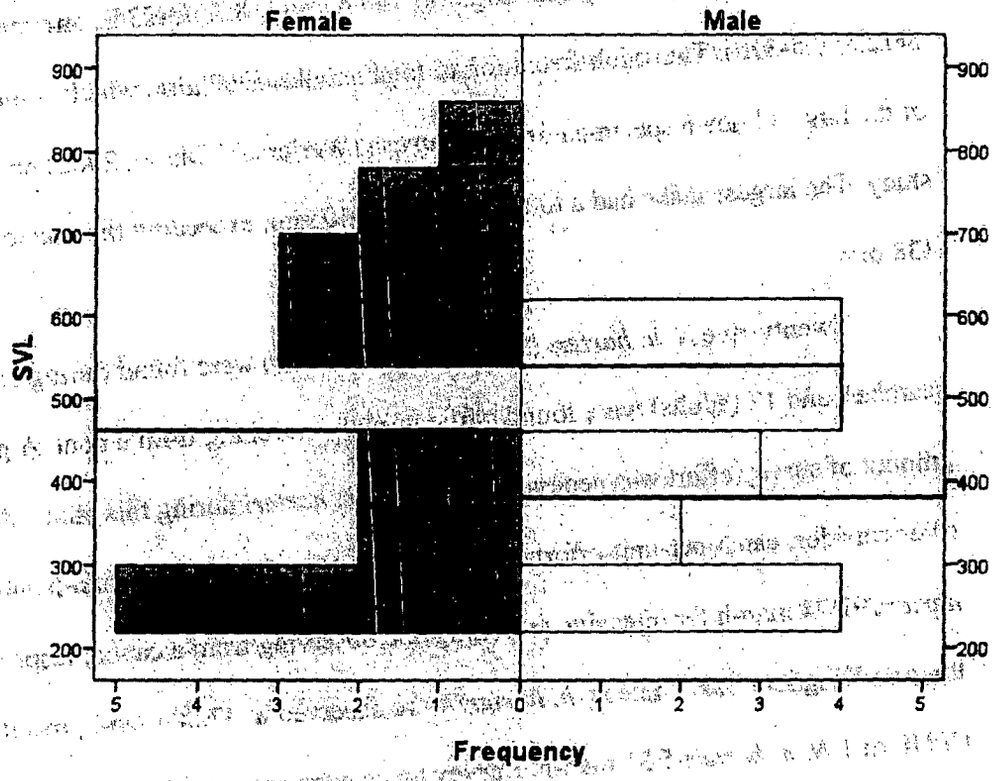



HASKELL
THROCKMORTON
YOUNG
PARKER
JONES
SHACKELFORD
STEPHENS
PALO PINTO
JOHNSON
HOOD
SOMERVELL
BOSQUE
Lake Stamford
Reynolds Bend
U.S. HWY 183
Fort Griffin
Eliasville
Brazos River
Possum Kingdom Lake
Type Locality
Lueders
Clear Fork Brazos River
Albany
Hubbard Creek Reservoir
Palo Pinto
Hittson Bend
Littlefield Bend
Dennis
Horseshoe Bend
Lake Granbury
Thorp Spring
Granbury
Walters Bend
De Cordova Bend
Paluxy River
Rainbow
Glen Rose
Brazos Point
0 10 20 40 Kilometers
0 5 10 20 Miles
N

#29

FIGURE 2. Size class distribution by sex for *N. h. harteri* captured along the upper Brazos River drainage, Texas, 2006-2008. Solid horizontal lines represent the minimum SVL at sexually maturity reported for *N. h. paucimaculata* (Greene et al., 1999).




Female
Male
SVL
900
800
700
600
500
400
300
200
5
4
3
2
1
0
1
2
3
4
5
Frequency

different from parity. Captured *N. h. harteri* ($N = 35$) had a mean (±1 SE, range) SVL of 456.6 mm (±28.1, 245-805), tail length of 143.4 mm (±8.3, 73-235), and mass of 80.2 g (±12.7, 7.5-320). Two adult females had total lengths >902 mm, which is the total length of the largest known specimen of *N. h. harteri* (Werler and Dixon, 2000) prior to this study. The largest snake had a total length of 1040 mm, exceeding the previous record by 138 mm.

Twenty-five *N. h. harteri* (9 adults, 16 juveniles) were found during 15 intensive searches, and 17 (adults) were found while visually searching from a boat. A great amount of survey effort was necessary to find *N. h. harteri* during this study. Along the river corridor, catch-per-unit-effort (CPUE) was 1 *N. h. harteri*/9.30 man-h and 1 *N. h. harteri*/91.74 man-h for intensive searching and observing from a canoe, respectively. In Possum Kingdom Lake, nine *N. h. harteri* were observed in 47.80 man-h, resulting in CPUE of 1 *N. h. harteri*/5.31 man-h. Survey times were not recorded during searches of Lake Granbury; therefore, survey effort could not be calculated. Additionally, no *N. h. harteri* were captured using minnow traps, and because of their limited use in this study, these data were excluded. Overall, CPUE during this study was 1 *N. h. harteri*/24.15 man-h.

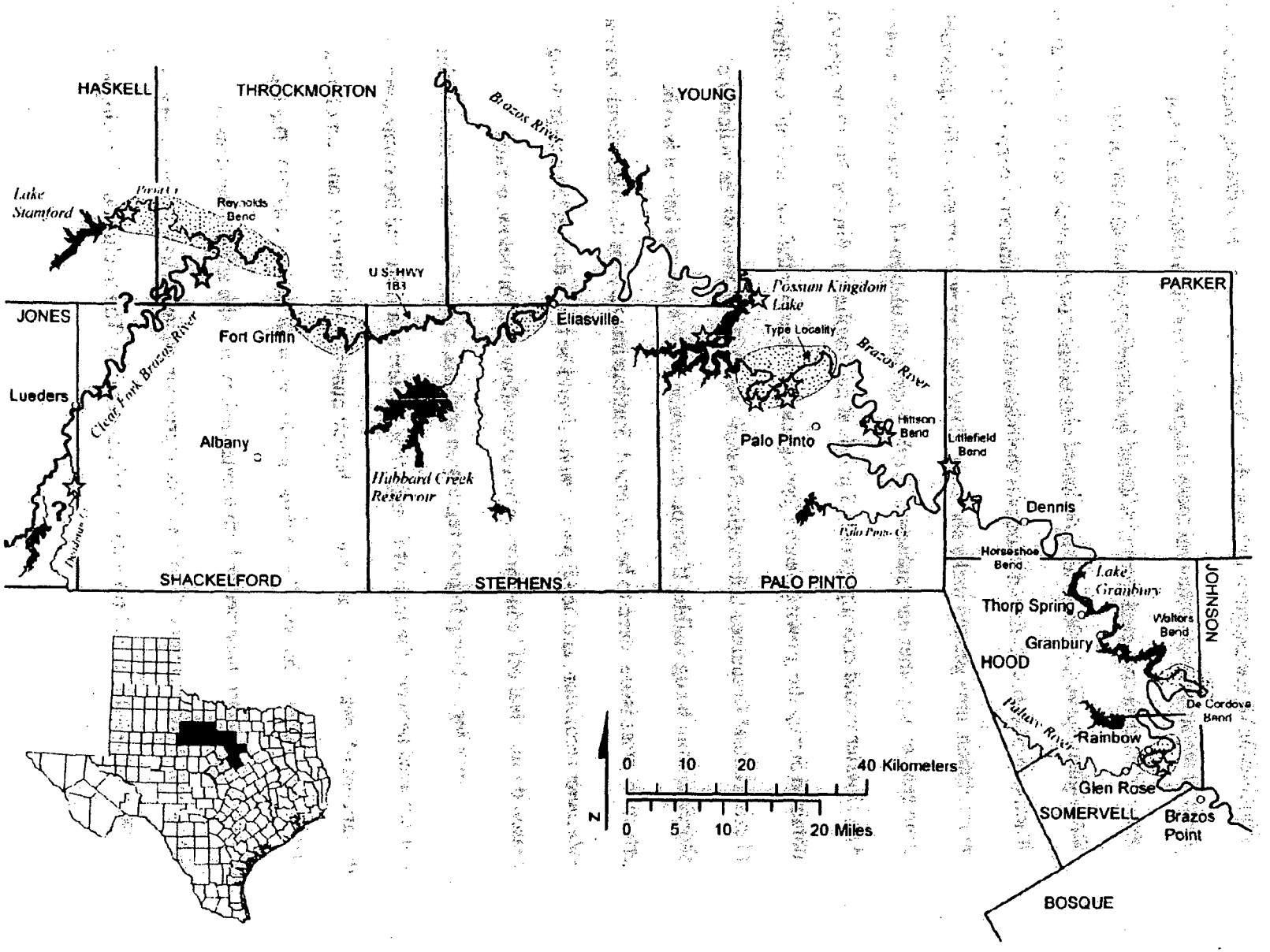
During intensive searches, 17 *N. h. harteri* were found under rock (3 adults, 14 juveniles), 7 (5 adults, 2 juveniles) were found in the water, and 1 (adult) was basking on a rock shelf. All *N. h. harteri* observed from a boat ($N = 17$) were adults swimming in the water, except for one adult found partially exposed in a rock pile along the shoreline. The mean (±1 SE, range) dimensions of rock (thickness × longest axis × shortest axis) that

adults and juveniles were found under were 11.3 cm (±2.3, 7-15) × 86.7 cm (±16.3, 61-117) × 65.3cm (±9.8, 46-78), and 8.2 cm (±0.7, 4-14) × 55.6 cm (±7.6, 30-127) × 36.5 cm (±4.1, 15-60), respectively. No significant difference was detected in thickness (t_{15} = 1.65, P = 0.12) or longest axis (t_{15} = 1.71, P = 0.11) of rocks that adult and juvenile *N. h. harteri* were found under; however, adults were found under rocks that had a significantly longer shortest axis (t_{15} = 2.91, P = 0.01). This result is likely an artifact of larger snakes needing larger cover objects.

Habitat Quantification and Delineation.—Six sections of river within the range of *N. h. harteri* contained the most rocky habitat (i.e., these stretches had counts for rock ≥10 cm that were in the highest two quartiles; Fig. 3). All sections identified encompassed localities where *N. h. harteri* have been previously documented except for one, immediately west of Eliasville, Texas. Habitat data could not be collected along approximately 46 km of the Clear Fork of the Brazos River, beginning in northwestern Shackelford County downstream to the confluence of Paint Creek, due to high water following heavy rain events during each of two surveys along this stretch of river. Additionally, habitat data were not collected along Deadman Creek due to a lack of access.

Using aerial imagery to delimit juvenile *N. h. harteri* habitat was unsuccessful for a number of reasons. Aerial photographs from Possum Kingdom Lake down to the upper reaches of Lake Whitney were taken on 04 August 2004, and photographs of the upper portion of the range of *N. h. harteri* were taken on 14-18 October 2004. Initial

FIGURE 3. Map of sections of river along the upper Brazos River drainage, Texas, which contained the greatest amount of rocky habitat, 2006-2008. Locations where *N. h. harteri* were found during this study are indicated by stars. Some stars may cover more than a single site. Habitat data were not collected along Deadman Creek and approximately 46 km of the Clear Fork of the Brazos River, indicated by the "?".


HASKELL
THROCKMORTON
YOUNG
PARKER
JONES
SHACKELFORD
STEPHENS
PALO PINTO
JOHNSON
HOOD
SOMERVELL
BOSQUE
Lake Stamford
Reynolds Bend
U S HWY 183
Brazos River
Possum Kingdom Lake
Type Locality
Eliasville
Fort Griffin
Clear Fork Brazos River
Lueders
Albany
Hubbard Creek Reservoir
Palo Pinto
Hilton Bend
Littlefield Bend
Dennis
Horseshoe Bend
Lake Granbury
Thorp Spring
Walters Bend
Granbury
De Cordova Bend
Paluxy River
Rainbow
Glen Rose
Brazos Point
0 10 20 40 Kilometers
0 5 10 20 Miles
N

examination of the imagery indicated that water levels were above normal throughout most of the study area at the time the photographs were taken. Examination of streamflow data collected from U.S. Geological Survey hydrologic stations (U.S. Geological Survey, 2008) within the study area confirmed this observation (Table 2). Another problem with this method was the resolution of the imagery; despite having a 1-m resolution, unvegetated rocky shoreline along the river was virtually indistinguishable from sand or any other bare substrate. Furthermore, calculation of the area of rock within 3 m of water would encompass only 3 pixels at this resolution. Finally, NAIP imagery is obtained during the growing season (spring and summer months) for "leaf on" conditions (Texas Natural Resources Information System, 2008). This prevents the majority of shoreline from being visible. If remote delineation of *N. h. harteri* habitat is to be effective, these issues need to be addressed. Suitable imagery for this task should have a sub-meter resolution, and aerial photographs should be taken during the non-growing season during "leaf off" conditions, when streamflow is at, or below, normal.

Modeling.—Using logistic regression analysis, a significant linear relationship was detected between the logit of finding *N. h. harteri* at a riffle and the combination of the amount of rock ≥10 cm at a site (i.e., habitat quality), and the total amount of rock ≥10 cm surrounding that site (i.e., habitat density; $\chi^2_2 = 18.046$, $P < 0.001$). The logit of finding *N. h. harteri* increased as both habitat quality at a site and habitat density surrounding a site increased (Table 3). The regression equation took the form: $g(x) = -5.318 + 0.020(\text{habitat quality}) + 0.016(\text{habitat density})$. The likelihood of finding *N. h.*

TABLE 2. Comparison of streamflow recorded 4 August 2004 to historic streamflow for 4 August from U.S. Geological Survey hydrologic stations along the upper Brazos River, Texas. Discharge >75th percentile is above normal. Data obtained from U.S. Geological Survey (2008).

Station no.	Location	Mean daily discharge 4 Aug 2004 (m^3/sec)	Historic median daily discharge (m^3/sec)	75th percentile (m^3/sec)
8088610[a]	Brazos River near Graford, TX	75.32	9.43	16.23
8089000	Brazos River near Palo Pinto, TX	90.90	11.47	30.02
8090800	Brazos River near Dennis, TX	151.78	11.38	20.25
8091000	Brazos River near Glen Rose, TX	37.38	10.48	29.73

[a]<30 yr of recorded data.

TABLE 3. Results from logistic regression analysis used to model the likelihood of finding *N. h. harteri* along the upper Brazos River drainage, Texas, 2006-2008.

Variable	*d.f.*	β	SE	Wald χ^2	*P*	e^{β}	95% CI for e^{β} Lower	Upper
Constant	1	-5.318	1.080	24.250	<0.001	0.005	-	-
Habitat quality[a]	1	0.020	0.010	4.487	0.034	1.021	1.002	1.040
Habitat density[b]	1	0.016	0.005	10.617	0.001	1.016	1.006	1.026

[a]Amount of rock ≥10 cm at a site.
[b]Amount of rock ≥10 cm within 5 km up- and downstream from a site.

harteri at a site increased by 2.1% with every additional rock ≥10 cm recorded at a site, holding habitat density constant. Likewise, the likelihood of finding *N. h. harteri* at a site increased by 1.6% with every additional rock ≥10 cm recorded within 5 km up- and downstream of a site, holding habitat quality constant.

DISCUSSION

Current Status.—From the time of its discovery and initial description (Trapido, 1941) through the mid-1980s (Scott et al., 1989), *N. h. harteri* was the common and abundant snake in areas with suitable habitat throughout its range. Concern was expressed in 1999 regarding an apparent rapid disappearance of the snake from the section of river known historically to support the largest population (Rossi and Rossi, 1999). Results from this study indicate that while the range of *N. h. harteri* remains intact (Fig. 1), the population density has declined significantly and *N. h. harteri* is now a rare snake throughout its range. Compared to surveys conducted during the 1980s (N. J. Scott, Jr., U.S. Geological Survey, retired, unpublished data), these snakes were found at fewer sites and in drastically reduced numbers. To illustrate the magnitude of the current decline the following example is offered. During a single survey at the type locality of *N. h. harteri* (11 km north of Palo Pinto, Texas) in May 1984, 36 individuals were found in about 3 man-h of effort (N. J. Scott, Jr., unpublished data). During this study more than 11 man-h were spent searching this location and no *N. h. harteri* were found. The most productive sites in this study yielded only four individuals during a single survey.

Scott et al. (1989) observed that the majority of *N. h. harteri* at sites were <1 yr old. The overall paucity of juveniles found during this study was alarming and indicates a contracting population. Life history studies of *N. h. paucimaculata* (Mueller, 1990;

Greene et al., 1999; Whiting et al., 2008) suggest that *N. h. harteri* is an early-maturing, short-lived snake that exhibits relatively high fecundity to offset low annual survivorship. Female *N. h. paucimaculata* give birth to their first clutch at 24-25 or 36-37 months (Werler and Dixon, 2000). Clutch sizes range from 4-29 young (mean = 11) and are positively correlated with female SVL (Greene et al., 1999). Clutch sizes reported for *N. h. harteri* range from 4-23 young (Conant, 1942; McCallion, 1944; Carl, 1981). Annual survival for adult and juvenile *N. h. paucimaculata* is about 0.23 and 0.14, respectively (Whiting et al., 2008), and approximately 1 in 100 (0.012-0.018) snakes are estimated to survive to age five (Mueller, 1990; Whiting, 1993). Given this life history strategy, a high juvenile to adult ratio is expected for a relatively stable or expanding population.

Potential Causes of Decline.—Six factors have been associated with the worldwide decline of amphibians and reptiles: habitat loss and degradation, introduced invasive species, environmental pollution, disease and parasitism, unsustainable use, and global climate change (Gibbons and Stangel, 1999). While this study was not able to provide direct evidence to explain the recent decline of *N. h. harteri*, anecdotal evidence has allowed for speculation on a number of potential factors.

Dams and water development projects have been the primary factor responsible for the degradation and loss of *N. h. harteri* habitat (Scott et al., 1989). Several low-head dams along the Clear Fork of the Brazos River and two major impoundments along the Brazos River, Possum Kingdom Lake and Lake Granbury, lie within the range of *N. h. harteri*. Aside from inundation of river habitat upstream from these dams, the negative effects from a modified flow regime must be considered. Analysis of streamflow data

(U.S. Geological Survey, 2008) recorded at the type locality of *N. h. harteri* clearly demonstrates how impoundment of the upper Brazos River drainage has dramatically altered the natural flow regime of the system (Fig. 4). Prior to the completion of Possum Kingdom Lake in 1941, streamflow mimicked the bimodal pattern of precipitation, with a late spring peak followed by a smaller peak in the fall. Following impoundment, the magnitude of spring and fall streamflow has been reduced and there is now a single peak in early summer followed by a gradual reduction in flow through the fall. Summer flow is dramatically higher and winter flow is slightly greater. Additionally, the magnitude of extreme high and low flow events has been reduced following impoundment (Table 4) and the variability of streamflow has increased dramatically (Fig. 5), with the median annual number of reversals (i.e., the number of days in which the direction of flow rate reverses) more than doubling from 71.5 to 147 for pre- and post-impoundment conditions, respectively. Suitable rocky riffles still exist below Possum Kingdom Lake, and while the Brazos River has not experienced sedimentation of riffle habitats like that observed along the Colorado River (Fig. 4 in Scott et al., 1989), the reduction of extreme high flow events has likely reduced flushing and scouring of the river channel and threatens juvenile *N. h. harteri* habitat. Furthermore, the attenuation of extreme events may affect the riparian vegetation by promoting the establishment of invasive species such as saltcedar over native plants. As discussed below, this can also lead to degradation of riffle habitat. Finally, the constant variability of flow caused by frequent hydroelectric releases, particularly during the summer months, may directly affect *N. h. harteri*. These usually short periods of increased flow cause riffle habitat to become inundated. The

FIGURE 4. Median monthly streamflow at the type locality of *N. h. harteri*, 11 km north of Palo Pinto, Texas, before and after impoundment of the Brazos River upstream by Morris Sheppard Dam in 1941. Data were recorded from U.S. Geological Survey hydrologic station 8089000 (U.S. Geological Survey, 2008).

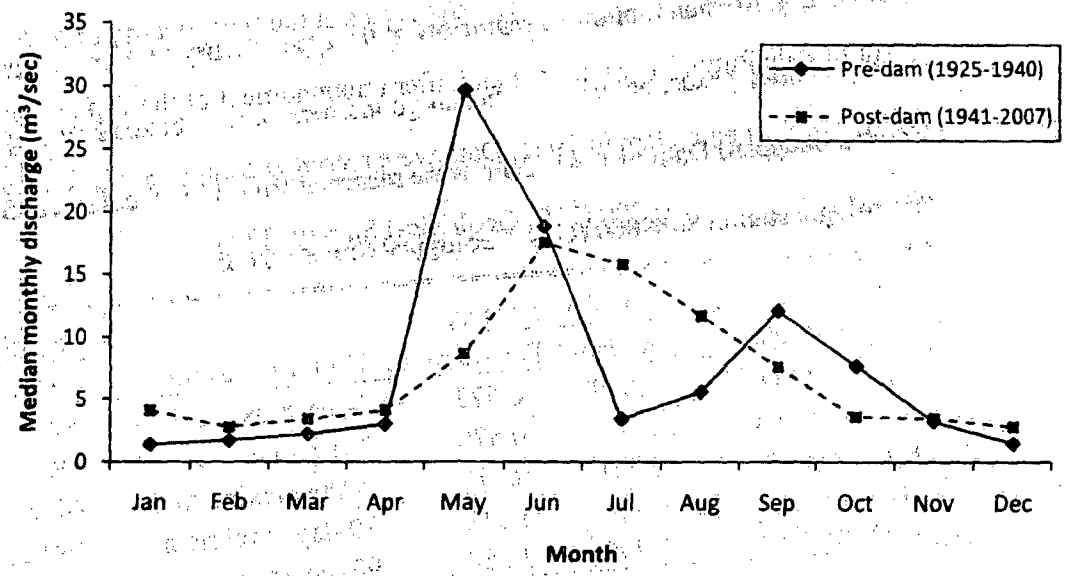
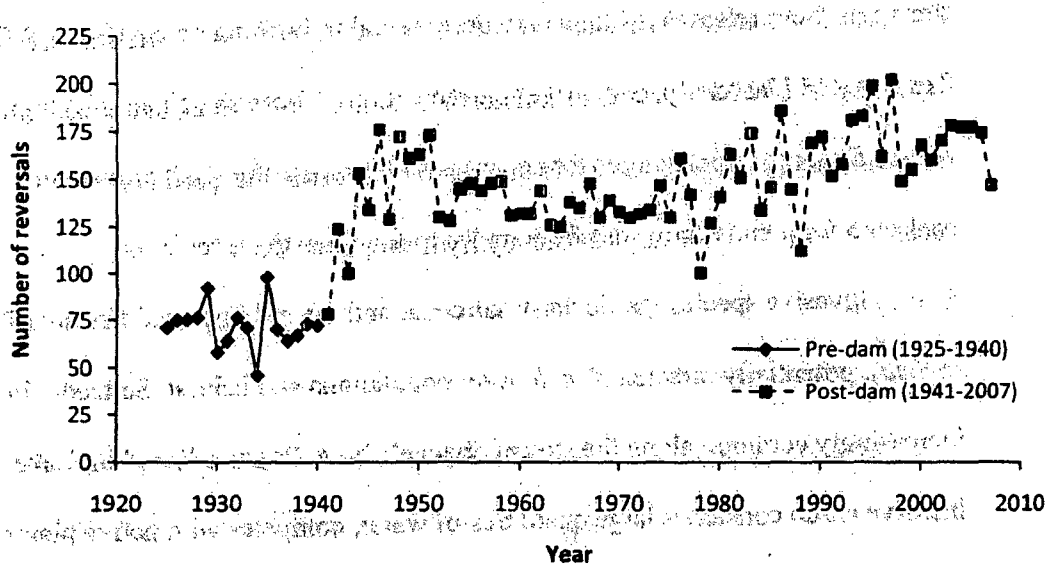

Median monthly discharge (m³/sec)
35
30
25
20
15
10
5
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Pre-dam (1925-1940)
Post-dam (1941-2007)

TABLE 4. Comparison of extreme flow events at the type locality of *N. h. harteri*, 11 km north of Palo Pinto, Texas, before and after impoundment of the Brazos River upstream by Morris Sheppard Dam in 1941. Data were recorded from U.S. Geological Survey hydrologic station 8089000 (U.S. Geological Survey, 2008).

	Median (m^3/sec)			Median (m^3/sec)	
Low flow events	Pre-dam	Post-dam	High flow events	Pre-dam	Post-dam
1-day minimum	0.000	0.623	1-day maximum	872.2	368.1
3-day minimum	0.000	0.670	3-day maximum	683.4	262.6
7-day minimum	0.001	0.777	7-day maximum	444.0	166.7
30-day minimum	0.111	1.518	30-day maximum	149.2	88.3
90-day minimum	1.793	3.288	90-day maximum	75.6	46.9

FIGURE 5. Number of days the rate of change of streamflow switched direction at the type locality of *N. h. harteri*, 11 km north of Palo Pinto, Texas, before and after impoundment of the Brazos River upstream by Morris Sheppard Dam in 1941. Data were recorded from U.S. Geological Survey hydrologic station 8089000 (U.S. Geological Survey, 2008).


225
200
175
150
125
100
75
50
25
0
Number of reversals
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year
Pre-dam (1925-1940)
Post-dam (1941-2007)

timing of these releases is likely very detrimental to birthing on a riffle (J. R. Dixon, Texas A&M University, personal communication). These short bursts of high water may reduce foraging opportunities for neonates and increase the risks of predation by forcing snakes to frequently move out from under rocks when the river rises.

Invasive species, particularly saltcedar and the red imported fire ant (*Solenopsis invicta*), potentially threaten *N. h. harteri* populations and habitat. Saltcedar becomes increasingly common along the stream channel above Possum Kingdom Lake. This invasive shrub consumes large quantities of water, competes with native plants, increases sediment deposition within the stream channel, and ultimately results in contraction of the stream channel (Blackburn et al., 1982; Brotherson and Field, 1987). These effects can quickly reduce a rocky riffle to a slow, sediment filled channel, and threatens juvenile *N. h. harteri* habitat. Negative impacts of *S. invicta*, both direct and indirect (e.g., reduced survival, behavioral changes, and changes in habitat use), have been reported for several species of herpetofauna (reviewed in Allen et al., 2004), including snakes. These ants are common in Texas, and were observed at several potentially suitable riffles where they were found under nearly every rock turned. No snakes of any species were found in this situation, and a snake seeking refuge in these areas would likely be exposed to significant risks of injury or mortality from ants. No direct evidence exists to indicate that *S. invicta* negatively impacts *N. h. harteri*; however, these ants are recognized as a threat to *N. h. paucimaculata* (Forstner et al., 2006) and can likewise be considered a threat to *N. h. harteri*.

Another factor potentially affecting *N. h. harteri* populations are the rather recent outbreaks of toxic *Prymnesium parvum* (golden algae) blooms within the Brazos River drainage. Toxins produced during blooms are not known to directly affect lung-respiring organisms; however, ichthyotoxins released by *P. parvum* disrupt the functioning of gills in fish, mollusks, arthropods, and gill-breathing amphibians (Paster, 1973), and can result in extensive mortalities (James and De La Cruz, 1989; Rhodes and Hubbs, 1992). Within the Brazos River drainage, confirmed fish kills by *P. parvum* blooms were first reported in 1988 and have subsequently continued to be documented throughout the range of *N. h. harteri* (Texas Parks and Wildlife Department, 2007b). While the prevalence of *P. parvum* in Texas is poorly understood, its effect on fish populations may pose a significant threat to *N. h. harteri*. The diet of *N. h. harteri*, inferred from the feeding ecology of *N. h. paucimaculata* (Greene et al., 1994), is almost entirely piscivorus with minnows (Cyprinidae) constituting the largest component. A reduction in prey availability, particularly during crucial feeding periods (e.g., after spring emergence or after parturition in the fall), may reduce survivorship. The actual effects of *P. parvum* blooms on *N. h. harteri* prey are not well known; however, the coincidence of massive fish kills within the range of *N. h. harteri* and the observed decline of the snake is apparent.

Rossi and Rossi (1999) found many juvenile *N. erythrogaster transversa* in areas where *N. h. harteri* were previously found and suggested that competition between syntopic snake species for food and hiding places may be a significant factor affecting *N. h. harteri* populations. According to the competitive exclusion principle (Gause, 1934;

Hardin, 1960), species competing for the same resources cannot coexist indefinitely in a stable environment. *Nerodia h. harteri* fills a unique niche (i.e., shallow riffle habitats) not typically exploited by *N. rhombifer* and *N. e. transversa* (Werler and Dixon, 2000), except perhaps for a short period when snakes are young. During this study, juvenile *N. rhombifer* and *N. e. transversa* were found under rocks in apparently suitable habitat lacking *N. h. harteri*. Additionally, juveniles of all three snakes were found occupying the same riffles, and on occasion *N. h. harteri* were found under the same rock as a congener. Large *N. rhombifer* and *N. e. transversa* were not found in shallow riffles during this study, but adults of all three snakes were found together in deeper waters. These areas however, were typically occupied only by *N. rhombifer* and *N. e. transversa*. Scott et al. (1989) reported similar findings. Niche partitioning and ontogenetic shifts in prey, habitat preferences, and activity patterns likely relax direct competition between these syntopic snakes (see Gibbons and Dorcas, 2004). While competition may have had an important influence in the present distribution of these three snake species (Tinkle and Conant, 1961), it is unlikely that it has had a major role in the reduction of *N. h. harteri* presently observed.

A final potential factor warranting discussion is direct anthropogenic impacts on *N. h. harteri*. Of particular concern are the combined pressures from increasing human densities and recreational use of the Brazos River system. During this study recreational use was observed to be highest along the Brazos River below Possum Kingdom Lake; however, evidence of extensive recreational use was also observed along the more remote stretches of the Clear Fork along the western extent of the range of *N. h. harteri*. Juvenile

N. h. harteri habitat consists of low lying, rocky shorelines adjacent to shallow waters, and this habitat is ideal for human recreation. During this study, many people were observed utilizing these areas. Additionally, anglers often turn rocks along the riverbank in search of fishing bait. These circumstances have undoubtedly led to the unexpected discovery of snakes and their likely demise. Turtles and one *N. e. transversa* were found shot by small caliber firearms during this study. Turtles were also found snagged on trot-lines, and one dead *N. rhombifer* was found entangled in a limb-line overhanging the river. Furthermore, extensive efforts were made searching for *N. h. harteri* at one of the historically most productive sites without success; coincidentally, this is also the site of a very popular campground. While this evidence is largely anecdotal and speculative, the notion of direct anthropogenic impacts on *N. h. harteri* is shared by other experienced herpetologists (J. R. Dixon, personal communication; M. R. J. Forstner, personal communication).

Distribution and Habitat.—This study provided a detailed account of the distribution of *N. h. harteri* throughout the range of the snake (Fig. 1). At the most upstream extent of the range, Scott et al. (1989) noted an apparently isolated population along Deadman Creek, a small tributary to the Clear Fork of the Brazos River east of Lake Fort Phantom Hill, Jones County. A single individual was found 7 km upstream from the confluence with the Clear Fork, and approximately 3.5 km downstream from the locality reported by Scott et al. (1989). In accordance with Scott et al. (1989), habitat exists from the mouth of the creek upstream approximately 16 km. At all sites examined

upstream from this point, the creek was slow flowing, choked by heavy vegetation, and unsuitable for *N. h. harteri*.

Along Paint Creek, Smith (1983) reported *N. h. harteri* from just below Lake Stamford Dam in Haskell County. Scott et al. (1989) found the snake approximately 2 km below the dam and assumed populations to be present along the entirety of the creek below Lake Stamford. Subsequent to the study by Scott et al. (1989) a dam was built on Paint Creek near where they reported finding *N. h. harteri*. The dam allows water to pass during normal flows, but inundates the stream channel and surrounding area upstream during high flows. As a result, the upstream habitat has been reduced to a muddy flat and is unsuitable for *N. h. harteri*. Surveys during this study began at the dam on Paint Creek, approximately 2 km below Lake Stamford, and proceeded downstream to the creek's confluence with the Clear Fork. One *N. h. harteri* was found <1 km downstream from where Scott et al. (1989) reported finding the snake, and six additional snakes were found <4.5 km downstream (Fig. 1). No additional *N. h. harteri* were observed along Paint Creek beyond this point despite the presence of suitable habitat.

Below the confluence of Deadman Creek, the Clear Fork of the Brazos River is impounded approximately 11 km downstream by an old dam and grist mill at the small town of Lueders, Jones County, and is unsuitable for *N. h. harteri*. Previous investigators have documented *N. h. harteri* from below the dam at Lueders (Scott et al., 1989; Forstner et al., 2006; F. L. Rose, Texas State University – San Marcos, personal communication); however, none were found during this study. From Lueders downstream to the confluence of Paint Creek in Throckmorton County, *N. h. harteri* have not been

documented prior to this survey, but were assumed to be present (Scott et al., 1989). One individual was found 8.8 km downstream from the dam at Lueders and another was found 10.9 km upstream from the confluence of Paint Creek (Fig. 1). Approximately 17 km downstream from Lueders, river habitat is impounded by a low-head dam, and water is backed up for several kilometers upstream and is unsuitable for *N. h. harteri*.

Nerodia h. harteri have previously been documented along the Clear Fork near the mouth of Paint Creek, downstream at Reynolds Bend, Throckmorton County, and at Fort Griffin, Shackelford County (Tinkle and Knoph, 1964; Scott et al., 1989). During this study *N. h. harteri* were not found at any of these locations, or along the remainder of the Clear Fork below the Paint Creek confluence. Habitat was present along the Clear Fork from the dam at Lueders downstream to the Shackelford/Stephens county line. This finding is similar to Scott et al. (1989) who reported suitable habitat from Lueders downstream to Fort Griffin. Except for a stretch of river near the mouth of Paint Creek, rocky habitat was never abundant along the Clear Fork and was often separated by long stretches of deep, slow moving water. Downstream from the Shackelford-Stephens county line, rocky habitat is rare and the river becomes impounded by a series of six low-head dams from below the U.S. Highway 183 crossing in Stephens County, downstream to Eliasville, Young County. These dams create still backwaters for several kilometers upstream, and only short sections of river flow at normal levels downstream before becoming impounded again. Below Eliasville habitat is lacking overall, except for an isolated rocky riffle at the confluence of the Clear Fork and the Brazos River.

The Brazos River below the confluence of the Clear Fork is impounded by Possum Kingdom Lake and unsuitable for *N. h. harteri*. Porter (1969) reported the snake in the still waters of Possum Kingdom Lake, and Scott et al. (1989) found it along approximately 17 km of the upper end of the lake. Eight *N. h. harteri* (not including a recapture) were found at three sites previously reported by Scott et al. (1989; Fig. 1). All sites where *N. h. harteri* were found had similar habitat characteristics that included a gently sloping, rocky lake bottom adjacent to rocky shoreline, and were in relatively calm waters protected from wave action. These findings are similar to those reported by Scott et al. (1989), and by Whiting et al. (1997), who investigated the spatial ecology of *N. h. paucimaculata* at E. V. Spence Reservoir in Coke County, Texas.

Between Morris Sheppard Dam, Palo Pinto County, and Lake Granbury, Hood County, *N. h. harteri* have been reported from several locations (e.g., Trapido, 1941; Tinkle and Conant, 1961; Scott et al., 1989; Dorcas and Mendelson, 1991). Nineteen *N. h. harteri* were found at eight locations along this stretch of river (Fig. 1), and of these, four locations have not been previously reported. Scott et al. (1989) observed a 100 km hiatus in the distribution of *N. h. harteri* from Hittson Bend, downstream to Lake Granbury, and attributed it to a lack of cover and the sandy nature of the river along this section. Furthermore, they assumed populations within this stretch of river to be sparse and ephemeral (Scott et al., 1989). In agreement with Scott et al. (1989), the riverbed below Hittson Bend becomes increasingly sandy and habitat was less abundant compared to upstream; however, some habitat does occur, such as at Littlefield Bend where *N. h. harteri* were found in this study and by others (Wade, 1968; Dorcas and Mendelson,

1991). Downstream from Littlefield Bend, habitat becomes increasingly rare. The Brazos River reaches Lake Granbury at Horseshoe Bend, approximately 12 km downstream from the FM 1189 crossing near Dennis, Parker County.

Scott et al. (1989) documented *N. h. harteri* at only one location within Lake Granbury (U.S. Highway 377 bridge near Granbury, TX), and this has been the only report of the snake's presence since the lake's impoundment in 1969. Prior to impoundment, Wade (1968) found *N. h. harteri* near Walters Bend, approximately 4.8 km upstream from De Cordova Dam. *Nerodia h. harteri* were not observed within Lake Granbury during this study; however, it is important to note that surveys of the lake were conducted primarily in July 2007, and the combined effects of high lake levels from spring flooding and reduced activity of *N. harteri* during hot summer months (Greene et al. 1993) likely reduced the chances of detecting the snake. Furthermore, the shoreline around Lake Granbury has been modified extensively by human development and very little habitat was observed. If populations are present within the lake, they are likely isolated and small.

Below Lake Granbury, Wade (1968) documented *N. h. harteri* along De Cordova Bend approximately 4.5 km below the dam, and at the U.S. Highway 67 bridge east of Glen Rose, Somervell County. Scott et al. (1989) found *N. h. harteri* at the FM 200 crossing east of Rainbow, Somervell County, and at the FM 1118 bridge east of Brazos Point, Bosque County. While no *N. h. harteri* were found at these locations during this study, three snakes were found at a new locality east of Glen Rose, Texas, 10.5 km downstream from the U.S. Highway 67 crossing (Fig. 1). In agreement with Scott et al.

(1989), the river below De Cordova Dam is suitable downstream to the FM 1118 bridge. A short distance below this point the river becomes inundated by Lake Whitney. *Nerodia h. harteri* have not been documented from Lake Whitney or any point downstream.

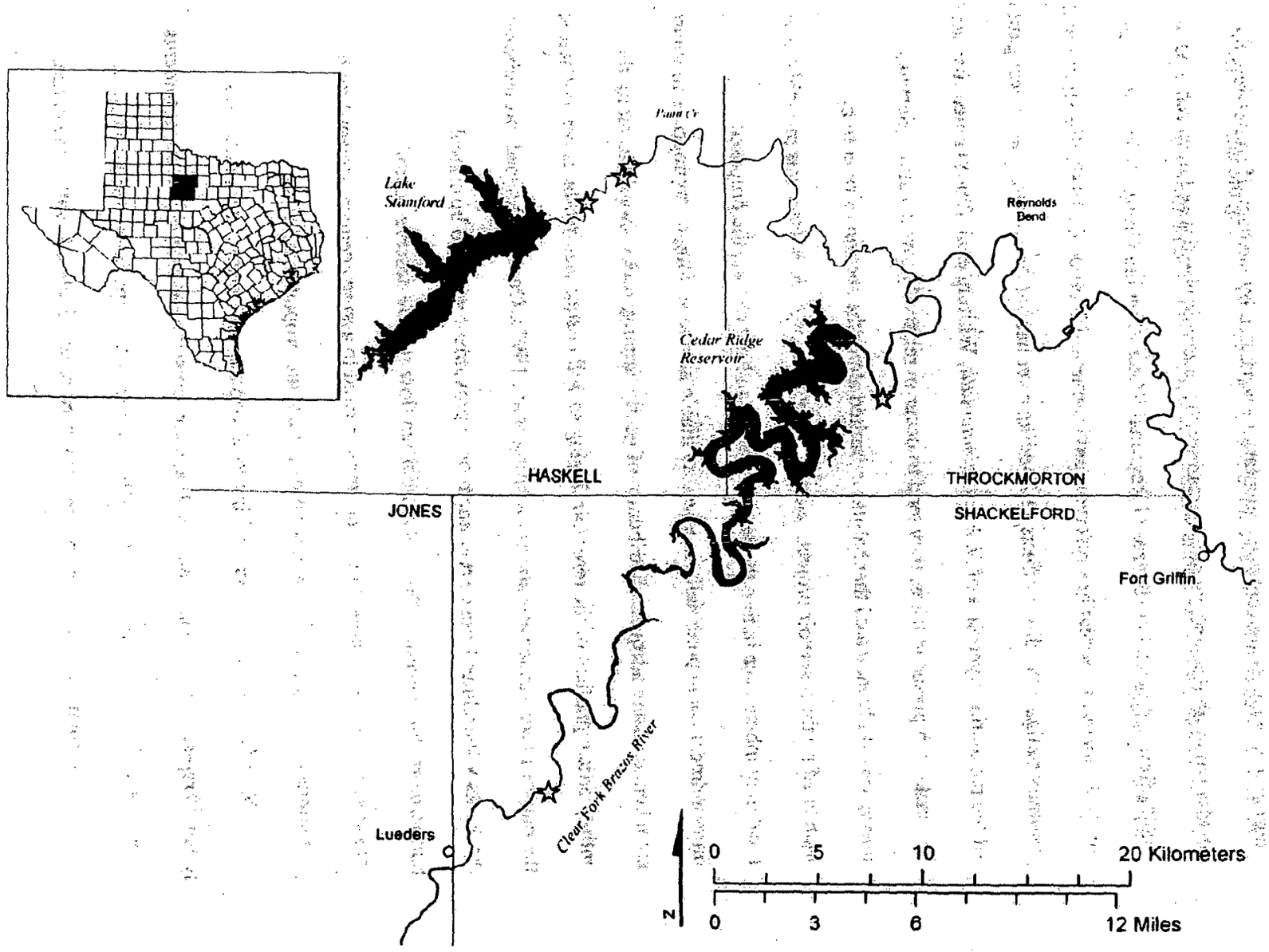
Modeling.—The objective of this study was not only to assess the current status of *N. h. harteri*, but also to investigate habitat relationships of the snake. Logistic regression analysis indicated that the abundance of rock ≥10 cm along the shoreline, both at a riffle and in proximity to a riffle, were significantly related to the likelihood of finding *N. h. harteri* at a site. The scope and design of this study did not allow for the use of presence-absence data to estimate occupancy and detection probabilities as described by MacKenzie et al. (2006). The low probability of detection, based on studies of *N. h. paucimaculata* (≤0.2; J. M. Mueller, Tarleton State University, personal communication), and the perceived low occupancy (probably <0.1) suggest that ≥7 surveys at each site would be necessary to estimate occupancy (MacKenzie et al., 2006). This was not feasible in this study. These findings suggest that *N. h. harteri* are more likely to be found in areas with higher amounts of rocky shoreline, and this fits the current understanding of the needs of juveniles.

An attempt was made to incorporate human recreational use of the river system into the logistic regression model by calculating the shortest distance of public access points (i.e., road crossings, campgrounds, public use areas) for each site. When added to the model, analysis indicated that the covariate was not useful (Wald $\chi^2_1 = 0.269$, $P = 0.604$) in explaining where *N. h. harteri* were found during this study. Several access points exist above Possum Kingdom Lake, in areas that are far less densely populated

compared to below the lake. To accurately model the impact of human use along the river, the chosen variable needs to incorporate not only access points along the river, but also the surrounding human density. This was not possible during this study.

Future.—Historically, *N. h. harteri* were found to be remarkably abundant in rocky areas throughout the range of the snake (Trapido, 1941; Scott et al., 1989); however, narrow habitat requirements and a limited distribution make it exceptionally vulnerable to environmental disturbances (Scott et al., 1989). *Nerodia h. harteri* has experienced a drastic reduction in population size since the 1980s and the reasons for this contraction are not well understood. Several potential factors have been addressed, although supporting evidence is largely anecdotal. Anthropogenic factors, particularly dam construction, appear to have had the greatest effect on reducing *N. h. harteri* habitat (Scott et al., 1989). In response to projected increasing water demands for the City of Abilene and irrigated agriculture in Throckmorton County, the 2007 State Water Plan (Texas Water Development Board, 2007) recommended that Cedar Ridge Reservoir, a proposed impoundment project along the Clear Fork of the Brazos River in southwestern Throckmorton County (Fig. 6), be designated as a unique reservoir site by the Texas legislature to ensure availability of the site for future water supply development. If constructed, Cedar Ridge Reservoir will inundate approximately 55 km of river habitat. Although *N. h. harteri* have not been documented along this stretch of river, snakes were found both up- and downstream from the proposed impoundment during this study (Fig. 6), and populations are likely present. In addition to inundating occupied river habitat, Cedar Ridge Reservoir will likely significantly alter the flow regime below the dam and

FIGURE 6. Map of proposed site for Cedar Ridge Reservoir along the upper Brazos River drainage, Texas. Locations where *N. h. harteri* were found during this study are indicated by stars.


Lake Stamford
Paint Cr
Reynolds Bend
Cedar Ridge Reservoir
HASKELL
THROCKMORTON
JONES
SHACKELFORD
Fort Griffin
Clear Fork Brazos River
Lueders
N
0
5
10
20 Kilometers
0
3
6
12 Miles

curtail genetic exchange between populations separated by the dam. If completed, the median monthly streamflow downstream of the reservoir is estimated to be reduced by ≥85% from July-October (Brazos G Regional Water Planning Group, 2006). The ability of *N. h. harteri* to persist in a reservoir environments (Scott et al., 1989; this study) will partially mitigate the direct effects of flooding river habitat. However, in an investigation of the population dynamics of *N. h. paucimaculata*, Whiting et al. (2008) noted that while the snake can persist in lakes, they tend to occur in relatively low densities. Surveys during this study indicated that habitat is limited along the section of river to be inundated by the reservoir project, and the population of *N. h. harteri* was probably never great in numbers even before the recent decline. In light of this, the proposed impoundment could potentially increase available habitat so long as appropriate measures are taken to ensure adequate distribution of gently sloping, rocky shorelines along the entire vertical gradient of the reservoir. Doing so will ensure that habitat is present across the range of lake surface elevations (Whiting et al., 1997). Once established, protection of these rocky shorelines from development or improvement will also be critical. Furthermore, the potential effects of a modified flow regime deserve careful consideration and provisions should be implemented to assure adequate streamflow for the maintenance of riffle habitat downstream from the proposed reservoir.

Nerodia h. harteri can obtain high local population densities within the river system (Trapido, 1941; Scott et al., 1989) and can persist in unnatural lake environments (Scott et al., 1989; this study). In the absence of long term population trend data for *N. h. harteri*, it is difficult to assess whether the observed recent decline is within the natural

range of variability for the population (Gibbons et al., 2000). Nonetheless, small population size (Pimm et al., 1988), small geographic range (Gaston, 1994), and specialized habitat requirements (Brown, 1995) have been hypothesized to increase a species vulnerability to extinction. Furthermore, Pimm et al. (1988) predicted that risk of extinction is greater at low population densities for species that are small-bodied, fast-growing, and short-lived, compared to those that are large-bodied, slow-growing, and long-lived. *Nerodia h. harteri* is restricted to one of the smallest geographic ranges of any North American snake, and is a highly aquatic, riffle dependent snake, whose life history is characterized by a relatively short life span, quick maturation, and high fecundity. Given the recent population decline and current scarcity of *N. h. harteri*, high recreational use of the Brazos River system, and proposed water development projects within its range, this snake may now be more vulnerable than *N. h. paucimaculata*, which has recently been proposed for removal from the list of species protected by the Endangered Species Act.

This study investigated the current status and distribution of *N. h. harteri* throughout its range and modeled the relationship between the abundance of rocky habitat and the likelihood of finding the snake. Results suggest that *N. h. harteri* is now a rare snake and the presence of riffle habitat is crucial for its continued persistence. Education and public awareness will be key in mitigating direct human impacts on *N. h. harteri* populations and habitat. In light of ever increasing human densities and demands for water and the climatic uncertainties of global climate change, the assurance of adequate instream flows and maintenance of the river channel will be critical for the

conservation of this Texas endemic snake. Given the rate at which this snake has declined, future conservation efforts need to be implemented in a timely manner, and consideration of a captive breeding program and potential reintroductions may be warranted. Future research should focus on assessment of local population dynamics, as well as the feasibility of reintroduction efforts. Other research should include an accurate survey of Lake Granbury, an assessment of the flow regime necessary for maintenance of riffle habitat, and the prevalence of fish kills caused by the microalga *P. parvum* within the upper Brazos River drainage and the response of forage fish populations. Finally, if construction of Cedar Ridge Reservoir is approved, there will be a unique opportunity to investigate the response of *N. h. harteri* to a major impoundment project.

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APPENDIX 1

TABLE 5. Data for individual *N. h. harteri* captured along the upper Brazos River drainage, Texas, 2006-2008.

			Length (mm)[b]								Rock size (cm)[e]		
Date	County[a]	Coordinates	SVL	T	TL	T:TL[c]	Mass (g)	Sex	Age	MF no.[d]	T	L	S
1. 03 Sep 2006	PP	32°49.60'N 98°21.07'W[f]	730	201	931[g]	0.216	180.0	F	ad	-	-	-	-
2. 16 Sep 2006	PA	32°42.40'N 98°03.28'W	255	93	348	0.267	12.0	M[h]	juv	-	7	62	48
3. 16 Sep 2006	PA	32°42.40'N 98°03.28'W	245	78	323	0.241	9.5	F	juv	-	8	61	60
4. 16 Sep 2006	PA	32°42.37'N 98°03.26'W	248	78	326	0.239	9.0	F	juv	-	10	34	33
5. 07 Oct 2006	PA	32°38.91'N 98°01.21'W[f]	268	100	368	0.272	12.0	M[h]	juv	-	11	41	22
6. 07 Oct 2006	PA	32°38.91'N 98°01.21'W[f]	264	90	354	0.254	9.5	F	juv	-	6	35	25
7. 07 Oct 2006	PA	32°38.91'N 98°01.21'W[f]	249	82	331	0.248	9.5	F	juv	-	7	41	15
8. 22 May 2007	PP	32°46.26'N 98°11.70'W[f]	642	204	846	0.241	200.0	F	juv	-	-	-	-
9. 31 Jul 2007	PP	32°48.52'N 98°23.98'W	407	133	540	0.246	48.0	F	juv	-	-	-	-
10. 15 Sep 2007	PP	32°48.69'N 98°20.58'W	577	174	751	0.232	125.0	F[h]	ad	-	-	-	-
11. 08 Apr 2008	PP	32°45.05'N 98°10.25'W[f]	805	235	1040[g]	0.226	320.0	F	ad	27370	-	-	-
12. 08 May 2008	PP	32°48.46'N 98°23.90'W	248	91	339	0.268	7.5	M	juv	27371	7	30	22
13. 08 May 2008	PP	32°48.46'N 98°23.90'W	301	112	413	0.271	13.0	M[h]	juv	27372	6	46	37
14. 09 May 2008	PP	32°49.53'N 98°21.05'W[f]	470	160	630	0.254	63.0	M	ad	27373	-	-	-
15. 09 May 2008	PP	32°50.04'N 98°20.20'W	637	182	819	0.222	150.0	F	ad	27374	-	-	-
16. 14 May 2008	SO	32°14.62'N 97°41.03'W[f]	568	211	779	0.271	98.0	M	ad	27375	-	-	-
17. 14 May 2008	SO	32°14.55'N 97°40.95'W[f]	715	187	902	0.207	210.0	F	ad	27376	-	-	-
18. 14 May 2008	SO	32°14.60'N 97°41.03'W[f]	690	200	890	0.225	195.0	F	ad	27377	-	-	-

TABLE 5. Continued.

Date	County[a]	Coordinates	Length (mm)[b] SVL	T	TL	T:TL[c]	Mass (g)	Sex	Age	MF no.[d]	Rock size (cm)[e] T	L	S
19. 15 May 2008	PP	32°54.53'N 98°29.57'W	582	165	747	-	105.0	M	ad	27378	-	-	-
20. 15 May 2008[i]	PP	32°54.53'N 98°29.57'W	-	-	-	-	-	-	ad	-	-	-	-
21. 15 May 2008[i]	PP	32°58.37'N 98°24.78'W	-	-	-	-	-	-	ad	-	-	-	-
22. 16 May 2008[i]	PP	32°54.58'N 98°29.67'W	-	-	-	-	-	-	ad	-	-	-	-
23. 16 May 2008[j]	PP	32°54.53'N 98°29.58'W	-	-	-	-	-	-	-	-	-	-	-
24. 16 May 2008	PP	32°58.25'N 98°24.98'W	617	195	812	0.240	148.0	F	ad	27379	-	-	-
25. 16 May 2008[i]	PP	32°58.24'N 98°25.02'W	-	-	-	-	-	-	ad	-	-	-	-
26. 16 May 2008	PP	32°58.24'N 98°25.02'W	555	171	726	-	108.0	M	ad	27380	-	-	-
27. 16 May 2008	PP	32°57.91'N 98°23.51'W	518	146	664	-	80.0	M	ad	27381	-	-	-
28. 20 May 2008	HA	33°05.08'N 99°32.54'W	257	80	337	0.237	10.5	F	juv	27382	12	40	24
29. 20 May 2008	HA	33°05.72'N 99°31.48'W[f]	417	142	559	0.254	57.0	M	ad	27383	7	117	78
30. 20 May 2008	HA	33°05.76'N 99°31.36'W[f]	333	93	426	0.218	23.5	F	juv	27384	4	49	34
31. 20 May 2008[k]	HA	33°05.76'N 99°31.37'W[f]	-	-	-	-	-	-	-	-	-	-	-
32. 20 May 2008[l]	HA	33°05.76'N 99°31.37'W[f]	-	-	-	-	-	-	juv	-	-	-	-
33. 20 May 2008	HA	33°05.76'N 99°31.37'W[f]	303	91	394	0.231	19.5	F	juv	27385	7	110	58
34. 21 May 2008	HA	33°05.99'N 99°31.21'W[f]	276	91	367	0.248	15.5	M	juv	27386	6	44	26
35. 21 May 2008	HA	33°06.01'N 99°31.21'W[f]	578	227	805	0.282	130.0	M	ad	27387	-	-	-
36. 23 May 2008	JO	32°40.60'N 99°37.04'W[f]	524	183	707	0.259	90.0	M	ad	27388	-	-	-
37. 23 May 2008	SH	32°49.60'N 99°33.73'W[f]	555	136	691	-	118.0	F	ad	27389	-	-	-

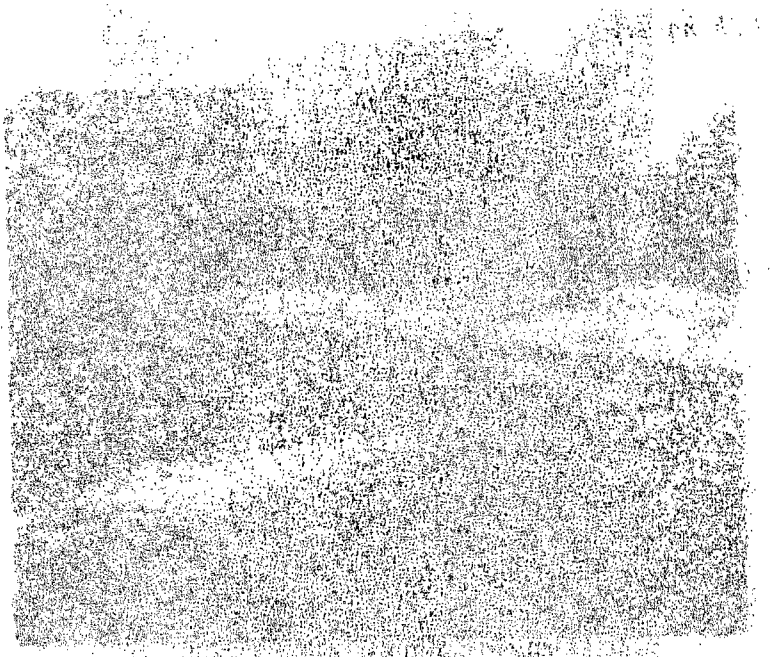
TABLE 5. Continued.

Date	County[a]	Coordinates	Length (mm)[b] SVL	T	TL	T:TL[c]	Mass (g)	Sex	Age	MF no.[d]	Rock size (cm)[e] T	L	S
38. 27 May 2008	TH	32°59.98'N 99°23.39'W[f]	494	185	679	0.272	68.0	M	ad	27390	-	-	-
39. 03 Jun 2008	PA	32°42.38'N 98°03.24'W	386	73	459	-	32.0	M	ad	27391	15	82	72
40. 03 Jun 2008	PA	32°42.40'N 98°03.28'W	455	141	596	0.237	52.0	F	juv	27392	10	58	49
41. 03 Jun 2008	PA	32°42.43'N 98°03.34'W	374	136	510	0.267	29.0	M	juv	27393	14	127	58
42. 03 Jun 2008	PA	32°42.42'N 98°03.30'W	439	152	591	0.257	50.0	M	ad	27394	12	61	46

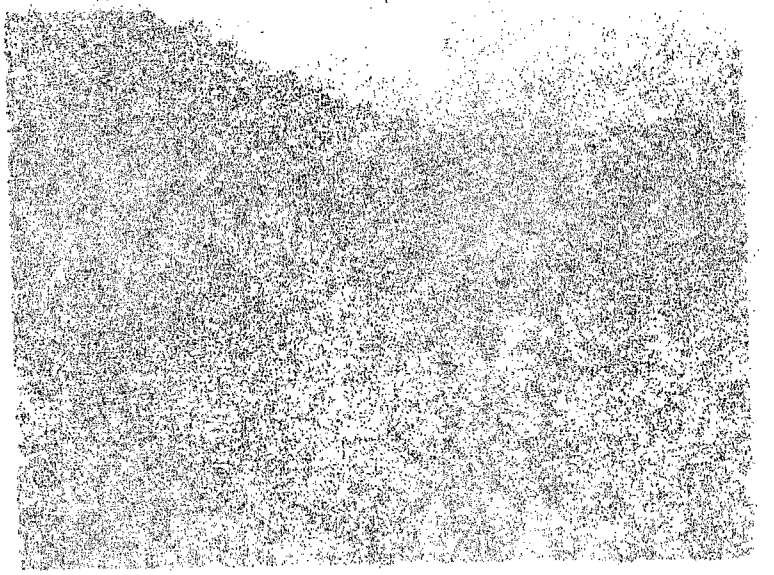
[a]PP = Palo Pinto, PA = Parker, SO = Somervell, HA = Haskell, JO = Jones, SH = Shackelford, TH = Throckmorton.
[b]SVL = snout-vent length, T = tail length, TL = total length.
[c]Tail length:total length ratio calculated for snakes with complete tails.
[d]MF Tissue Catalog no. at Texas State University - San Marcos Department of Biology (Michael Forstner, curator).
[e]T = thickness, L = long axis, S = short axis.
[f]New locality record ≥1 km from previously reported records.
[g]> largest known specimen (Werler and Dixon, 2000).
[h]Corrected sex based on tail length:total length ratio.
[i]Observation only.
[j]Recapture of no. 19.
[k]Recapture of no. 29.
[l]Escaped after capture.

APPENDIX 2

FIGURE 7. Photograph of the largest *N. h. harteri* captured along the upper Brazos River drainage, Texas, in hand for scale reference, 2006-2008. Total length = 1040 mm.



APPENDIX 3



Pictures of habitat encountered during this study and examples of habitat occupied by *N. h. harteri*.

FIGURE 8. *Nerodia h. harteri* habitat along Deadman Creek near the Rising Sun Cemetery, Jones County, Texas, May 2008.

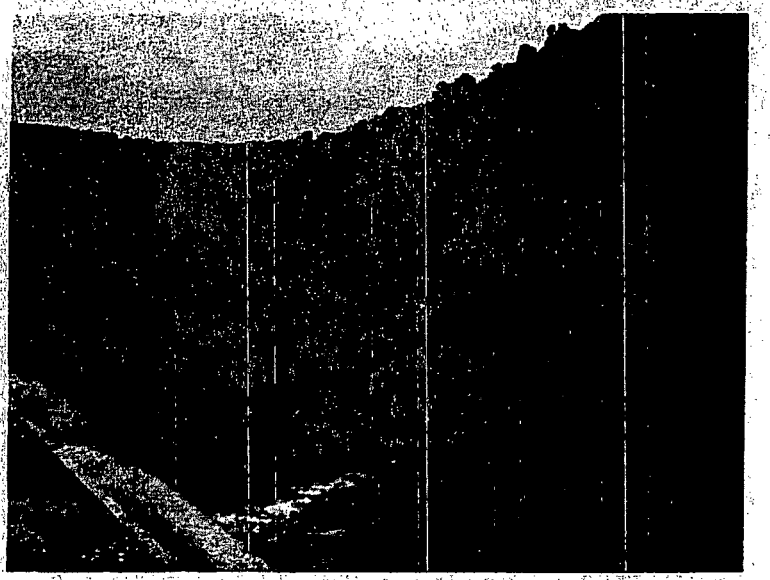


FIGURE 9. Muddy flat upstream of dam on Paint Creek, Haskell County, Texas, approximately 2 km below Lake Stamford Dam, May 2008.

FIGURE 10. *Nerodia h. harteri* habitat along Paint Creek, Haskell County, Texas, May 2008.

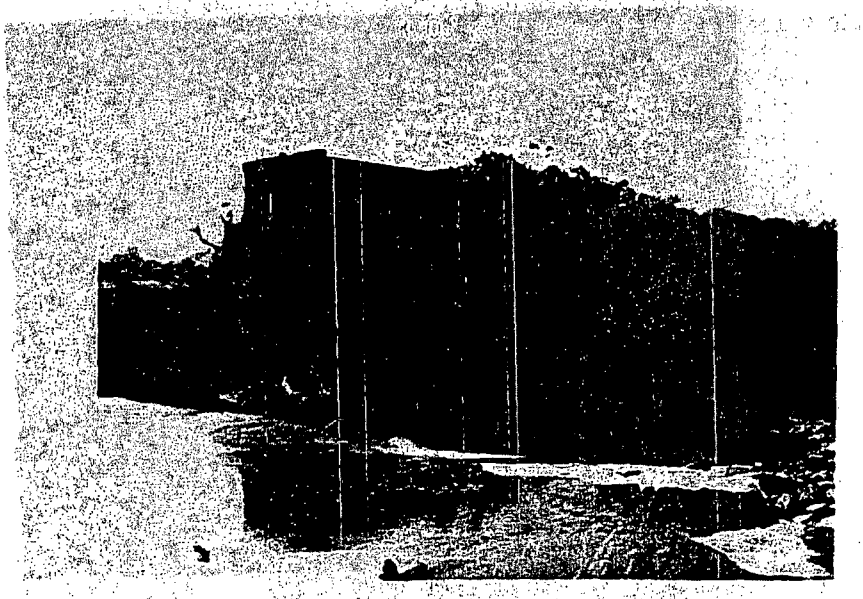


FIGURE 11. Historic locality of *N. h. harteri* along the Clear Fork of the Brazos River at an old dam and grist mill near Lueders, Jones County, Texas, looking downstream, May 2008.

FIGURE 12. Historic locality of *N. h. harteri* along the Clear Fork of the Brazos River at an old dam and grist mill near Lueders, Jones County, Texas, looking upstream, May 2008.

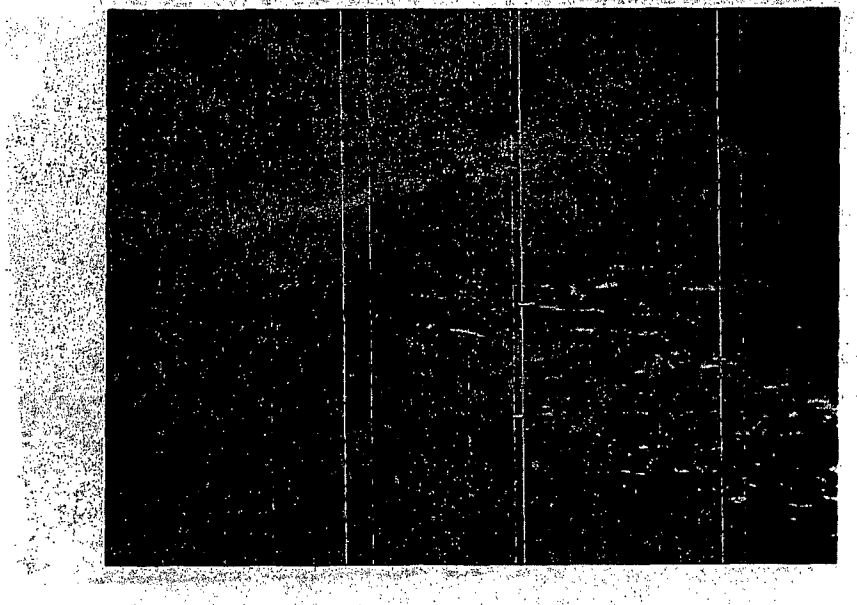


Figure 13. Historic locality of *N. h. harteri* along the Clear Fork of the Brazos River at Paint Crossing on the Lambshead Ranch, Throckmorton, County, Texas, April 2008.

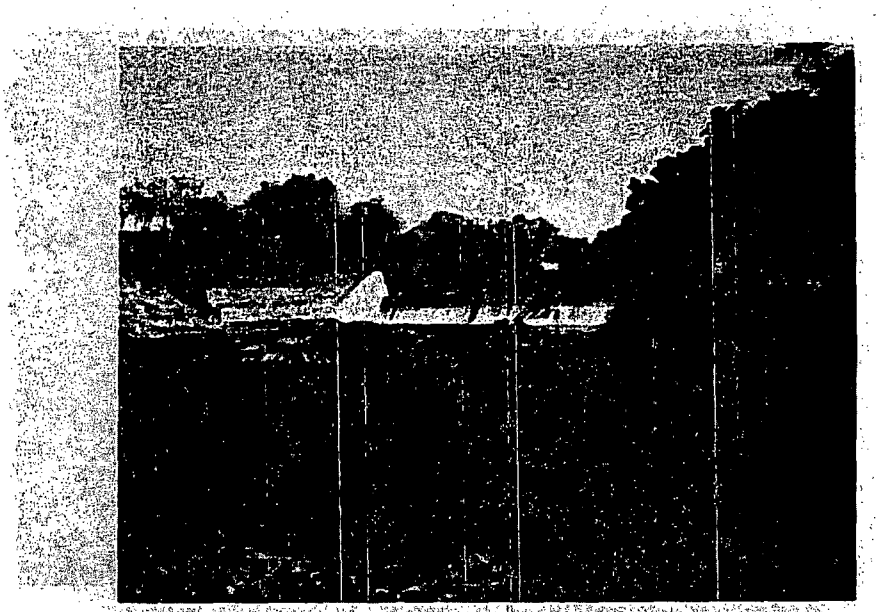


FIGURE 14. Example of one of the seven low-head dams along the Clear Fork of the Brazos River within the range of *N. h. harteri*, April 2008. This dam is east of the U.S. Highway 183 crossing, Stephens County, Texas.

FIGURE 15. *Nerodia h. harteri* habitat in Possum Kingdom Lake along the mouth of Ramsey Creek, Palo Pinto County, Texas, May 2008.

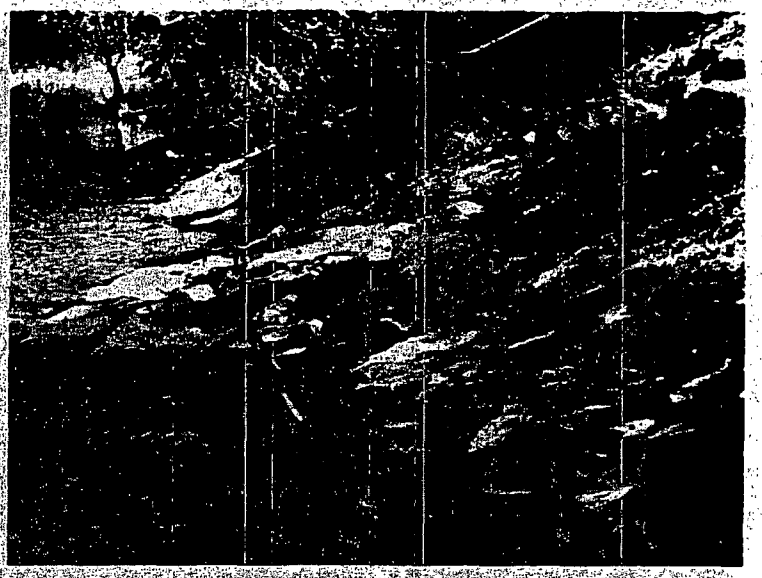


FIGURE 16. *Nerodia h. harteri* habitat in Possum Kingdom Lake near the end of Farm-to-Market 1148, Palo Pinto County, Texas, with a snake peering out from the rocks at the center of the photograph, May 2008.

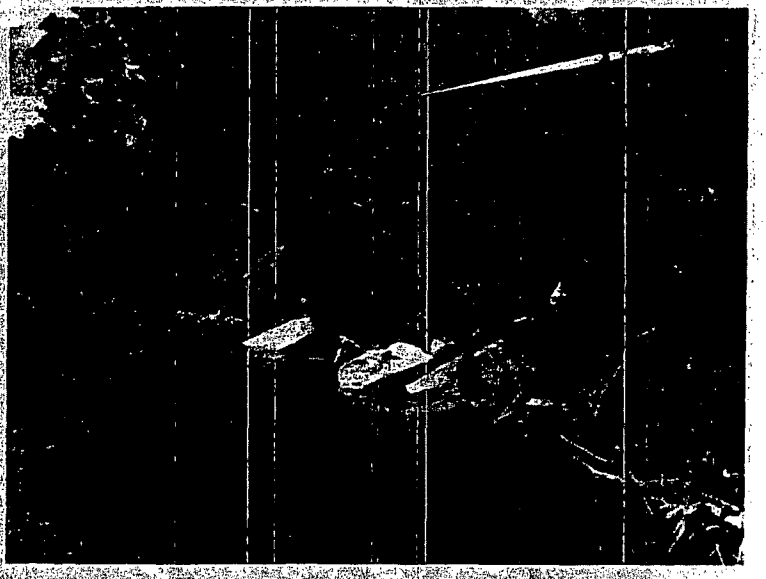


FIGURE 17. *Nerodia h. harteri* habitat in Possum Kingdom Lake near the end of Farm-to-Market 1148, Palo Pinto County, Texas, May 2008.

FIGURE 18. *Nerodia h. harteri* habitat along the Brazos River at Fortune Bend, Palo Pinto County, Texas, May 2008.

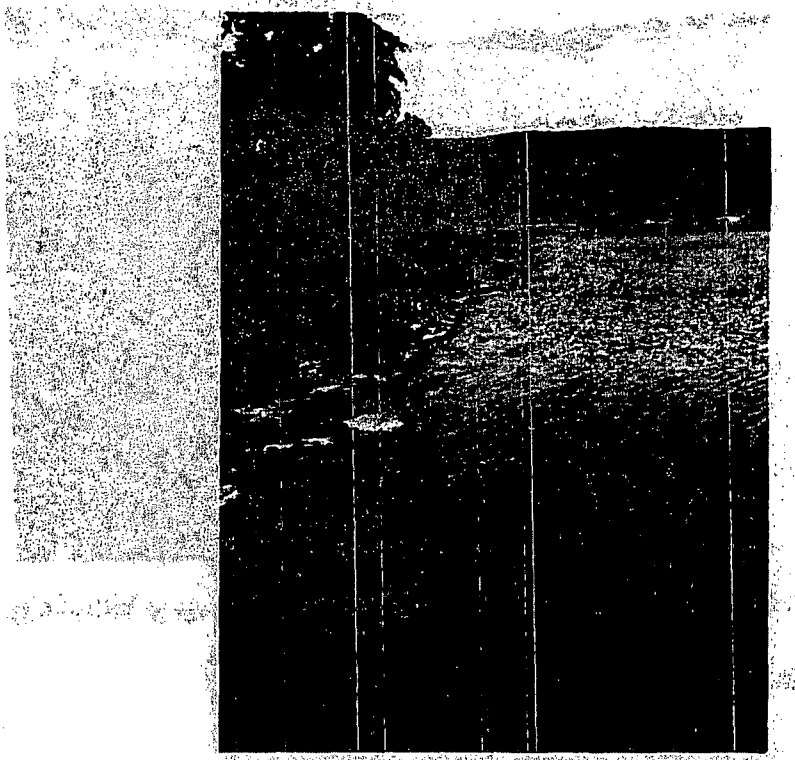


FIGURE 19. *Nerodia h. harteri* habitat along the Brazos River at Dalton Bend, Palo Pinto County, Texas, May 2008.

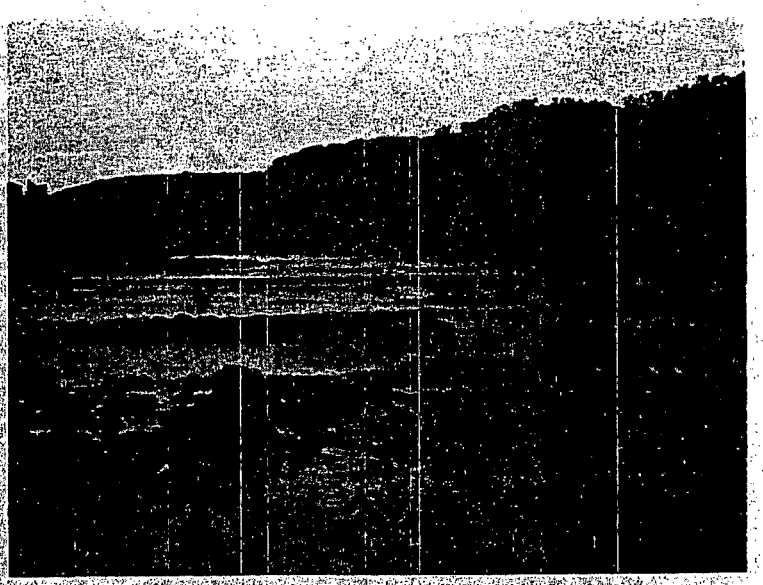


FIGURE 20. *Nerodia h. harteri* habitat along the Brazos River at Littlefield Bend, Parker County, Texas, September 2006.

FIGURE 21. Historic locality of *N. h. harteri* along the Brazos River at the U.S. Highway 67 crossing east of Glen Rose, Somervell County, Texas, May 2008.

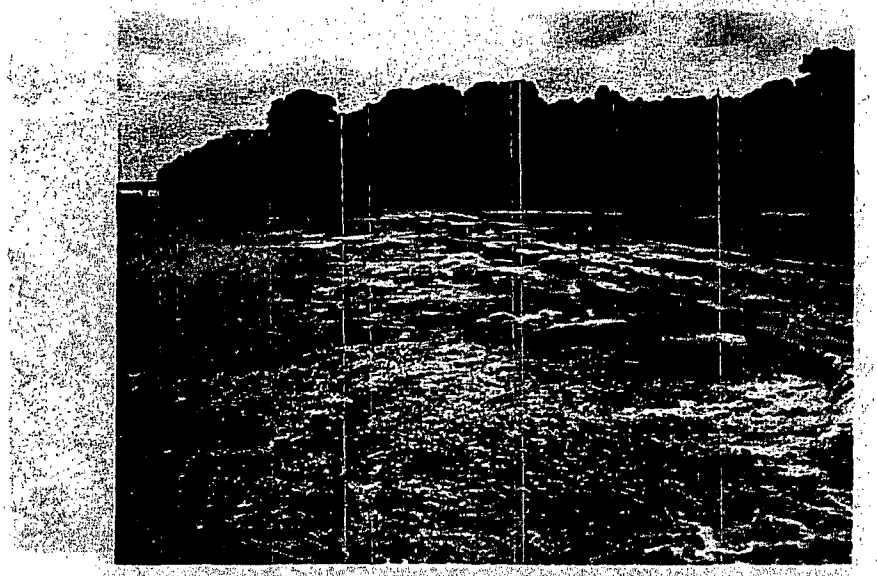


FIGURE 22. Historic locality of *N. h. harteri* along the Brazos River at the old Farm-to-Market 200 crossing, east of Rainbow, Somervell County, Texas, May 2008. Note the new Farm-to-Market 200 crossing in the background.

FIGURE 23. *Nerodia h. harteri* habitat along the Brazos River east of Glen Rose, Somervell County, Texas, May 2008.