Section 6 (Texas Traditional) Report Review

Form emailed to FWS S6 coordinator (mm/dd/yyyy): 3/1/2011

TPWD signature date on report: 12/3/2010

Project Title: Status Assessment and Ecological Study of *Styrax platanifolius* ssp. *texanus*

Final or Interim Report? Final

Grant #: TX E-92

Reviewer Station: Austin ESFO

Lead station concurs with the following comments: NA (reviewer from lead station)

Interim Report (check one):

- ☐ Acceptable (no comments)
- ☐ Needs revision prior to final report (see comments below)
- ☐ Incomplete (see comments below)

Final Report (check one):

- ☐ Acceptable (no comments)
- ☒ Needs revision (see comments below)
- ☐ Incomplete (see comments below)

Comments:

We appreciate the amount of effort and data collected during this study. We only have minor comments/requests:

1. For each ranch surveyed, the report states the acreage of each ranch surveyed, but then refers to the priority areas in ArcGIS. Were only these priority areas surveyed within the larger ranch tracts?
2. We are unable to open any of the excel spreadsheets saved in the "Alternative Habitat vs. Recognized Habitats Graphical Comparisons." Could you please resubmit these files, preferably in a more recent version of Excel?
3. Can you please explain the differences between the GIS shape files labeled "steep_slope" and "steep_slope_2010"?

FINAL REPORT

As Required by

THE ENDANGERED SPECIES PROGRAM

TEXAS

Grant No. TX E-92-R

Endangered and Threatened Species Conservation

Status Assessment and Ecological Study of Styrax platinifolius ssp. Texanus

Prepared by:

Steve Fulton

TEXAS PARKS & WILDLIFE

Carter Smith
Executive Director

Clay Brewer
Acting Division Director, Wildlife

2 December 2010

FINAL REPORT

STATE: ____Texas_______________ **GRANT NUMBER:** ___TX E-92-R___

GRANT TITLE: Status Assessment and Ecological Study of Styrax platinifolius ssp. Texanus

REPORTING PERIOD: ____6 Sep 07 to 28 Feb 11_

OBJECTIVE(S):

To examine geographic distribution; estimate abundance and reproductive status; and to assess pollination, herbivory, and microclimate of the Texas snowbell over three years.

Segment Objectives:

1. GIS delineation of areas of possible Texas snowbell habitat in the watersheds of the Devil's River, East Nueces, West Nueces, Sycamore Creek, and Frio River.
2. Conduct searches on properties granting access during the two week bloom periods in April. Populations discovered will be plotted using GPS; the number of individuals will be recorded; and their reproductive status documented (seedling, nonreproductive juvenile, reproductive adult). Access to 5 ranches per year is the goal of this work.
3. Flowering populations of Texas snowbells in the Devil's River, East Nueces, and West Nueces watersheds will be monitored and experimented with to determine the most effective pollinators and whether outcrossing is needed for seed viability. No more than 10% of the blossoms of any one individual will be manipulated during the blossom exclusion and emasculation experiments. These studies will take place during the two week bloom period in April. Pollen load analysis will also take place during this time period.
4. Climate sensors and data loggers (Hobos) will record data from the Devil's River, East Nueces, and West Nueces populations. Precipitation, temperature, relative humidity, soil moisture, and photosynthetically active radiation will be recorded continuously throughout the years. Two days of every month will be spent retrieving the recorded climate data.
5. Digital motion activated cameras will be used to monitor any herbivory of the populations in the Devil's River, East Nueces, and West Nueces watersheds. Three camera traps will be set up at each aforementioned location. The camera traps will be in place and recording continuously throughout the years. Two days of every month will be spent retrieving recorded photographs.
6. Due to the location of many of the surviving populations of Texas snowbells, seed transportation by water has been questioned as a viable mode of seed dispersal. Experimentation with seed submersion and seed viability will be

conducted at Bamberger Ranch Preserve. Experiments will take place during the months of October, November, and December of each year.

Significant Deviation:

None

Summary Of Progress:

Please see Attachment A (files on CD, sent separately).

Location: Edwards, Real, Kinney, Val Verde, Uvalde, and Blanco Counties, Texas.

Cost: ___Costs were not available at time of this report, they will be available upon completion of the Final Report and conclusion of the project.__

Prepared by: _Craig Farquhar_____________ **Date:** _3 December 2010

Approved by: ______________________________ **Date:**___ 3 December 2010 _______

C. Craig Farquhar

Status Assessment and Ecological Study

Of *Styrax platanifolius* ssp. *texanus*

Need

Texas snowbell (*Styrax platanifolius* ssp. *texanus* (Cory) Fritsch) is a deciduous woody shrub inhabiting southwestern Edwards Plateau. It was listed as an endangered species on October 12, 1984 (Federal Register 49 (199): 40036-40038) and listed as endangered by the State of Texas on January 23, 1987. 'Although research has been done on the genetics and taxonomy (Fritsch 1995, 1996a & b, 1997), demographics (Poole 1993a, 1996, 1999), and reintroduction (Keeney 1989), additional information such as pollination biology and means of dispersal is needed for Texas snowbells.' (U.S. Fish and Wildlife Service 1999).

The Texas snowbell's home range is presently recognized as the watersheds of the Devil's River, West Nueces, and Nueces. The management of this species has taken the assumption that its range is limited to the afore-mentioned watersheds. A thorough search of areas and watersheds adjacent to the known populations may very well reveal populations never before located by humans, as well as relocate "lost" populations.

Review of the Recovery Plan (U.S. Fish and Wildlife Service 1999) has illuminated many questions concerning the ecology of the Texas snowbell. Some believe that the Texas snowbell is confined to such inaccessible places as cliff faces to escape herbivory; however, 'there is only anecdotal evidence of these animals consuming Texas snowbells' (U.S. Fish and Wildlife Service 1999). Evidence gathered through observation will prove or disprove that herbivory is a threat. Others believe that the Texas snowbell grows in such places because the presence of surface water creates a microhabitat with lower temperatures and higher relative humidity; however, 'no site specific climatic data is available' (U.S. Fish and Wildlife Service 1999). It is presumed that Texas snowbells reproduce via out breeding and insect-pollination; however, these assumptions have not been verified and it has not been determined which pollinators are the most effective (U.S. Fish and Wildlife Service 1999). As a result of their position above or near water, many of the mature seeds drop into water. The effect submersion has on seed viability is unknown.

To aid in the management of this species there is a need to ascertain its pollination biology, to record its microclimate characteristics, and to determine if there is a correlation between seed submersion and viability. Although reintroduction of the Texas snowbell is already underway, information obtained from such studies will improve the survival rate of reintroduced plants as well as provide information and understanding concerning the ecology of the Texas snowbell.

Objective

The purpose of this project is to redefine or reaffirm the boundary of this species' home range; to provide a tally of naturally occurring individuals, as well as determine their reproductive status; and to gather data pertaining to the pollination/reproductive biology, herbivory, and the microclimate associated with the Texas snowbell in order to benefit the recovery of this rare and endangered shrub.

1. **Approach**

The Texas Snowbell has a broad range in the western Edwards Plateau that includes the watersheds of the Nueces, West Nueces, and Devil's Rivers. In order to narrow the field of search, GIS was used to delineate high priority search areas for remnant populations of Texas Snowbells.

Methodology

With the exception of the population at Dolan Falls, remnant mature individuals of Texas Snowbells are found growing from steep to vertical slopes directly adjacent to riparian areas. Parameters of 25-45% slope within 500 feet of a permanent to semi-permanent waterway include a high percentage of remnant Texas Snowbells. Using GIS, TIN's (triangular irregular networks) were created from USGS DEM's (digital elevation models). With the use of ARCMAP, polygons were drawn around the TIN surfaces that fell within the parameters listed above. Slope values were occasionally wide ranging along cliff areas, therefore, quad sheet contours were regularly used to refine the Steep Slope polygons.

Results

Polygons encompassing steep slopes along the Frio, Nueces, West Nueces, and Devil's Rivers, as well as, Sycamore Creek were delineated as priority search areas for the future. The ArcGIS shapefile containing those areas of high priority is attached as a zipped file to this report. (Attachment 1)

Future Need

A number of Texas Snowbells are found along tributaries of the Nueces, West Nueces, and Devil's Rivers. In addition to the major river riparian zones, identifying priority areas within tributary riparian zones will help direct future searches.

2. **Approach**

Searching for Texas Snowbells on private lands within and around the plant's known range has many benefits. The most valuable being the connections made between private landowners of that region and involved conservation organizations. With every ranch surveyed more understanding is gained concerning the status of the Texas Snowbell.

Methodology

Contacts with private landowners were made during the summer and fall of each year of the study period. If permission was granted the properties within the target area would be searched for Texas Snowbells during the plant's bloom period of mid-April.

Surveyors would concentrate their searches in priority areas described above in this report.

Results

In total (2008, 2009, 2010), 12 ranches were surveyed encompassing approximately 50,000 acres. The searched properties lie within the five target watersheds. No new individuals or populations of Texas Snowbells were discovered. One of the surveyed properties has received 20 Texas Snowbells via the recovery program and another of the landowners is receptive toward reintroductions.

- **2008:** Five ranches were surveyed for Texas Snowbells---4 in April and 1 in July. Exact locations and the names of these ranches will not be disclosed. Two project personnel (Steven Fulton, J. David Bamberger) and two volunteers (Rusty Yates, Steve Williams) participated in these surveys. Three of the ranches encompassing 18,900 acres, are located in the Sycamore Creek watershed, north of U.S. Highway 90 and south of the community of Carta Valley. Another of the ranches surveyed in April is an 8,000 acre ranch located north of the community of Vance, on Hackberry Creek in the Nueces River watershed. The final ranch surveyed is 400 acres in size and is located on Dolan Creek in the Devil's River watershed. The 400 acre ranch on Dolan Creek was surveyed in July.
- **2009:** Four ranches were surveyed for Texas Snowbells during April 15th-17th. Exact locations and the names of these ranches will not be disclosed. J. David Bamberger and Susan Sanders (volunteer) performed the surveys. Two of the ranches surveyed were near the town of Leakey on Kent Creek in the Upper Frio River watershed. The other two ranches surveyed are located approximately 10 miles north of Leakey on both the east and west sides of Highway 83. These properties are also located in the Upper Frio River watershed.
- **2010:** Three ranches were surveyed for Texas Snowbells in April. Exact locations and the names of these ranches will not be disclosed. Two project personnel (Steven Fulton, J. David Bamberger) and four volunteers (Scott Gardner, Steve Williams, Susan Sanders, Johanna Reese) participated in these surveys. Two of the ranches encompassing >15,000 acres, are located in the West Nueces watershed, southeast of Kickapoo Caverns State Park. The third ranch surveyed is approximately 600 acres in size and is located west of Barksdale in the Nueces River watershed.

Priority areas (outlined in Section1) searched are indicated in the ArcGIS shapefile that is zipped and attached to this report. (Attachment 2)

Future Need

To truly determine the status of the Texas Snowbells would require searching the plant's entire known range. As this is not a feasible short-term goal, it is important that future searches should first occur in areas deemed high priority. There is a definite need for continued outreach to landowners who own land within the known range of the Texas Snowbell and continued searches for remnant populations of Texas Snowbells.

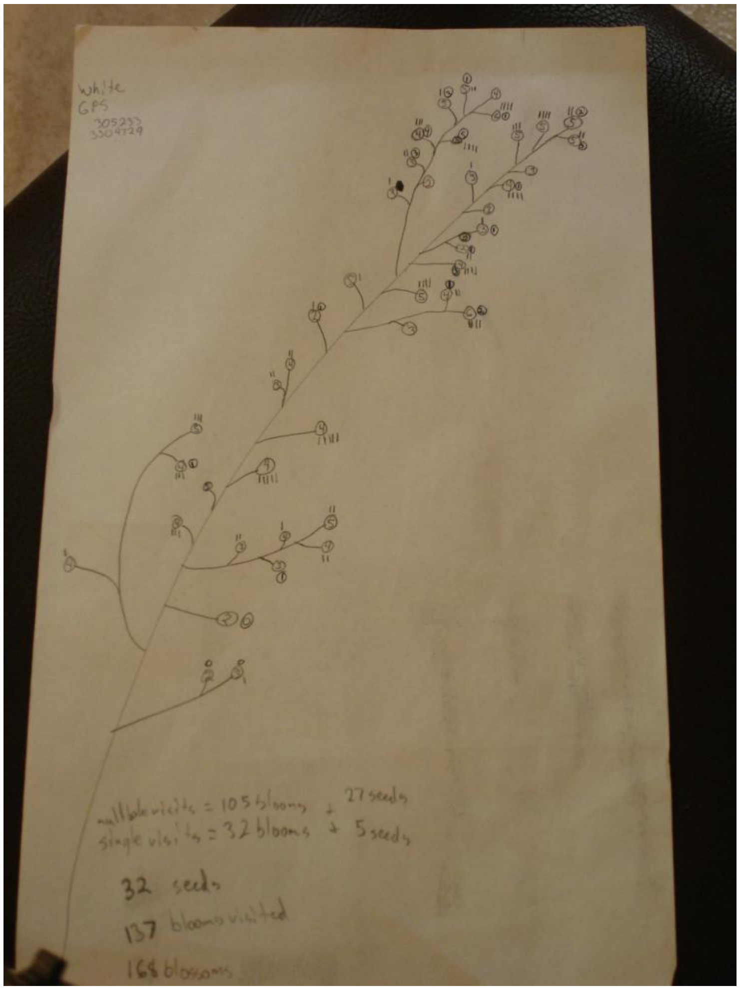
3. Approach

Observations prior to this study led to the hypothesis that the Texas Snowbell is pollinated by bees; and outcrossing is needed for abundant and viable seed production. During the course of this study flowering Texas Snowbells were experimented with to determine: a) Who is the primary pollinator?; b) Who is the most effective pollinator?; c) Is outcrossing required for seed viability and abundance?.

Methodology for Determining Pollinator Effectiveness

Reproductive Texas Snowbells targeted for the pollination experiments were chosen for their ease of access and observation. One week prior to the blossoms opening a number of branches were excluded from insect contact using fine mesh bridal veil netting.

No more than 10% of the blooms on any given individual were excluded. Prior to removing the exclusions, observations of non-target flowering Texas Snowbells revealed the target pollinators. Target pollinators were chosen due to their overall abundance in the vicinity of the Texas Snowbells and the rate at which they were visiting blossoms of the Texas Snowbells. Once a high percentage or all the blooms within the exclusion opened, the excluder was removed and a schematic of the branch was drawn locating spatially the clusters of blossoms on the target branch.



Only one species of target pollinators were allowed to visit a given branch. Listed below is the data collected for each excluded branch visited by pollinators.

- Location of the target plant using Garmin Etrex Legend sportsman's GPS.
- Number of blossoms on the excluded branch.
- Number of blossoms in each cluster and location of cluster on branch.
- Pollinator species assigned to the branch.
- Number of separate visits to each cluster of blossoms by the target pollinator.
- The rate at which the pollinator visited the blossoms. (blossoms/minute)

Once a high percentage or all the blossoms of that branch were visited the excluder was placed back on the branch. The excluders were removed 2 weeks later once the flower corollas had fallen off. A return trip in August was made to record how many fruit were produced from each cluster of blossoms. The ratio, # of fruit produced : # of blossoms visited, results in a pollination rate (%).

Methodology for Determining Effects of Outcrossing

Reproductive Texas Snowbells targeted for the outcrossing experiments were chosen for their ease of access and observation. One week prior to the blossoms opening a number of branches were excluded from insect contact using fine mesh bridal veil netting. No more than 10% of the blooms on any given individual were excluded. Two separate individuals were targeted for these experiments. Once the blossoms within the excluders were open a predetermined number of blossoms from one individual were severed at the pedicel and placed in an airtight container. These procedures were all performed carefully so as not to dislodge pollen from the anthers and in a short amount of time in order to prevent dessication. The severed blossoms were then mated with other excluded blossoms on the same tree. This process was repeated, differing only in that blossoms from two separate trees were mated (outcrossing). Once all of the crossing was completed the excluders were placed back on the branches. The excluders were removed 2 weeks later once the flower corollas had fallen off. A return trip in August was made to record how many fruit were produced from the crossing experiments. The percentage of seeds produced per treatment revealed the effects of outcrossing.

Results

- 2008: The population of Texas Snowbells in the Nueces River watershed was targeted for the 2008 pollination study. Due to time constraints and variability in the *Styrax*'s bloom period, only three individuals were available for observations during the study period. Data obtained from one of the individuals was deleted from this report due to the fact that it produced no fruit even though it bloomed profusely and only 10% of the blossoms were manipulated. The locations of the two remaining individuals area as follows: GPS, UTM 408012 3313500
NAD 83 398778 3320079

With only two individuals available, the data collected was limited. Without additional data to support this year's observations, any conclusions drawn form this data may prove to be faulty or not representative of the entire population of Texas Snowbells in the Nueces River watershed.

American Bumble Bee (*Bombus pensylvanicus*), Honey Bee (*Apis mellifera*), Sweat Bee (*Lasioglossum morrilli*), Northern Cloudy Wing Butterfly (*Thorybes pylades*), and Black-chinned Hummingbird (*Archilochus alexandri*) were all observed feeding from the blossoms of the Texas Snowbell and are potential pollinators. However, the bumble bee was the most frequent; visiting all 48 excluded blossoms before other pollinators, once the exclusions were removed. Observations also revealed that the bumble bee visited 13.48 blossoms per minute. Of the 48 blossoms visited 8 produced fruit, giving a pollination rate of 16.66%. Thirteen of the blossoms were allowed multiple visitations by the bumble bee and of those blossoms 5 produced fruit, increasing the pollination rate to 38.46%. Conversely, of the 35 blossoms visited once by bumble bees 3 produced fruit, giving a pollination rate of 8.57%.

Unfortunately, the out-crossing experiments were performed on the individual voided from this report.

- 2009: The population of Texas Snowbells in the Devil's River watershed was targeted for the 2009 pollination study. Due to time constraints and variability in the *Styrax*'s bloom period, only two individuals were available for observations during the study period. Their locations are:

GPS, UTM 305126 3309695
NAD 83 305299 3309734

With only two individuals available, the data collected was limited. Without additional data to support this year's observations, any conclusions drawn form this data may prove to be faulty or not representative of the entire population of Texas Snowbells in the Devil's River watershed.

The California Carpenter Bee (*Xylocopa californica*), Honey Bee (*Apis mellifera*), Tiger Swallowtail (*Papilio glaucus*), Pipevine Swallowtail (*Battus philenor*), and Black-chinned Hummingbird (*Archilochus alexandri*) were all observed feeding from the blossoms of the Texas Snowbell and are potential pollinators. However, the carpenter bee and the honey bee were the most frequent; visiting all 343 excluded blossoms before the other potential pollinators, once the exclusions were removed.

The carpenter bee visited 184 blossoms of which 30 produced fruit, resulting in a pollination success rate of 16.3%. 120 of the blossoms visited by the carpenter bee were allowed multiple visitations of which 17 produced fruit, revealing a decreased pollination success rate of 14.16%. Conversely, of the 64 blossoms visited only once by the carpenter bee 13 produced seed, revealing an increased pollination success rate of 21.66%.

The honey bee visited 159 blossoms of which 6 produced fruit, resulting in a pollination success rate of 3.77%. 71 of the blossoms visited by the honey bee were allowed multiple visitations of which 1 produced fruit, revealing a decreased pollination success rate of 1.41%. Conversely, of the 88 blossoms visited only once by the honey bee 5 produced fruit, revealing an increased pollination success rate of 5.68%.

Time limitations prevented the execution of the out-crossing experiments.

- **2010:** The populations of Texas Snowbells at Dolan Falls on the Devil's River and Dobbs Run Ranch on the West Nueces were targeted for the 2010 pollination study. Due to the limited number of accessible plants at Dobbs Run, only two plants were included in the experiment. Their locations are:

GPS, UTM NAD 83 366080 3282804

The American Bumble Bee (*Bombus pensylvanicus*), Honey Bee (*Apis mellifera*), Tiger Swallowtail (*Papilio glaucus*), and Black-chinned Hummingbird (*Archilochus alexandri*) were all observed feeding from the blossoms of the Texas Snowbell and are potential pollinators. However, the American bumble bee and honey bee were the most frequent; visiting all 220 excluded blossoms before the other potential pollinators, once the exclusions were removed.

The honey bee visited 197 blossoms of which 27 produced fruit, resulting in a pollination success rate of 13.71%. 59 of the blossoms visited by the honey bee were allowed multiple visitations of which 6 produced fruit, revealing a pollination rate of 10.17%. Conversely, of the 138 blossoms visited only once by the honey bee 21 produced fruit, revealing a pollination success rate of 15.22%.

The American bumble bee visited 23 blossoms and produced 7 fruit, revealing a pollination success rate of 30.43%.

Due to variation in the bloom periods only two individuals at Dolan Falls were targeted for the pollinator experiment. Their locations are:

GPS, UTM 305233 3309729
NAD 83 305472 3309745

The California Carpenter Bee (*Xylocopa californica*), Honey Bee (*Apis mellifera*), and Tiger Swallowtail (*Papilio glaucus*) were all observed feeding from the blossoms of the Texas Snowbell and are potential pollinators. However, the honey bee was the most abundant; visiting all 502 previously excluded blossoms. Observations revealed that the honey bee visited 5.02 blossoms per minute and the California carpenter bee visited 15.52 blossoms per minute. 247 fruits were produced from the 502 blossoms visited by the honey bee revealing a pollination success rate of 49.2%. 345 blossoms were allowed multiple visits by the honey bee and produced 148 fruit resulting in a pollination success rate of 42.9%. Conversely, 157 blossoms were visited only once by the honey bee and produced 99 fruit resulting in a pollination success rate of 63.06%.

Outcrossing: The outcrossing experiment was performed at Dolan Falls in the Devil's River watershed in April, 2010. The Texas Snowbell chosen as the primary target is located at:

GPS, UTM NAD 83 305121 3309686

A total of 152 blossoms were pollinated. 57 blossoms were mated with blossoms from the same tree and produced 0 fruit. 95 blossoms were mated with blossoms from a separate Texas Snowbell and produced 33 fruit. A 34.74% seed crop was produced with only one mating of the blossoms from separate individuals.

Summary: The outcrossing data, although limited, does support the hypothesis that the Texas Snowbell will benefit in both reproduction and regeneration from outcrossing. The data collected from the pollination experiments supports the hypothesis that bees are the pollinator for the Texas Snowbell (See Table 1). Three species of bees were found to be the most effective pollinators of the Texas Snowbell: Honey Bee (*Apis mellifera*), California Carpenter Bee (*Xylocopa californica*), American Bumble Bee (*Bombus pensylvanicus*).

Table 1

Summary of Pollinator Effectiveness (2008,2009,2010)			
Honey Bee			
Visitations	# of Blossoms Visited	# of Fruit Produced	Pollination Success Rate(%)
Single	383	125	32.64
Multiple	475	155	32.63
Total	858	280	32.63
California Carpenter Bee/American Bumble Bee*			
Visitation	# of Blossoms Visited	# of Fruit Produced	Pollination Success Rate(%)
Single	122	23	18.85
Multiple	133	22	16.54

Total	255	45	17.65

*California Carpenter Bee and American Bumble Bee displayed very similar pollination behavior; therefore, the data for both was combined.

Future Need

To gain a better understanding of the effects of outcrossing additional outcrossing experiments should be performed. The variation between the 2009 and 2010 pollination datasets may be linked to the variation in weather conditions during the study periods. Additional study, focusing on the effects of weather (i.e. precipitation, temperature) on the behavior and effectiveness of the primary pollinators of the Texas Snowbell may illuminate the cause of the variation between the 2009 and 2010 pollination datasets.

4. Approach

As described before, the Texas Snowbell is seemingly restricted to mesic riparian habitats. Some believe the plant's scarcity and limited distribution is due to the similarities between climate conditions of these mesic riparian locations and a past era when ***Styrax*** was more abundant and widely distributed. Climate monitoring arrays were used to gather data on the specific climate characteristics of the Texas Snowbell's habitat.

Additionally, the climate monitoring arrays were used to gather data on other distinct habitat types within the known range of the Texas Snowbell. In order to determine if the plant can survive outside of riparian zones, the data from these alternative habitats was compared to the data from the known Texas Snowbell habitat.

Methodology

- **2008:** One site in each of the three watersheds (Nueces, W.Nueces, Devil's Rivers) was chosen for the 2008 climate data collection. The exact location of the monitoring sites are as follows:

Nueces	UTM NAD83:	407379	3313746
West Nueces	" " :	367524	3290957
Devil's River	" " :	305475	3309746

The presence of Texas Snowbell regeneration was the determining factor for site selection, therefore, the sites were not randomly chosen due to the scarcity of regeneration. The climate arrays were set up among seedling and juvenile Texas Snowbells at each selected site. Precipitation, temperature, relative humidity, soil moisture content, and photosynthetic active radiation were recorded every minute from 3/2/2008—1/15/2009. The data collected was analyzed to; 1) determine similarities between habitats across the three watersheds and 2) determine the range of climate characteristics preferred by the Texas Snowbell.

- **2009:** All three climate monitoring arrays were set up in the Devil's River Watershed for 2009. The exact location of the monitoring sites are as follows:

  Data Logger #1—Open Site UTM NAD83 306250 3309675
  " " #2—Slope Site " " 306250 3309624
  " " #3—Control Site " " 305475 3309746

  Once again, an array was set up among seedling and juvenile Texas Snowbells and labeled Data Logger #3—Control Site. The other two arrays were set up nearby, yet, in alternative and distinct habitats within the Devil's River watershed. Data Logger #1—Open Site was placed in the open scrub brush. Data Logger #2—Slope Site was placed under the northeast drip line of a live oak growing on a north facing slope. Precipitation, temperature, relative humidity, soil moisture content, and photosynthetic active radiation were recorded every 10 minutes from 1/18/2009—1/13/2010. The data collected from Logger #1 & 2 was then compared to the data collected from Logger #3 to determine if the climate characteristics of the alternative habitats share similarities with the climate of the known habitat, Data Logger #3.
- **2010:** All three climate monitoring arrays were set up in the West Nueces River watershed for 2010. The exact location of the monitoring sites are as follows:

  Data Logger #1—Open Site UTM NAD83 367789 3290689
  " " #2—Slope Site " " 367782 3290601
  " " #3—Control Site " " 367524 3290957

  Once again, an array was set up among seedling and juvenile Texas Snowbells and labeled Data Logger #3—Control Site. The other two arrays were set up nearby, yet, in alternative and distinct habitats within the Devil's River watershed. Data Logger #1—Open Site was placed in the open savannah. Data Logger #2—Slope Site was placed under the northeast drip line of a live oak growing on a north facing slope. Precipitation, temperature, relative humidity, soil moisture content, and photosynthetic active radiation were recorded every 10 minutes from 1/15/2010—9/18/2010. The data collected from Logger #1 & 2 was then compared to the data collected from Logger #3 to determine if the climate characteristics of the alternative habitats share similarities with the climate of the known habitat, Data Logger #3.

BoxCar Pro 4.3 software was used to download the data from the Hobo data loggers and export the data to Microsoft Excel. The data was condensed and analyzed using Microsoft Excel and R 2.9.2 statistical software. Excel was used to condense the data down to daily averages and also used to produce the tables and graphs found in this report. The daily averages of the data were then loaded into R in order to run ANOVA and planned comparisons. The raw data, condensed data, and copies of the R files are attached to this report as Attachments 3, 4, & 5 respectively.

Result

What climate factor(s) limit the distribution of the Texas Snowbell? Can Texas Snowbells grow in habitats outside of riparian zones? Answering these two questions will increase our understanding of the ecology of the Texas Snowbell and will aid the recovery effort by providing climate parameters for reintroduction sites and, consequently, improving the success rate of reintroduced Texas Snowbells. The purpose of the climate monitoring was to provide data that may lead to the answers to questions such as the two posed above.

- **2008:** As predicted, variation in climate characteristics was statistically significant across the three watersheds that contain recognized Texas Snowbell habitats (see Table 2). This variation reveals a range of values for each climate characteristic and defines the climatic parameters of suitable Texas Snowbell habitat.
- **2009:** With all three climate arrays located in close proximity within the Devil's River watershed, three of the measured climate characteristics show very little variation: rainfall, temperature, relative humidity. Leaving soil moisture content and photosynthetic active radiation (PAR) as variable climate characteristics (see Table 3). Soil type and percent shade are two factors that are closely examined by the recovery team when choosing a planting site. The recovery team has experienced best success when juvenile Texas Snowbells are planted in dappled shade and medium-heavy soil ($\geq$30% clay). It is also well documented that in the Hill Country high diversity and high occurrence of broadleaf deciduous trees and shrubs are found on north facing slopes. These observations led to the hypothesis that the Texas Snowbell could survive as an under-story shrub/tree on a north facing slope. The soil moisture content for both the Open Site and Slope Site is significantly different statistically from the Control Site (see Table 3). However, when viewed in graphical comparison the soil moisture for the two alternative sites fall within or above (more moist) the soil moisture parameters of recognized habitats (see Fig. 1). The PAR for both the Open and Slope Sites is significantly different statistically from the Control Site (see Table 3). When viewed in graphical comparison the PAR for the Slope Site falls within the parameters of the PAR of recognized Texas Snowbell habitats (see Fig. 2). However, PAR for the Open Site was significantly higher than the PAR of recognized Texas Snowbell habitats (see Fig. 2).
- **2010:** With all three climate arrays located in close proximity within the West Nueces watershed, three of the measured climate characteristics show very little variation: rainfall, temperature, relative humidity. Leaving soil moisture content and PAR as variable climate characteristics (see Table 4). The soil moisture content for both the Open Site and Slope Site is significantly different statistically from the Control Site (see Table 4). However, when viewed in graphical comparison the soil moisture for the two alternative sites fall within or above the soil moisture parameters of recognized habitats (see Fig. 3). The PAR for the Slope Site is similar statistically to the Control Site (see Table 4). In contrast, the PAR for the Open Site is significantly different statistically from the Control Site. When viewed in graphical comparison the PAR for the Slope Site falls within the parameters of the PAR of recognized Texas Snowbell habitats (see Fig. 4).

However, PAR for the Open Site was significantly higher than the PAR of recognized Texas Snowbell habitats (see Fig. 2).

Summary: The climate data collected supports the hypothesis that the Texas Snowbell can survive as an understory tree/shrub on a north facing slope; and perhaps in the recent past the Texas Snowbell was more abundant and widely distributed. Another conclusion that can be drawn from this data is that as a juvenile plant, over exposure to sunlight is a limiting factor for the Texas Snowbell.

Future Need

Additional climate monitoring within recognized Texas Snowbell habitat will further refine the climatic parameters of suitable habitat. Further investigation may reveal additional micro-habitats in which the Texas Snowbell can survive.

Table 2

2008 Data Analysis Table for Climate Characteristics Of Texas Snowbell Habitat in Nueces, West Nueces, and Devil's Rivers Watersheds

Data Logger (#, Location)		Data Logger #1--Nueces River			Data Logger #2--W. Nueces River			Data Logger #3--Devil's River			
Comparisons	Data Logger #1,2,3		Mean	Data Logger #1,2		Mean	Data Logger #2,3		Mean	Data Logger #3,1	
Statistical Test	ANOVA			Tukey's HSD			Tukey's HSD			Tukey's HSD	
Test Result/Interpretation	P value	Significance		P value	Significance		P value	Significance		P value	Significance
Climate Characteristic											
Precipitation (in.)	0.5	Similar	0.04	0.83	Similar	0.03	0.47	Similar	0.05	0.83	Similar
Temperature (ºF)	0.003	Different	67.37	0.99	Similar	67.33	0.008	Different	70.72	0.009	Different
Relative Humidity (%)	4.93E-06	Different	61.11	0.094	Similar	63.49	0	Different	57.82	0.012	Different
Soil Moisture Content (m^3/m^3)	<2.2E-16	Different	0.034	0	Different	0.001	0	Different	-0.01	0	Different
Photosynthetic Active Radiation (uE)	<2.2E-16	Different	48.54	0	Different	64.41	0	Different	31	0	Different

Table 3

2009 Data Analysis Table for Climate Characteristics Of Texas Snowbell Habitat and Alternative Habitats in Devil's River Watershed

Data Logger (#, Location)		Data Logger #1--Open Site			Data Logger #2--Slope Site			Data Logger #3--Control Site			
Comparisons	Data Logger #1,2,3		Mean	Data Logger #1,2		Mean	Data Logger #2,3		Mean	Data Logger #3,1	
Statistical Test	ANOVA			Tukey's HSD			Tukey's HSD			Tukey's HSD	
Test Result/Interpretation	P value	Significance		P value	Significance		P value	Significance		P value	Significance
Climate Characteristic											
Precipitation (in.)	0.905	Similar	0.039	0.972	Similar	0.036	0.896	Similar	0.042	0.974	Similar
Temperature (ºF)	0.848	Similar	70.12	0.835	Similar	69.43	0.94	Similar	69.84	0.97	Similar
Relative Humidity (%)	0.993	Similar	56.79	0.999	Similar	56.79	0.993	Similar	56.65	0.993	Similar
Soil Moisture Content (m^3/m^3)	<2.2E-16	Different	0.094	0	Different	0.008	0	Different	0.045	0	Different
Photosynthetic Active Radiation (uE)	<2.2E-16	Different	432.6	0	Different	108.9	0.0008	Different	144.2	0	Different

2010 Data Analysis Table for Climate Characteristics Of Texas Snowbell Habitat and Alternative Habitats in the West Nueces Watershed

Data Logger (#, Location)			Data Logger #1--Open Site			Data Logger #2--Slope Site			Data Logger #3--Control Site		
Comparisons	Data Logger #1,2,3		Mean	Data Logger #1,2		Mean	Data Logger #2,3		Mean	Data Logger #3,1	
Statistical Test	ANOVA			Tukey's HSD			Tukey's HSD			Tukey's HSD	
Test Result/Interpretation	P value	Significance		P value	Significance		P value	Significance		P value	Significance
Climate Characteristic											
Precipitation (in.)	0.764	Similar	0.064	0.836	Similar	0.055	0.772	Similar	0.066	0.993	Similar
Temperature (ºF)	0.663	Similar	79.71	0.989	Similar	69.9	0.674	Similar	68.79	0.76	Similar
Relative Humidity (%)	0.078	Similar	69.51	0.355	Similar	70.63	0.065	Similar	70.63	0.661	Similar
Soil Moisture Content (m^3/m^3)	<2.2E-16	Different	0.179	0	Different	0.094	0	Different	-0.026	0	Different
Photosynthetic Active Radiation (uE)	<2.2E-16	Different	463.3	0	Different	140.8	0.561	Similar	130.3	0	Different

Figure 1

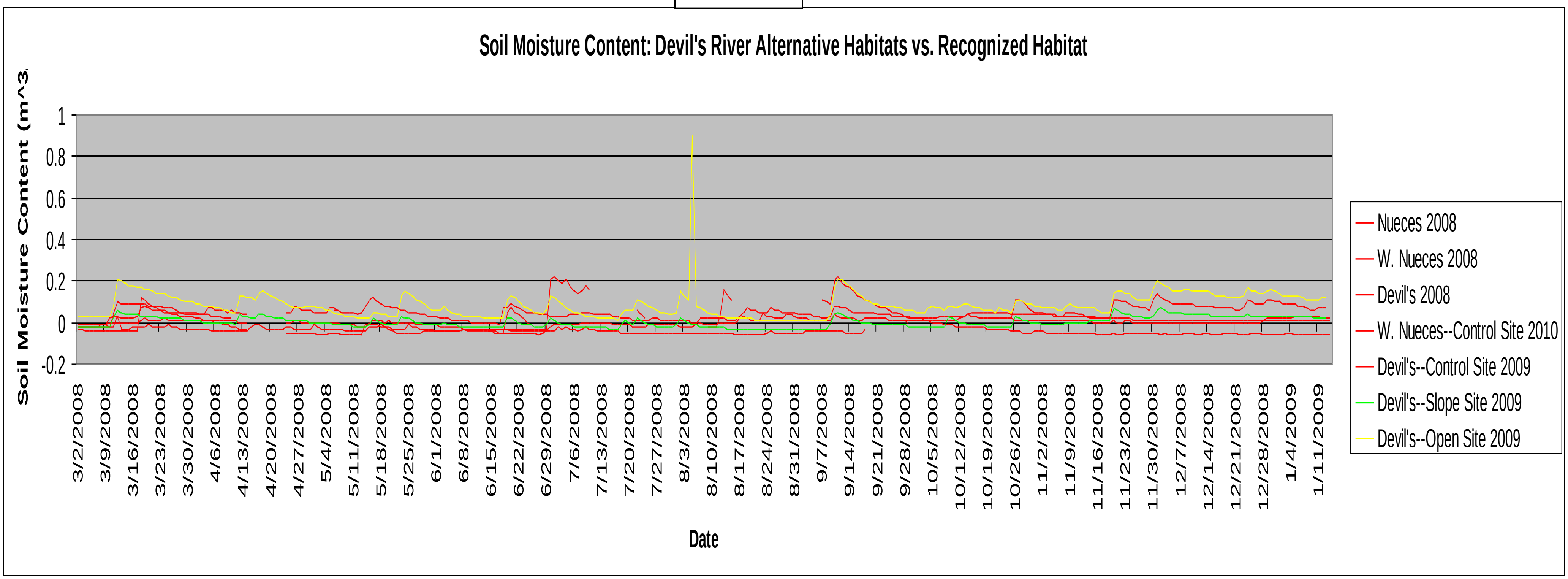


Figure 2

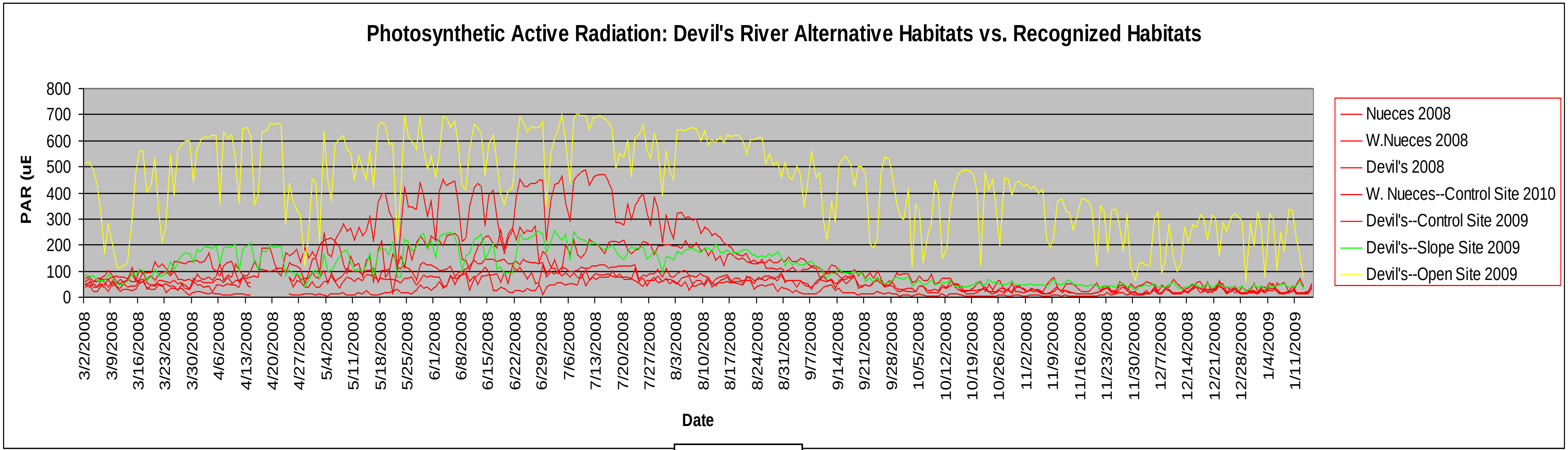


Figure 3

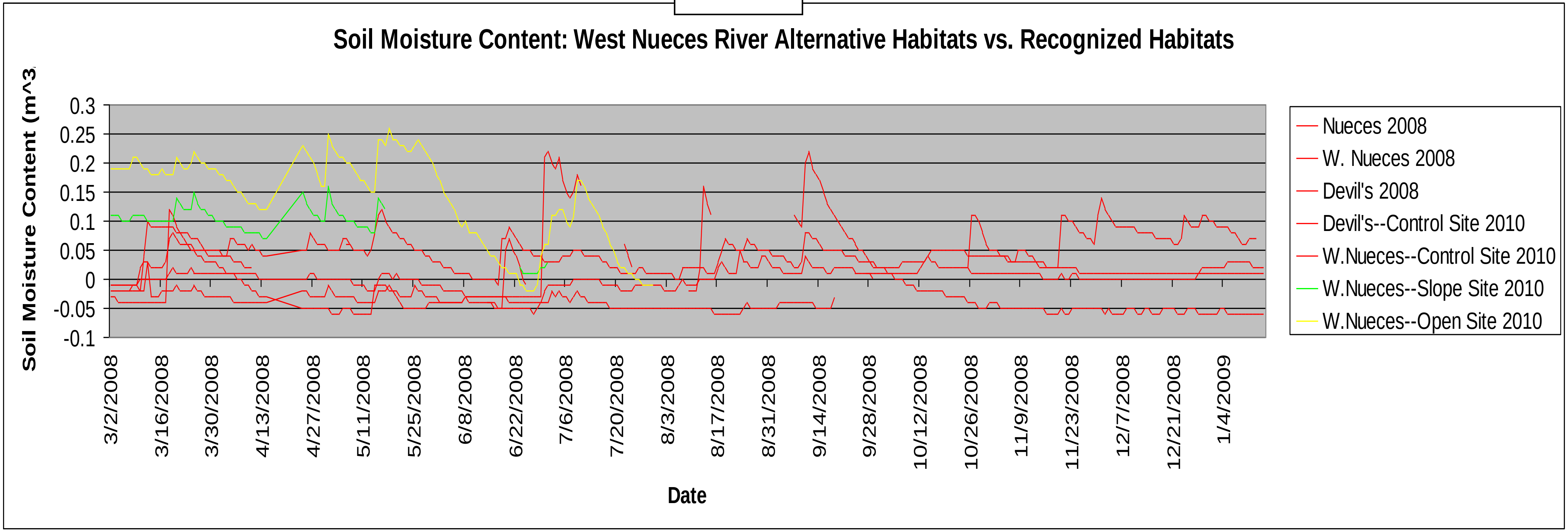
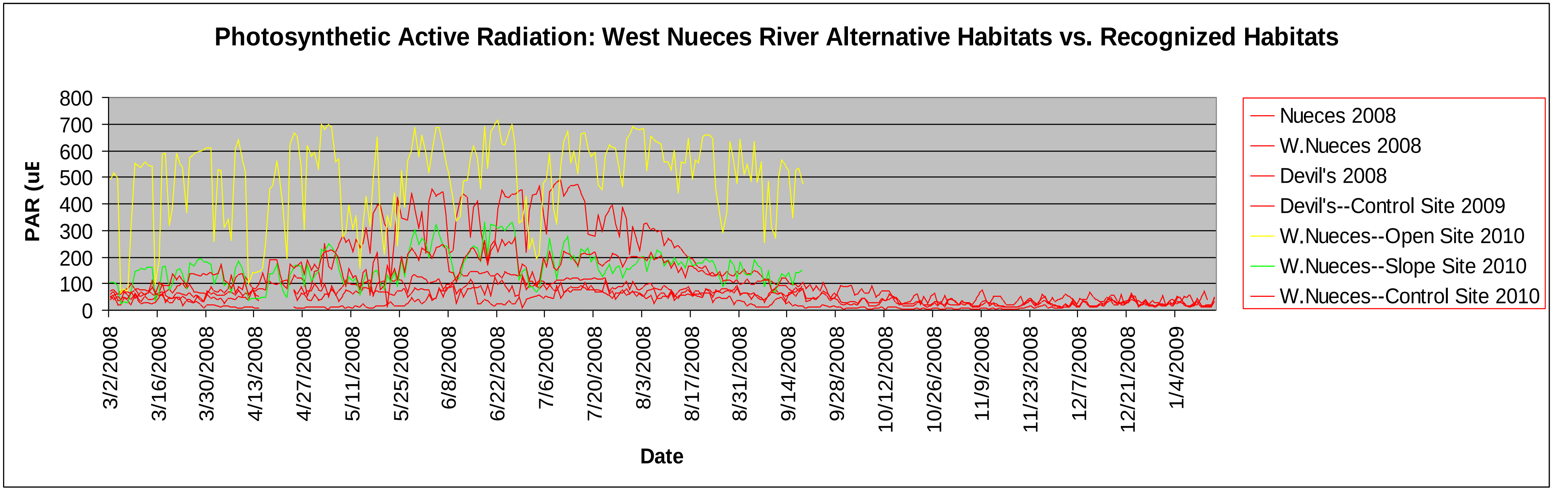


Figure 4



Photosynthetic Active Radiation: West Nueces River Alternative Habitats vs. Recognized Habitats
PAR (uE
800
700
600
500
400
300
200
100
0
3/2/2008
3/16/2008
3/30/2008
4/13/2008
4/27/2008
5/11/2008
5/25/2008
6/8/2008
6/22/2008
7/6/2008
7/20/2008
8/3/2008
8/17/2008
8/31/2008
9/14/2008
9/28/2008
10/12/2008
10/26/2008
11/9/2008
11/23/2008
12/7/2008
12/21/2008
1/4/2009
Date
Nueces 2008
W.Nueces 2008
Devil's 2008
Devil's--Control Site 2009
W.Nueces--Open Site 2010
W.Nueces--Slope Site 2010
W.Nueces--Control Site 2010

5. Approach

As described previously in this report, naturally occurring Texas Snowbells are found growing from rocky cliffs or steep slopes near waterways; this is especially true for Texas Snowbells found in the Nueces and West Nueces Rivers watersheds. One hypothesis as to why they grow in such inaccessible areas is that these cliffs are the only place the plant can escape from introduced/non-native herbivores. In an attempt to determine the presence and rate of herbivory of the Texas Snowbell, 9 motion activated digital cameras were trained on accessible individuals—3 cameras in each watershed.

Pictures of animals that either browse upon or eat the seed of the Texas Snowbells were downloaded and saved for future reference. The files containing those pictures are attached to this report. (Attachments 6 & 7)

In addition to the photographs from the camera traps, monthly monitoring pictures were taken of accessible snowbells in each watershed, to document the rate of herbivory. These photos are also included in this report. (Attachment 8)

Methodology

The sites chosen for photographic monitoring were not chosen at random. The determining factor in selection of monitoring sites was the accessibility of the plants by potential herbivores and research personnel. The motion activated cameras were placed very near the climate monitoring arrays of 2008; therefore, the coordinates for the 2008 climate monitoring arrays listed in this report are also accurate for the motion activated camera traps. The motion activated cameras were configured to take two pictures in close succession every 10 minutes if motion was detected; if no motion was detected the cameras would remain dormant. Only pictures with herbivores and some omnivores were downloaded and added to this report. Redundant photographs were deleted.
Easily accessible juvenile Texas Snowbells within the photographic range of the motion activated cameras were targeted for the monthly monitoring photography. (Attachment 9) The same individuals were photographed each month in order to visually record the occurrence of herbivory and document the extent of herbivory.

Results

During the course of the study 275 images were captured of herbivores and omnivores active within close vicinity of Texas Snowbells: 104 images of Aoudad, 50 images of squirrels, 32 images of Ringtail Cats, 30 images of White-tailed Deer, 23 images of Raccoons, 10 images of Mice, 7 images of Rats, 5 images of Angora Goats, 5 images of Feral Hogs, 4 images of Turkey, 2 images of Porcupine, 2 images of Unknown Ungulate Herbivores, 1 image of an Ibex. There is direct photographic evidence of browsing by Aoudad. (Attachment 9)

There is also indirect evidence that can be used to imply significant herbivory and seed predation. (Attachments 6,7,8 & 10)
The monthly monitoring photographs have recorded substantial foliage loss in both the Nueces and West Nueces monitoring sites. In contrast, there is no evidence that the Texas Snowbell was browsed in the Devil's River monitoring site. (Attachment 8)

Summary
The data collected during this study lends support to the hypothesis that herbivory is limiting the regeneration of the Texas Snowbell; however, that statement holds true only for the Texas Snowbells in the Nueces and West Nueces watersheds. No evidence of herbivory was collected in the Devil's River watershed during the course of this study. Limited direct evidence of seed predation (gnawed seeds) was collected during the course of this study; however, substantial indirect evidence and observations of seed predation (images of rodents, uncollected gnawed seeds) implies that seed predation is significant in all three watersheds.

Future Needs
Any Texas Snowbell occurring in an area accessible by herbivores will benefit from protection (i.e., fencing or piled brush). However, providing protection for planted or naturally occurring Texas Snowbells is only a short term cure. To increase regeneration and dispersion of the Texas Snowbell, ungulate herbivore populations need to be reduced and managed at low/sustainable levels.

5. Approach
Due to their location above waterways, the seeds of many naturally occurring Texas Snowbells fall directly into water. Seed submersion experiments were performed to determine the effect submersion has on the viability of Texas Snowbell seeds and, consequently, reveal whether water transportation is a viable mode of seed dispersion.

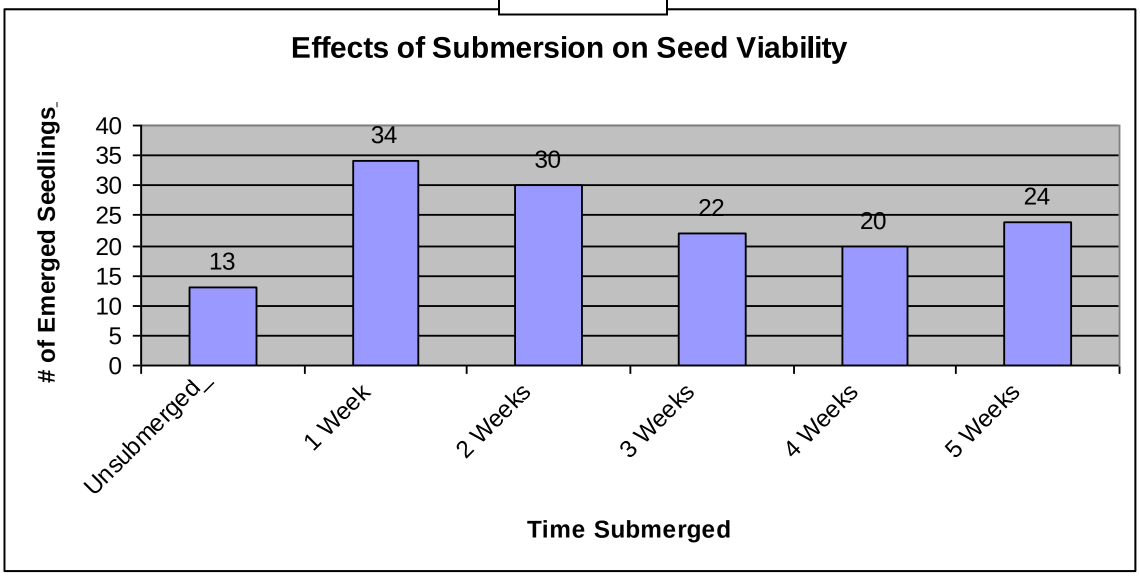
Methodology
Approximately 500 seeds were collected ensuring that no more than 10% of the seed crop was collected from any single Texas Snowbell. Only mature seeds from the tree were collected; no seeds were collected or included that had made contact with the ground. Seeds from multi-seeded fruit were not included in the submersion experiments. The remaining seeds were weighed and measured. The 300 most similar were included in the submersion experiment. Fifty seeds were placed in cold stratification, foregoing submersion, and were the control group. The remaining 5 groups of 50 seeds were submerged for 1 week, 2 weeks, 3 weeks, 4 weeks, and 5 weeks respectively. After their submersion period each group was placed in cold stratification. After 60 days in cold stratification the seeds were planted in 4 inch pots, in similar medium, and maintained under a similar watering regiment. A seed was deemed viable when a seedling emerged. All seeds not included in the experiment were placed in

stratification and germinated seeds were grown. All seedlings from produced from the seeds collected for the submersion experiment were assumed by the recovery team and are slated for reintroduction.

Results

- **2008:** The seeds for the 2008 seed submersion experiment were collected from the remnant population of Texas Snowbells on Dobbs Run Ranch located on the West Nueces River. The plant the seeds were collected from is located at the following coordinate: UTM NAD83: 366039 3282874. The results of the experiment can be seen in Fig. 6.

Figure 6



- **2009:** Due to the extremely low seed crop, the seed submersion experiment was not performed in 2009.
- **2010:** The seed submersion experiment for 2010 is underway. Upon completion of the experiment, the results will be forwarded to the U.S. Fish and Wildlife Service to be attached to this report.

Significant Deviations

1) The pollen load analysis was not performed during the course of this project.
2) An overall tally of naturally occurring Texas Snowbells was not recorded.