FINAL REPORT

As Required by

THE ENDANGERED SPECIES PROGRAM

TEXAS

Grant No. TX E-107-R

Endangered and Threatened Species Conservation

A model to predict the distribution of the Louisiana pine snake (*Pituophis ruthveni*), including habitat, land use, and ownership analysis of the historical range.

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1 November 2010

FINAL REPORT

STATE: Texas **GRANT NUMBER:** TX E-107-R

GRANT TITLE: A model to predict the distribution of the Louisiana pine snake (*Pituophis ruthveni*), including habitat, land use, and ownership analysis of the historical range.

REPORTING PERIOD: 1 Oct 08 to 1 Nov 10

OBJECTIVE(S):

To create a predictive habitat model for the Louisiana Pine Snake (*Pituophis ruthveni*) and to quantify land use and ownership within the historical range.

Segment Objectives:

Task 1. Consult with expert team to develop details of protocol for developing habitat model. Continuing for about 60 days from the date of the execution of this MOA.

Task 2. Gather and/or create GIS files needed to perform analysis: Continuing for 30 days after the completion of Task 1.

Task 3. Perform modeling and GIS analysis. Continuing for four months after the completion of Task 2.

Task 4. Ground truth GIS analysis and refine results through expert review. Continuing for approximately three months after the completion of Task 3.

Significant Deviations:

None.

Summary Of Progress:

Please see attached pdf file.

Location: Eastern Texas and Northwestern Louisiana.

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:** 1 November 2010

Approved by: [signature] **Date:** 1 November 2010

C. Craig Farquhar

A Habitat Model for the Louisiana Pine Snake And Its Implementation as a Conservation Template

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In Fulfillment of the Requirements of
Section 6 Contract # 203971

October 31, 2010

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INTRODUCTION

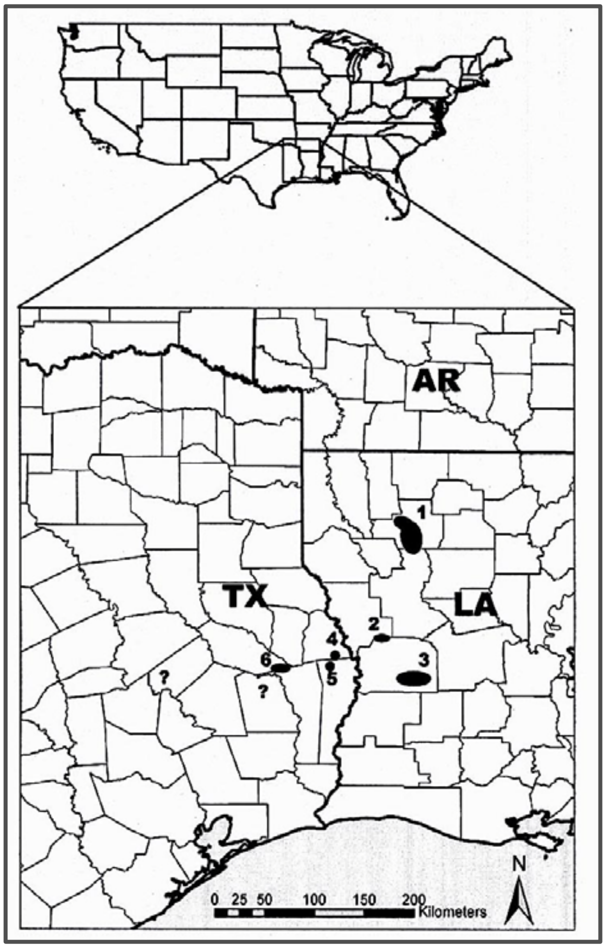
The Louisiana Pine Snake

The Louisiana pine snake (*Pituophis ruthveni,* hereafter often referred to as LPS) has long been recognized as one of North America's rarest snakes (Conant 1956; Jennings and Fritts 1983; Young and Vandeventer 1988; Rudolph et al 2006). In her 1929 description of *P. m. ruthveni* and in her 1940 review of the genus, Stull discussed pine snakes as a single wide ranging species (*Pituophis melanoleucus*) with four subspecies, and until recently biologists followed that taxonomy. Reichling (1995) presented evidence that the LPS differed significantly from other pine snakes in a number of morphological traits. Based on that evidence and the principles of the Evolutionary Species Concept (Simpson 1961; Wiley 1978; Collins, 1991), he proposed elevating the form to full species status (*P. ruthveni*).

The historical range of the LPS is restricted to eastern Texas and west-central Louisiana, a range that coincides with that of the historical range of the longleaf pine (*Pinus palustris*) on the West Gulf Coastal Plain (Conant 1956, Thomas et al. 1976, Young and Vandeventer 1988; Rudolph et al. 2006), but the current distribution of the species is restricted to six disjunct populations (Rudolph, et al. 2006; Figure 1): 1) western Bienville and extreme northern Natchitoches Parish; 2) Peason Ridge Military Reservation; 3) Fort Polk Military Reservation; 4) southern portion of the Sabine National Forest; 5) southern portion of the Angelina National Forest; and 6) Scrappin' Valley (a block of private land in Newton County). There are two recent records outside of these areas in Polk and Trinity counties but evaluation of the habitat quality of these sites in a recent study (Rudolph et al. 2006) questioned that these population could remain viable. There is some skepticism that even the other small isolated populations in more suitable habitat in eastern Texas can remain viable given their small population size, low reproductive rate, and susceptibility to road mortality (Rudolph and Burgdorf 1997; C. Rudolph, pers. comm.).

Because of its rarity, little was known of its ecology until data began to be analyzed from radio-tracking studies begun by the U.S. Forest Service Southern Research Station (SRS) and their partners in 1993. Certain macro ecological associations have long been recognized, such as the Louisiana Pine Snake's relationship with longleaf forest growing on sandy, well-drained soils (Conant 1956; Reichling 1995; Young and Vandeventer 1988), and furthermore, additional recent research has revealed that the LPS has very low reproductive rates with the smallest clutch size of any North American colubrid (Reichling 1988, 1990) and that females do not reach sexual maturity until around three years at a minimum length of 120 cm (Himes et al. 2002), increasing reasons to elevate conservation concerns for this rare and poorly known snake. Like their primary prey, pocket gophers (*Geomys breviceps*), they are associated with well developed herbaceous and grassy ground covers (Rudolph and Burgdorf 1997; Rudolph et al. 2002; Ealy et al. 2004; Himes et al. 2006a,b). The LPS also uses pocket gopher burrow systems for subsurface retreats, including hibernacula and to escape from fire (Rudolph and Burgdorf 1997; Rudolph et al. 1998, 2002; Young and Vandeventer 1988). Ealy, et al. (2004) reported that Louisiana Pine Snakes in their study were essentially diurnal, that they spent 59% of the day underground, and that they moved <10 m on 54.5% of the days they were monitored.

Figure 1. Extant Louisiana Pine Snake populations as delineated by Rudolph et al. (2006)



Habitat and Habitat Modeling

Habitat is understood by even the non-scientist to mean a place where an animal resides, but that definition of habitat is useless as a predictive tool; it is a concept cluster (Peet 1974; Morrison and Hall 2002). At a finer scale, habitat has a spatial extent during a given time period (Morrison and Hall 2002). For the purposes of this report, we define habitat after the definition of Morrison and Hall (2002) as "a concept that serves as an umbrella under which specific relationships between an animal and its surroundings are stated as testable hypotheses". The USGS Southern Research Station in Nacogdoches and their students and partners have answered many important questions about the life history of the Louisiana Pine Snake, and in the process have collected a considerable amount of crucially important spatial data. We know rather precisely how 22 radio-transmittered snakes were distributed across those study sites. We know, with varying degrees of certainty, how 189 historical records are distributed across the historical range of the species. This project sought to identify a common set of variables associated with the known spatial distribution of the LPS that could be used to extrapolate or predict potential LPS habitat at a landscape scale.

One can find an abundance of methods for modeling species' distributions that vary in how they model the distribution of the response, select relevant predictor variables, define fitted functions for each variable, weight variable contributions, allow for interactions, and predict geographic patterns of occurrence (Guisan and

Zimmerman 2000; Burgman et al. 2005). For models in which the response variable is binomial e.g. present/absent, actual/random, selected/available, a Generalized Linear Model (GLM) that assumes a binomial distribution and employs a logistic transformation of the data is a natural and commonly selected model (Guisan et al. 2002; Kneib et al 2007; Manly et al, 2002; Wagner et al. 2009). Various techniques have also been employed to supply the other parameter of the binomial response variable where only presence data are available. The easiest way to choose pseudo-absences is simply to generate them totally at random over the study area (Hirzel et al 2001; Zaniewski, et al. 2002). Wagner et al. (2009) created a model for the LPS in which they selected a study area that consisted only of those counties with known occurrences of the LPS and some connecting counties. They generated "used" and "available" datasets after the method of Manly et al. (2002) creating a 0.25 km radius polygon around snake localities to generate a "used resources" dataset and a 3 km radius polygon around snake locations to generate an "available resources" polygon (Wagner et al. 2009).

A Conservation Solution

The relationship of the Louisiana Pine Snake and other pine snakes (Duran 1998) to the longleaf forest is clear (Rudolph et al. 2006). The longleaf forest which totaled 92 million acres at the time of European settlement (Frost 1993) has now been reduced to less than 5% (3.2 million acres) of its historical range (Outcalt and Outcalt 1994) and much that remains has been severely altered by changes in silviculture practices and fire regimes (Frost 1993). While there is little empirical data to support it, one might rationally assume that the Louisiana Pine Snake has declined somewhat in proportion to its macro habitat.

Ignoring for the moment that LPS population segments may have become so isolated that genetic viability is an issue and that some populations may be at or nearing minimum population size thresholds (Shaffer 1981; Samson 1983; Shaffer and Samson 1985; C. Rudolph, pers. comm.), the obvious solution to saving a species that has declined so severely due to habitat loss is to try to restore some of that habitat. But a **fundamental** prerequisite to conservation planning and action is the understanding and assimilation of detailed information about the species' ecological and geographic distribution. One of the difficulties encountered by conservation organizations and conservation managers charged with buying or otherwise conserving lands for rare and endangered species is that they may not understand the specific habitat requirements of a target species, and the information they are getting from the science community or their science team is too vague (or too detailed) and rarely comes with easy to follow directions for use. On the other hand, scientists working alongside them may develop complex models of rare species and their habitats but sometimes fail to demonstrate the practical utility of those models to the conservation community.

The LPS predictive habitat model created by Wagner et al. (2009) appears to be a satisfactory model to use as a tool for prioritizing privately owned land with potential LPS habitat. In this paper, we report on some modeling exercises that we performed, and some potential models that we considered, but a primary objective was to validate or reject the Wagner et al. (2009) model. The final model should be one that effectively predicts potential Louisiana Pine Snake habitat, but it should, nearly as importantly, be a model that is relatively simple and can be readily applied in the construction of a template that allows conservation managers to precisely target conservation action.

METHODS

Habitat Model Dataset Construction and Study Area

We used ArcGIS v9.3.1 to create point files from historical and transmittered snake x-y locality data supplied to me by the U.S. Forest Service Southern Research Station in Nacogdoches, Texas. We created these data in the Texas Statewide Mapping System projection and projected all data obtained to that projection before any other analysis was performed. In order to account for the variability inherent in the historical dataset due to the imprecision of locality comments upon which they were based, we designated a precision value of High, Medium High, Medium and Low to each point. We then buffered the points by 10, 50, 200, and 1000 m respectively—e.g., points that were digitized from imprecise locality comments such as "6 mi. N. of Crockett" were assigned to the "Low" category and buffered by 1 km to create a 2 km diameter polygon and points that were based on GPS coordinates were buffered by 10 m (Table 1). We will refer to random and actual locality-polygons throughout this document by their buffered distance, i.e., a "1000 m polygon" means "a point buffered equilaterally by 1000 m" or a 2 km diameter round polygon.

To help determine the study area, we used the ArcGIS extension, Hawth Tools (v 3.27) to create a minimum convex polygon (MCP) around all LPS historical locations and buffered this polygon by 5 km. The LPS is known from only 18 counties and parishes (Table 2) within the 60 counties intersected by that MCP. We then considered two potential study areas. One consists of only those counties from which there were records and some connecting counties as Wagner et al. (2009) had done, and the other consists of all the counties within the MCP. After considering that the earliest record from our dataset was 1927 and assuming that the LPS probably occurred over a wider area when habitat conditions were more pristine, we decided to include all of the counties within the MCP polygon (Figure 2) so that we could examine marginal areas where the LPS might have occurred historically and connections between areas. We also chose the larger study area and made the decision to randomly select polygons within the whole study area so that we could compare our results with Wagner et al. (2009), based on considerably different methodologies. Wagner et al. (2009) also chose to create their model from the historical LPS dataset (HLD) and validated their model with the transmittered LPS dataset (TLD). We took the opposite approach and chose to build our model from the TLD and to attempt to validate it with the HLD. "Pseudo-absence" points were randomly selected within the study area and subsets of those points were randomly selected for buffering in the same proportions as the "present" dataset. For the TLD, which was based on high precision GPS observations, we created a point file in the same manner as with the HLD and buffered each of those records to 20 m to account for some variability. To determine the TLD study area we again drew a 5 km-buffered MCP around all transmittered locations. We then randomly distributed our 20 m pseudo-absence polygons within that study area. We began with all the historical locations that could be logically mapped even with those based on very vague locality data, but left the "buffer distance' field so that later we could eliminate the low precision points if we felt they were causing problems with the fit. We did find that fits were better if we eliminated the low precision (1 km) polygons and much better if eliminated all but the very highest precision polygons (10m).

Figure 2. Louisiana Pine Snake habitat study areas

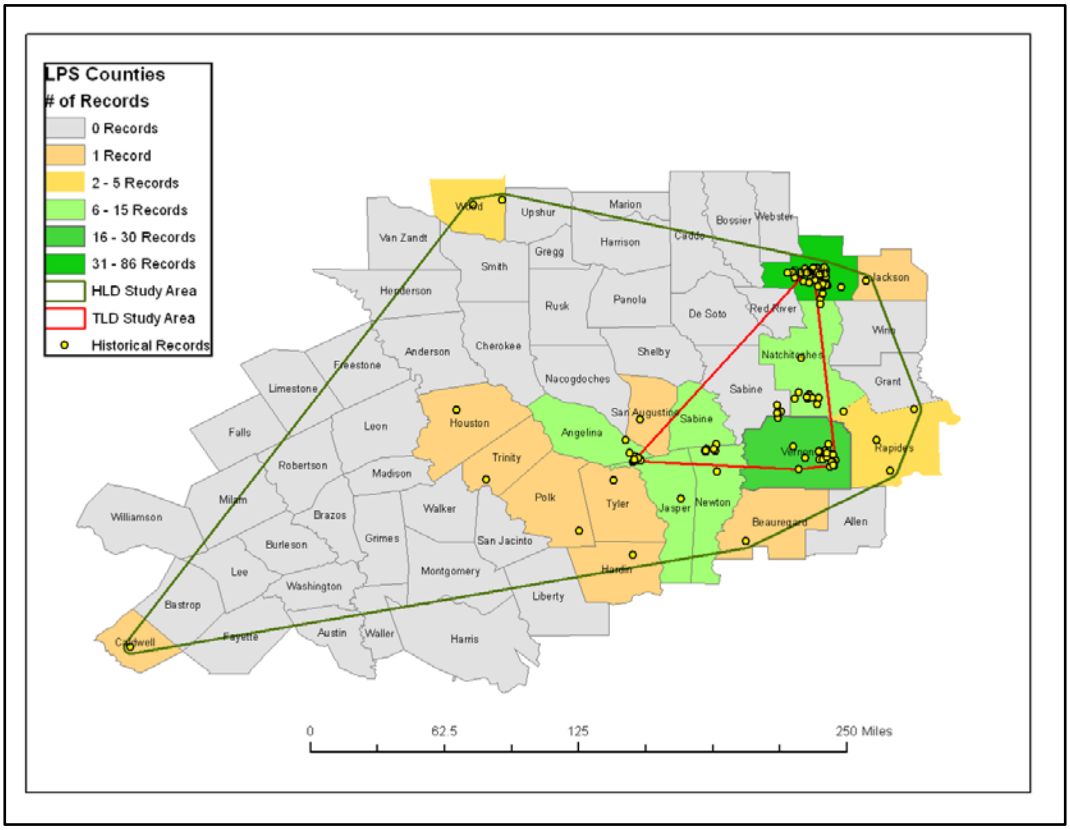


Table 2. LPS records by county/parish.

County	LPS Records
Angelina	11
Beauregard	1
Bienville	86
Caldwell	1
Hardin	1
Houston	1
Jackson	1
Jasper	7
Natchitoches	15
Newton	15
Polk	1
Rapides	5
Sabine Co.	6
Sabine Par.	4
San Augustine	1
Trinity	1
Tyler	1
Vernon	30
Wood	2

We determined that three datasets contained all the spatial information that might be useful in creating a model to select preferred LPS habitat— the Soil Survey Geographic (SSURGO) dataset, the National Hydrography Dataset (NHD), and the National Elevation Dataset (NED). We obtained and evaluated the Texas Ecological Systems Classification (TESC) dataset—while that dataset appeared to correctly delineate relationships between Texas LPS locations and ecological systems, the data are not available for Louisiana and therefore were determined to have little utility to this project. We also considered the Geological Association of Texas coverage but decided that the geological data would take an enormous amount of processing time and that the scale of the geological delineations was too coarse to fit our modeling objectives. The spatial data (SSURGO, NHD, NED and ownership parcels) were projected to Texas Statewide Mapping System (TSMS) coordinate system before any other processing or analysis was performed.

The shapefiles from the SSURGO dataset from the 60 counties included in the study area were merged into a single file. The data tables "chorizon", "mapunit", and "component" from the SSURGO dataset were appended and summarized by H1 horizon component percent for numerical variables, then joined to the shapefiles. Some fields that contained no data were deleted during the appending process.

We used the ArcGIS 9.3.1 tool "Intersect" to create a dataset that joined historical, transmittered, and random polygons and tables to soil polygons and tables. The SSURGO numerical (continuous) variables which had previously been weighted by component percent were then weighted and summarized by the percent of the soil mapunit that intersected the polygons. For categorical variables, only the parameter represented by the maximum intersecting mapunit was selected—the percent of the maximum mapunit intersected was later used as a weighting function in the statistical analyses. We used the ArcInfo Spatial Analysts tool "Tabulate Areas" to determine, from the NED dataset, mean slope and aspect of TLD, HLD and random polygons. We used the ArcInfo Spatial Analyst tool "Near" and the NHD dataset to determine distance from drainages. A column was then added to the tables that identified the records as "present" or "absent" and the data tables were appended for statistical analysis.

For each numerical variable, the SSURGO dataset included a "high", a "low" and a "representative value. We only used the representative value. We further edited the SSURGO dataset to eliminate fields for which there were insufficient data—this left me with 40 variables---27 numeric, which included the variables, "slope", "aspect" and "drain_dist" from the NED and NHD datasets and 9 categorical variables from the SSURGO dataset:

> hzdepb, sieveno4, sieveno10, sieveno40, sieveno200, sandtotal, sandvc, sandco, sandmed, sandfine, sandvf, silttotal, claytotal, om, dbthirdbar, dbfifteenbar, dbovendry, ksat, awc, wthirdbar, wfifteenba, wsatiated, lep, ll, pi, ec, cec7, ph1to1h2o, hydricrati, drainagecl, geomdesc, hydgrp, taxorder, taxsuborde, taxgrtgrop, taxsubgrp, taxpartsiz, slope, aspect, drain_dist

For definitions of the variable see Table 3.

Statistical Analysis

While the final model would clearly not be linear due to the binary nature of the response variable, we used stepwise linear regression in JMP (SAS Institute Inc 2008) to suggest variables and groups of variables that appeared to explain significant amounts of the variation in LPS occurrences. We created a correlation matrix with JMP to examine collinearity between numeric variables (Table 4) and deleted the less significant variables that were more than 30% correlated with variables of greater significance. We fit our selected variables using JMP v. 8.0 (SAS Institute Inc 2008) to a binomial GLM with a "logit" or logistic transformation. We examined chi-square goodness of fit statistics to assess if the fit of our model differed significantly from expected values. We examined chi-square contingency tables to assist us in valuing our graphical representations of the models in ArcGIS.

Ownership Analysis—Building the Conservation Template

We obtained digital data of parcels with ownership attributes from the counties and parishes with more than five historical LPS records and some adjacent counties and parishes, except for Vernon Parish which did not have digital data available. Those data were projected to the Texas Statewide Mapping System coordinate system before any other operations were performed. We added a “Unique ID” field to the ownership attribute table. After selecting the best model to predict LPS preferred habitat we used ArcGIS 9.3.1 Statistical Analyst-Zonal Statistics-Tabulate Area to add fields to the parcel data that calculated the area of preferred habitat occurring in each parcel or “Unique ID” field. We exported the results of this operation to Microsoft Access which was used to make the summary calculations. One county (San Augustine) and one parish (Natchitoches) had data in CAD format. We converted this to ESRI shapefiles but the data format for CAD data is polylines rather than polygons—we could produce graphical representations for those areas overlain by our habitat model, but without parcel polygons to tabulate by the parameters of our habitat model we couldn’t include those counties/parishes in the summaries. Newton County provided polygon shapefiles for parcels but provided ownership data in non-tabular text format that could not be linked to the parcels. So Newton County was included in the county summaries but not in the ownership summaries.

RESULTS

Habitat Analysis

A stepwise linear regression was helpful in suggesting that a significant amount of the variation in the occurrence of Louisiana Pine Snakes could be explained by the categorical soil variable Taxonomic Subgroup (TAXSUBGRP), which is the finest level of soil taxonomy in the SSURGO dataset. The subgroup is below soil great group and above soil family. TAXSUBGRP had 203 parameters but actual and random polygons intersected only 68 TAXSUBGRP polygons. Stepwise linear regression was helpful in determining the best set of TAXSUBGRP parameters to explain the maximum amount of the variation in LPS occurrence. The selected parameters were then fit to a binomial GLM model using the “logit” function in JMP (SAS Institute). The model selected ($p < .0001$) included these 14 parameters of the categorical variable TXSUBGRP:

> Aeric Fluvaquents Albaquic Hapludalfs   Aquic Hapludults   Arenic Paleudults   Chromic Dystraquerts   Grossarenic Paleudults   Humaqueptic Psammaquents   Lamellic Paleudults   Plinthic Paleudults   Typic Glossaqualfs   Typic Hapludalfs   Typic Hapludults   Typic Paleudults   Vertic Hapludalfs .

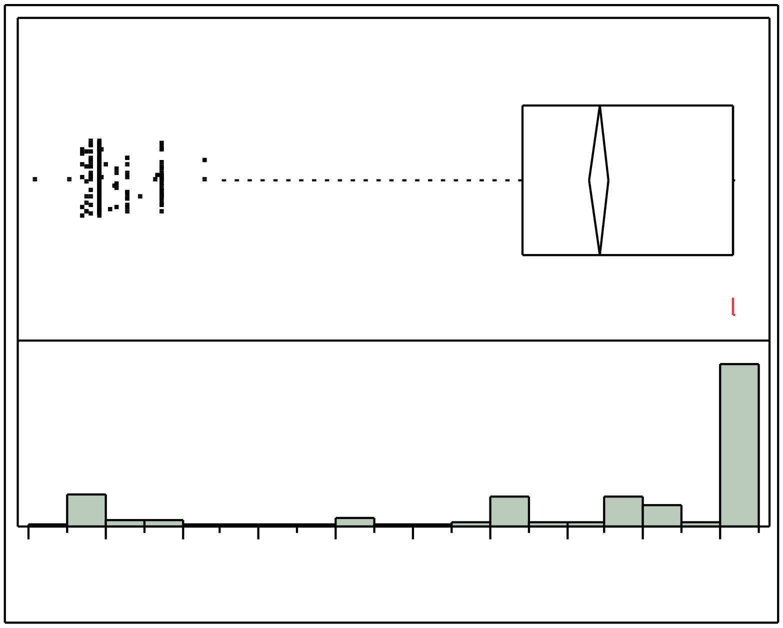
The Pearson Goodness of Fit statistic indicated no significant probability that the counts we observed differed from those expected. The model is best illustrated graphically (Figures 3,4,5) with preferred taxonomic subgroup polygons drawn in shades of green varied by the ratio of present (actual) intersections to absent (random) intersections, values obtained from a chi-square contingency table (Tables 5,6,7,8).

From the historical dataset, 89 of the 189 historical locality polygons fell on areas predicted to be preferred LPS habitat by the TXSBGRP Model. However, 31 localities occurred on taxonomic subgroups that the TXSBGRP model predicted would be less preferred or avoided. Results were much better when only the 200 random and actual polygons with very high precision are considered, but still, the large number of parameters spread over relatively few samples made it difficult to develop a strong statistical argument for a fit. Wagner et al. (2009) had made an *a priori* deletion of the TAXSUBGRP variable based on the fact that it just had too many parameters. That was probably a wise decision. While this model is compelling and deserves further attention, our objective was to create a model that not only effectively predicted LPS habitat but that had substantive conservation utility—because of this models complexity (60 degrees of freedom), because there was so much area (mostly outside of the core range) that was not classified by this model, and because the validation fit to the HLD dataset was only mediocre, we rejected it as one that would not be the most helpful in classifying ownership parcels.

Stepwise linear regression suggested that the next most significant variable, explaining 40.5% of the variation in presence/absence of transmittered snakes was the numerical variable KSAT, which is defined as: “The amount of water that would move vertically through a unit area of saturated soil in unit time under unit hydraulic gradient” A little more of the variation (43.3% was explained by KSAT + Cec7 (”The amount of readily exchangeable cations that can be electrically adsorbed to negative charges in the soil, soil constituent, or other material, at pH 7.0, as estimated by the ammonium acetate method.), but given that Cec7 was 25% correlated with KSAT, we decided to go with the simpler model in which the prediction depends only on the variation in KSAT. The mean value for KSAT at locations where transmittered snakes occurred was 74.2. The mean value for KSAT at random locations was 19.7. The historical dataset (with all but the “very high” precision records removed) fit the model fairly well—mean KSAT value for actual polygons from the HLD was 72.0 and 80 of the 100 records occurred within the range predicted with a nearly identical distribution (Figures 6,7). Therefore KSAT looked like a good model for delineating LPS habitat but was it the model for turning into a conservation tool? Figures 8 and 9 are graphical representations of the KSAT model.

After removing TXSUBGRP and the other soil taxonomic groupings, TAXPARTSIZ, and GEOMDESC because that they all had had the same problem as TAXSUBGRP, each having large numbers of variables, some combination of which would explain a good deal of the variation in LPS occurrence but including them in a model would make it too complex to have practical utility. Therefore the categorical variable HYDGRP, (hydrogroup), simply defined as “A group of soils having similar runoff potential under similar storm and cover conditions” was left as offering the best potential model for creating a conservation template. About 33% of the variation in LPS occurrence could be explained by HYDRGRP (Figure 10, Tables 9, 10, 11).

Figure 6. Distribution of KSAT by Present



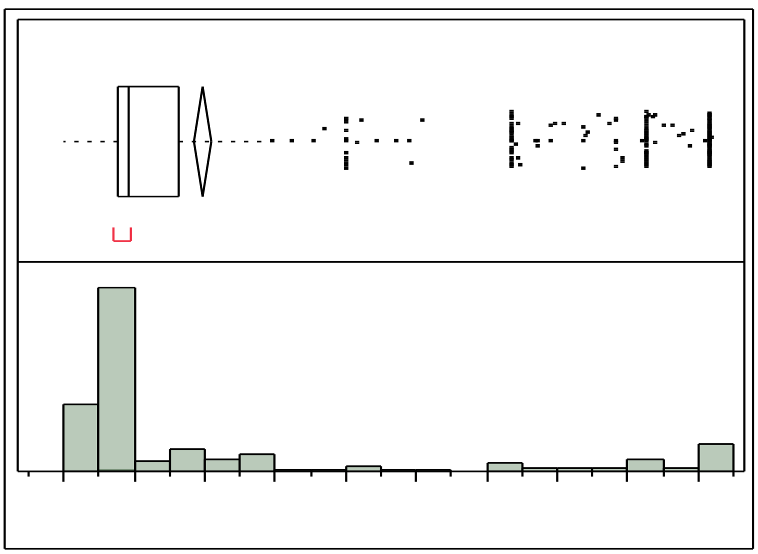
Quantiles

100.0%	maximum	92.000
99.5%		92.000
97.5%		92.000
90.0%		91.740
75.0%	quartile	91.740
50.0%	median	91.740
25.0%	quartile	64.400
10.0%		9.170
2.5%		9.170
0.5%		7.650
0.0%	minimum	0.920

Moments

Mean	74.215535
Std Dev	27.820576
Std Err Mean	0.6404425
Upper 95% Mean	75.471585
Lower 95% Mean	72.959485
N	1887

Figure 7. Distributions of KSAT by Absent



Quantiles

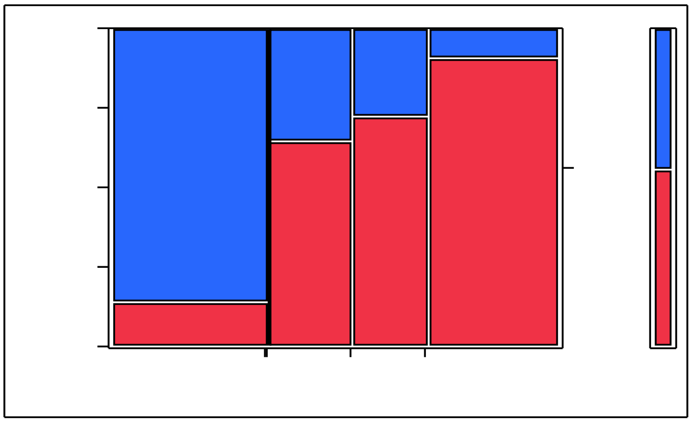
100%	Maximum	92.000
97.5%		91.740
90.0%		82.800
75.0%	quartile	16.210
50.0%	median	9.170
25.0%	quartile	7.768
10.0%		0.210
2.5%		0.000
0.5%		0.000
0.0%	minimum	0.000

Moments

Mean	19.760644
Std Dev	26.805501
Std Err Mean	0.6169116
Upper 95% Mean	20.970544
Lower 95% Mean	18.550743
N	1888

Figure 10. Contingency Analysis of Present By HYDGRP

Mosaic Plot



Weight = MU_pct

Table 9. Contingency Table: HYDGRP by Present

Count Total % Col % Row %	Absent	Present	
A	153 5.05 9.03 14.39	913 30.06 68.21 85.61	1067 35.11
A/D	3 0.10 0.18 100.00	0 0.00 0.00 0.00	3 0.10
B	372 12.23 21.87 64.76	202 6.66 15.11 35.24	574 18.89
C	369 12.15 21.72 72.32	141 4.65 10.55 27.68	510 16.80
D	802 26.40 47.19 90.71	82 2.70 6.14 9.29	884 29.10
	1699 55.93	1339 44.07	3038

Tables 10 and 11. Tests for logistic fit of HYDGRP by Present

N	DF	-LogLike	RSquare (U)
3038	4	698.12989	0.3349

Test	ChiSquare	Prob>ChiSq
Likelihood Ratio	1396.260	<.0001*
Pearson	1256.856	<.0001*

The HYDGRP model was attractive because of its simplicity—83% of all transmittered snake locations fell on HYDGRP “A” and “B”. Present/Random ratio for HYDGRP “A” was 85.6%. HYDGRP “B” was a much poorer predictor of the TLD occurrences, selected only 35.2% of the time compared to random occurrence. However, the model fit the historical dataset better than it did the TLD explaining about 39.1% of the variation with 88 out of 96 (with missing values and after deletion of low precision records) historical LPS occurrences falling on HYDGRP “A” or “B”. For the historical dataset, HYDGRP “A” was selected at a much greater rate than its availability (85.6%) and B was selected at about the same rate. This is nearly the same final result that Wagner et al. (2009) reported. It is easy to see why they selected a model based on HYDGRP. While the model based on KSAT may be nearly equal to the HYDGRP model as a predictor of LPS habitat, the simplicity of the HYDGRP model and its decent fit to both datasets made it the best model to use to define high priority ownership parcels. Figures 11-14 are graphical illustrations of the HYDGRP model.

The Conservation Template

The figures produced for this template show ownership parcels classified by the amount of LPS priority soils that fall within a single parcel. “Priority soils” is defined as “the total area of HYDGRP “A” and “B” that occurs within a single parcel. We sometimes refer to “priority soils” as “potential LPS habitat”. Parcels containing less than 200 acres are shown in red. Parcels with more than 200 acres or priority soils are shown in shades of green, varying from light to dark as the area of priority soils increases. A red parcel does not necessarily indicate that the area does not include LPS priority soils, just that the parcel probably has little conservation potential because of its small size. Within the nine counties for which we had the type of data that could be summarized by parcel there are 1.97 million acres of potential LPS habitat contained in parcels of all sizes (Table 12). That total includes National Forest parcels and other protected land. Of the parcels we were able to identify as privately owned, about 716,000 acres of parcels containing more than 200 acres of LPS priority soils were under private ownership. A better measurement of conservation potential is probably the area of privately owned parcels with greater than1000 acres of potential LPS habitat in a single parcel. There are about 169,000 acres of potential LPS habitat under private ownership in parcels larger than 1000 acres across the nine counties and parishes that we analyzed. All but one of the remaining populations of Louisiana pine snakes occur within those nine counties. It was unfortunate that Vernon Parish did not have the kind of data (digital) that would have been useful to this project, but the Vernon Parish population occurs mainly within the Fort Polk Military Reservation and the Kisatchie National Forest, which covers about 30% of the county (Figure 15). This may be one of the more secure population segments.

Table 12. Summation of parcels with LPS priority soils by county.

County	Total LPS Priority Soils	LPS Priority Soils >200 ac in a single parcel	LPS Priority Soils >1000 ac in a single parcel
Polk	238988.86	133389.86	43437.69
Angelina	119590.85	16780.33	3219.61
Bienville	187891.45	54480.49	22697.83
Tyler	365301.00	183381.00	57070.00
Jasper	292288.61	111526.62	15261.51
Newton	330259.01	179888.29	25919.72
Sabine County	46060.05	6024.16	1276.89
Rapides	293894.09	12179.13	0.00
Sabine Parish	95993.13	18664.17	0.00
Total Priority LPS Soils	1970267.05	716314.05	168883.26

Forty-five percent of all LPS records have come from **Bienville Parish**—it is clearly the conservation priority and with ~54,000 acres of LPS priority soils in ownership parcels >200 acres and ~23,000 acres in ownership parcels >1000, there should be opportunities for conservation action there. The three owners of largest land parcels with priority LPS soils in Bienville Parish are Sustainable Forests, LLC, (~28,689 acres), LA. Minerals, LTD (~ 18,000) acres and the Weyerhaeuser Company (~15,000 acres).

Tyler County has ~57,000 acres in greater than 1000 acre privately owned parcels (Figure 17), but has only one LPS record (from 1994). There are some older records in adjacent counties. The historic range of the LPS probably included much of Tyler County but land management and silviculture practices may have now extirpated it from the county or nearly so. Most large Tyler County private ownership parcels are probably too far from extant LPS populations to be considered conservation priorities at this time, but in the future Tyler County could offer some LPS habitat restoration and reintroduction possibilities with cooperation from large private landowners. Crown Timber is the biggest owner of land with priority LPS soils in Tyler County and the biggest owner of LPS priority soils (121,000 acres) summarized for the nine counties (Table 13, 14). Likewise, **Polk County**, with 43,000 acres of preferred LPS soils (Figure 18), but only a single old record (1951), is not an immediate conservation priority but may have future possibilities.

There are six historical records from the Angelina National Forest in the northeastern part of **Jasper County**, but only a single old (1966) record from elsewhere in the county. The conservation of LPS habitat south of the Angelina National Forest population in Jasper County through engagement with private landowners should be a conservation priority. With 33,600 acres of LPS priority soils in ownership parcels larger than 1000 acres in Jasper County (Figure 19) there would appear to be ample opportunity for conservation action.

The data provided by **Sabine County** appeared to be incomplete, but Sabine County is largely covered by the Sabine National Forest (Figure 20), and it may be that the data just didn't included national forest land. Six LPS records have come from Sabine County including one that the lead author removed from a trap in 1994. There appears to be little potential for large-scaled conservation actions in Sabine County. The only large tracts with significant amounts of LPS priority soils adjacent to the southern Sabine County LPS population are identified as belonging to "421 Development, Ltd."

Eleven records have come from the Angelina National Forest in the southeastern portion of **Angelina County** (Figure 21), but with only about 3200 acres of priority LPS soils contained in parcels greater than 1000 acres which are mostly widely separated from the Angelina LPS population by non-preferred soils and/or smaller parcels, there appears to be little opportunity for positive conservation action in Angelina County.

Sabine Parish, with four historical LPS records, has no parcels larger than 1000 acres (Figure 22), but there are a few parcels with 300-600 acres of LPS priority soils adjacent to the Peason Ridge Military Reservation which might offer some possibilities for expanding habitat for that population. Timberstar Louisiana ILP is the largest owner of LPS priority soils in Sabine Parish with about 6500 acres.

There was only 2454 acres of LPS priority soils within privately owned parcels greater than 1000 acres in **Rapides Parish**, from where five historical LPS records have come (Figure 23). All but one of those records are over 50 years old. The recent record (2001) from the northern border of the parish would appear to be part of the population segment that was mostly known from the Kisatchie National Forest in southern Natchitoches Parish but may now be nearly extirpated (Rudolph et al. 2006). Most LPS priority soils in Rapides Parish occur within the Kisatchie National Forest and the larger privately owned parcels appear to be widely separated from the population in northern Rapides and southern Natchitoches parishes.

Most of the LPS priority soils in **Natchitoches Parish** are within the Kisatchie National Forest. We were unable to calculate ownership by parcels from the data provided to us by Natchitoches Parish but there does not appear to be a great deal of conservation potential except for possibly some large parcels adjacent to the northwestern corner of the Kisatchie National Forest in the southern part of the parish (Figure 24).

The data provided by **Newton County** allowed us to calculate LPS priority soils by parcel and create a graphical representation (Figure 25), but we could not join the spatial data to the owner's name, only to a parcel ID number and often the Parcel ID number was missing. So Newton County is included in the county summaries (Table 12) but not in the ownership summaries (Tables13 and 14). As the site of the extant Scrappin' Valley population segment and with 15 historical records and 180,000 acres of LPS priority soils contained in parcels >200 acres, Newton County is a priority area for conservation action. Newton County has nearly 30,000 acres of LPS priority soils contained in parcels larger than 1000 acres so considerable potential exist for successful conservation action through engagement with private landowners.

CONCLUSIONS AND DISCUSSION

The quality of analyses based on datasets obtained from third parties can only be as good as the data. Generally the data we obtained from county and parish appraisal districts and tax assessors appeared to be relatively complete, but we mentioned a few examples where it was not. Even the SSURGO dataset has some obvious problems which are only apparent when the mapunit being mapped abruptly changes at county lines because different surveyors evaluated it differently. We believe that the HYDGRP model developed by Wagner et al. (2009) and confirmed here is probably the best model to use as a conservation template with the data now available, but as new versions of the SSURGO dataset are released each year, that could change.

In Texas, the Louisiana Pine Snake is critically endangered. It may be too late to save the few remaining isolated populations, but if this daunting task is to be accomplished it will is crucial that conservation action be precisely targeted. We hope that this template can play an important role in assuring that conservation action is directed where it will do the most good for restoration and recovery of the Louisiana Pine Snake.

“Conservation action” or “engagement” of private landowners might include any number of strategies ranging from outright acquisition of the property to the purchase or acceptance of conservation easements to agreements with landowners along the lines of U.S. Fish and Wildlife Service’s Candidate Conservation Agreements (CCA). It is difficult to assess whether the existing CCA for the Louisiana Pine Snake has benefited the species at all. The signatories are mainly the U.S. National Forests within the range of the species and the states of Texas and Louisiana. While the Ranger Districts are now managing the forests in ways clearly beneficial to the species, it seem likely that they would have been doing that anyway under the federal mandate to manage for the roughly sympatric Red-cockaded Woodpecker (*Picoides borealis*). In some cases, private landowners who had been cooperators and/or signatories to the agreement have sold their lands to other companies, who had no continuing obligation to uphold the conditions of the agreement. Certainly in the beginning, the CCA gave everyone concerned the feeling that they had “done” something and some were just relieved that the LPS didn’t have to be listed, but eight years later the snake appears to be more threatened than ever, mostly by incompatible silviculture practices on privately owned land. The National Forests are doing all they can to protect the populations within their boundaries but most of the threats come from outside those boundaries. Only the cooperation of private landowners can save the species from complete extirpation in Texas.

In Bienville Parish, where 45% of all LPS historical records have come, nearly the whole parish is privately owned. Engagement of private landowners in Bienville Parish is imperative if that population segment is to survive. In Texas the best opportunities for conservation appear to be in those counties south of the Angelina and Sabine national forests in Jasper and Newton counties. The Nature Conservancy has long recognized the conservation value of “Longleaf Ridge” in the northern portions of Jasper, Newton, and Tyler counties which clearly stands out in dark green in all three habitat models we presented. It is perplexing that more LPS records have not come from there--that could be because of limited access to the mostly private tracts have presented fewer opportunities for detecting the snake, but more likely it’s because management practices have eliminated it from much of the area. The best chance for the survival of the LPS in Texas is through massive conservation actions on the Longleaf Ridge.

This document and an ArcGIS project folder with all associated files will be made available to The Nature Conservancy’s conservation managers and to any conservation organization or partners that requests them. We hope this will lead to precision conservation action at Longleaf Ridge, in Bienville Parish, and in other places identified as priorities for conservation action.

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Tables

Table 1. Historical Louisiana Pine Snake Records with Distance Buffered for Habitat Analysis.

Orig_ID	Uniq_ID	Precision	Buffer	Date	County_Par	State	Area	Acres
1	1	L	1000	3/24/1927	Rapides	Louisiana	3141177.00	776.20
2	2	M	200	5/9/1931	Angelina	Texas	125581.04	31.03
3	3	M	200	4/1/1948	Natchitoches	Louisiana	125581.03	31.03
4	4	M	200	5/2/1948	Natchitoches	Louisiana	125581.05	31.03
5	5	L	1000	2/2/1949	Jackson	Louisiana	3141176.99	776.20
6	6	L	1000	1/1/1927	Rapides	Louisiana	3141177.00	776.20
8	7	L	1000	6/2/1951	Polk	Texas	3141177.00	776.20
9	8	L	1000	5/5/1953	Natchitoches	Louisiana	3141176.98	776.20
10	9	L	1000	1/1/1953	Rapides	Louisiana	3141177.01	776.20
12	10	M	200	2/1/1955	Rapides	Louisiana	125581.04	31.03
14	11	L	1000	5/9/1956	Bienville	Louisiana	3141177.00	776.20
15	12	M	200	5/5/1956	Houston	Texas	125581.04	31.03
16	13	M	200	5/19/1944	Vernon	Louisiana	125581.04	31.03
19	14	L	1000	5/15/1944	Vernon	Louisiana	3141177.00	776.20
21	15	L	1000	2/2/1956	Wood	Texas	3141176.98	776.20
22	16	M	200	5/4/1959	Hardin	Texas	125581.03	31.03
24	17	H	10	6/13/1965	Bienville	Louisiana	312.57	0.08
26	18	H	10	4/20/1967	Beauregard	Louisiana	312.57	0.08
27	19	M	200	8/23/1967	Natchitoches	Louisiana	125581.04	31.03
28	20	M	200	7/3/1968	Bienville	Louisiana	125581.05	31.03
29	21	MH	50	5/22/1968	Bienville	Louisiana	7833.33	1.94
30	22	M	200	8/27/1968	Bienville	Louisiana	125581.04	31.03
31	23	MH	50	3/17/1969	Bienville	Louisiana	7833.32	1.94
32	24	L	1000	6/1/1969	Bienville	Louisiana	3141177.00	776.20
33	25	MH	50	6/13/1971	Natchitoches	Louisiana	7833.33	1.94
34	26	L	1000	6/9/1971	Bienville	Louisiana	3141177.00	776.20
35	27	L	1000	6/1/1971	Bienville	Louisiana	3141177.00	776.20
36	28	MH	50	4/28/1971	Bienville	Louisiana	7833.33	1.94
37	29	M	200	5/19/1972	Bienville	Louisiana	125581.04	31.03
38	30	L	1000	3/1/1972	Bienville	Louisiana	3141176.98	776.20
39	31	L	1000	5/10/1973	Newton	Texas	3141177.01	776.20
40	32	L	1000	5/26/1973	Wood	Texas	3141177.01	776.20
41	33	MH	50	5/16/1964	Newton	Texas	7833.33	1.94
42	34	M	200	4/26/1975	Bienville	Louisiana	125581.04	31.03
44	35	H	10	1/1/1977	Natchitoches	Louisiana	312.57	0.08
45	36	H	10	4/8/1977	Newton	Texas	312.57	0.08
46	37	L	1000	4/23/1979	San Augustine	Texas	3141177.00	776.20
48	38	H	10	1/1/1980	Angelina	Texas	312.57	0.08
49	39	M	200	2/2/1983	Sabine	Louisiana	125581.04	31.03
50	40	H	10	1/1/1984	Natchitoches	Louisiana	312.57	0.08
51	41	H	10	1/1/1984	Natchitoches	Louisiana	312.57	0.08
52	42	M	200	8/2/1987	Bienville	Louisiana	125581.04	31.03
53	43	H	10	9/25/1987	Natchitoches	Louisiana	312.57	0.08
54	44	L	1000	4/16/1966	Jasper	Texas	3141177.00	776.20
55	45	MH	50	4/21/1971	Bienville	Louisiana	7833.33	1.94
57	46	H	10	4/5/1988	Bienville	Louisiana	312.57	0.08
58	47	MH	50	8/17/1988	Bienville	Louisiana	7833.33	1.94
59	48	MH	50	7/3/1988	Bienville	Louisiana	7833.33	1.94
60	49	M	200	8/17/1988	Bienville	Louisiana	125581.05	31.03
62	50	M	200	2/2/1987	Trinity	Texas	125581.04	31.03
63	51	L	1000	11/19/1986	Bienville	Louisiana	3141177.00	776.20
64	52	L	1000	11/19/1986	Bienville	Louisiana	3141177.00	776.20
77	53	MH	50	5/26/1989	Bienville	Louisiana	7833.33	1.94
78	54	MH	50	7/7/1990	Bienville	Louisiana	7833.32	1.94
79	55	MH	50	4/24/1990	Bienville	Louisiana	7833.33	1.94
80	56	M	200	8/13/1990	Bienville	Louisiana	125581.03	31.03

Orig_ID	Uniq_ID	Precision	Buffer	Date	County_Par	State	Area	Acres
81	57	MH	50	6/24/1990	Bienville	Louisiana	7833.32	1.94
82	58	MH	50	10/6/1990	Bienville	Louisiana	7833.32	1.94
83	59	M	200	5/18/1992	Bienville	Louisiana	125581.05	31.03
84	60	MH	50	4/4/1992	Bienville	Louisiana	7833.33	1.94
85	61	L	1000	4/5/1992	Bienville	Louisiana	3141177.00	776.20
86	62	L	1000	4/18/1992	Bienville	Louisiana	3141177.00	776.20
87	63	MH	50	6/7/1993	Bienville	Louisiana	7833.33	1.94
88	64	MH	50	5/19/1993	Bienville	Louisiana	7833.33	1.94
89	65	MH	50	5/7/1993	Angelina	Texas	7833.33	1.94
90	66	H	10	6/2/1993	Vernon	Louisiana	312.57	0.08
91	67	H	10	6/4/1993	Sabine	Texas	312.57	0.08
91	68	H	10	6/23/1994	Sabine	Texas	312.57	0.08
92	69	L	1000	6/5/1993	Angelina	Texas	3141177.02	776.20
93	70	MH	50	1/1/1994	Bienville	Louisiana	7833.32	1.94
94	71	MH	50	5/7/1994	Tyler	Texas	7833.32	1.94
95	72	H	10	6/23/1994	Sabine	Texas	312.57	0.08
96	73	H	10	6/30/1994	Sabine	Texas	312.57	0.08
97	74	M	200	12/6/1995	Bienville	Louisiana	125581.04	31.03
98	75	MH	50	1/1/1995	Angelina	Texas	7833.33	1.94
99	76	M	200	3/24/1995	Bienville	Louisiana	125581.04	31.03
100	77	H	10	4/12/1995	Jasper	Texas	312.57	0.08
101	78	H	10	4/18/1995	Jasper	Texas	312.57	0.08
102	79	L	1000	4/22/1995	Bienville	Louisiana	3141177.00	776.20
103	80	H	10	5/11/1995	Bienville	Louisiana	312.57	0.08
104	81	H	10	5/31/1995	Bienville	Louisiana	312.57	0.08
105	82	H	10	5/31/1995	Bienville	Louisiana	312.57	0.08
106	83	H	10	6/7/1995	Vernon	Louisiana	312.57	0.08
107	84	MH	50	6/8/1995	Newton	Texas	7833.33	1.94
108	85	H	10	6/14/1995	Bienville	Louisiana	312.57	0.08
108	86	H	10	6/6/1996	Bienville	Louisiana	312.57	0.08
109	87	H	10	6/15/1995	Sabine	Texas	312.57	0.08
110	88	M	200	6/20/1995	Newton	Texas	125581.03	31.03
111	89	H	10	6/30/1995	Bienville	Louisiana	312.57	0.08
112	90	H	10	7/5/1995	Bienville	Louisiana	312.57	0.08
113	91	H	10	8/2/1995	Bienville	Louisiana	312.57	0.08
114	92	H	10	8/23/1995	Bienville	Louisiana	312.57	0.08
115	93	M	200	8/23/1995	Newton	Texas	125581.03	31.03
116	94	M	200	8/30/1995	Bienville	Louisiana	125581.04	31.03
117	95	M	200	9/1/1995	Newton	Texas	125581.04	31.03
118	96	M	200	5/10/1996	Newton	Texas	125581.03	31.03
119	97	M	200	5/10/1996	Newton	Texas	125581.03	31.03
120	98	L	1000	5/20/1996	Vernon	Louisiana	3141177.00	776.20
121	99	M	200	5/21/1996	Vernon	Louisiana	125581.04	31.03
122	100	H	10	7/4/1996	Bienville	Louisiana	312.57	0.08
123	101	H	10	8/7/1996	Bienville	Louisiana	312.57	0.08
124	102	MH	50	1/1/1997	Bienville	Louisiana	7833.32	1.94
127	103	L	1000	6/5/1997	Vernon	Louisiana	3141176.99	776.20
128	104	M	200	12/17/1997	Angelina	Texas	125581.03	31.03
129	105	MH	50	1/1/1998	Angelina	Texas	7833.33	1.94
130	106	MH	50	5/16/1998	Bienville	Louisiana	7833.33	1.94
131	107	M	200	4/17/1998	Newton	Texas	125581.04	31.03
132	108	L	1000	6/1/1998	Sabine	Louisiana	3141176.97	776.20
133	109	MH	50	4/3/1999	Bienville	Louisiana	7833.32	1.94
134	110	M	200	1/1/1999	Bienville	Louisiana	125581.04	31.03
139	111	H	10	4/24/2000	Vernon	Louisiana	312.57	0.08
140	112	H	10	6/6/2000	Natchitoches	Louisiana	312.57	0.08
141	113	H	10	6/6/2000	Natchitoches	Louisiana	312.57	0.08
141	114	H	10	5/30/2001	Natchitoches	Louisiana	312.57	0.08

Orig_ID	Uniq_ID	Precision	Buffer	Date	County_Par	State	Area	Acres
142	115	H	10	6/7/2000	Jasper	Texas	312.57	0.08
143	116	H	10	6/12/2000	Vernon	Louisiana	312.57	0.08
144	117	H	10	11/1/2000	Vernon	Louisiana	312.57	0.08
145	118	H	10	8/8/2001	Vernon	Louisiana	312.57	0.08
146	119	H	10	6/4/2002	Vernon	Louisiana	312.57	0.08
147	120	H	10	6/4/2002	Vernon	Louisiana	312.57	0.08
148	121	H	10	6/5/2002	Vernon	Louisiana	312.57	0.08
149	122	H	10	7/17/2002	Vernon	Louisiana	312.57	0.08
150	123	H	10	9/5/2002	Vernon	Louisiana	312.57	0.08
151	124	H	10	9/11/2002	Vernon	Louisiana	312.57	0.08
152	125	H	10	5/28/2003	Vernon	Louisiana	312.57	0.08
153	126	H	10	5/28/2003	Vernon	Louisiana	312.57	0.08
154	127	H	10	6/13/2003	Jasper	Texas	312.57	0.08
155	128	H	10	6/2/2004	Vernon	Louisiana	312.57	0.08
156	129	H	10	6/8/2004	Vernon	Louisiana	312.57	0.08
157	130	L	1000	8/26/2004	Vernon	Louisiana	3141177.01	776.20
158	131	H	10	4/19/1995	Angelina	Texas	312.57	0.08
159	132	H	10	5/5/2005	Vernon	Louisiana	312.57	0.08
159	133	H	10	6/25/2005	Vernon	Louisiana	312.57	0.08
160	134	H	10	11/1/2005	Newton	Texas	312.57	0.08
161	135	H	10	3/1/2006	Newton	Texas	312.57	0.08
162	136	H	10	5/23/2006	Sabine	Louisiana	312.57	0.08
163	137	H	10	6/1/2006	Vernon	Louisiana	312.57	0.08
164	138	L	1000	6/1/2006	Sabine	Louisiana	3141177.01	776.20
165	139	H	10	3/19/2007	Natchitoches	Louisiana	312.57	0.08
166	140	H	10	4/13/2007	Jasper	Texas	312.57	0.08
167	141	H	10	4/21/2007	Natchitoches	Louisiana	312.57	0.08
168	142	H	10	4/25/2007	Bienville	Louisiana	312.57	0.08
168	143	H	10	8/19/2008	Bienville	Louisiana	312.57	0.08
169	144	H	10	4/30/2007	Jasper	Texas	312.57	0.08
169	145	H	10	5/1/2009	Angelina	Texas	312.57	0.08
170	146	L	1000	5/24/2007	Vernon	Louisiana	3141177.00	776.20
171	147	H	10	6/13/2007	Bienville	Louisiana	312.57	0.08
172	148	H	10	6/25/2007	Angelina	Texas	312.57	0.08
173	149	H	10	6/27/2007	Vernon	Louisiana	312.57	0.08
175	150	H	10	8/20/2007	Angelina	Texas	312.57	0.08
176	151	H	10	11/14/2007	Vernon	Louisiana	312.57	0.08
179	152	H	10	4/3/1996	Bienville	Louisiana	312.57	0.08
180	153	H	10	4/14/2004	Bienville	Louisiana	312.57	0.08
181	154	H	10	4/19/2004	Bienville	Louisiana	312.57	0.08
182	155	H	10	4/28/2004	Bienville	Louisiana	312.57	0.08
183	156	H	10	5/19/2004	Bienville	Louisiana	312.57	0.08
183	157	H	10	6/10/2009	Bienville	Louisiana	312.57	0.08
184	158	H	10	5/27/2004	Bienville	Louisiana	312.57	0.08
185	159	H	10	5/27/2004	Bienville	Louisiana	312.57	0.08
185	160	H	10	7/27/2004	Bienville	Louisiana	312.57	0.08
186	161	H	10	6/10/2004	Bienville	Louisiana	312.57	0.08
187	162	H	10	7/27/2004	Bienville	Louisiana	312.57	0.08
188	163	H	10	8/18/2004	Bienville	Louisiana	312.57	0.08
188	164	H	10	4/29/2005	Bienville	Louisiana	312.57	0.08
189	165	H	10	8/28/2004	Bienville	Louisiana	312.57	0.08
190	166	H	10	6/29/2005	Bienville	Louisiana	312.57	0.08
191	167	H	10	7/15/2005	Bienville	Louisiana	312.57	0.08
192	168	H	10	7/1/2003	Natchitoches	Louisiana	312.57	0.08
193	169	H	10	8/13/2007	Bienville	Louisiana	312.57	0.08
194	170	H	10	9/5/2007	Bienville	Louisiana	312.57	0.08
195	171	MH	50	10/1/2006	Bienville	Louisiana	7833.33	1.94
196	172	MH	50	7/8/1988	Bienville	Louisiana	7833.33	1.94

Orig_ID	Uniq_ID	Precision	Buffer	Date	County_Par	State	Area	Acres
197	173	H	10	4/26/2008	Newton	Texas	312.57	0.08
198	174	L	1000	5/29/2008	Newton	Texas	3141176.97	776.20
199	175	MH	50	1/1/2001	Rapides	Louisiana	7833.33	1.94
200	176	H	10	6/6/2008	Newton	Texas	312.57	0.08
201	177	H	10	6/9/2008	Bienville	Louisiana	312.57	0.08
202	178	H	10	6/9/2008	Bienville	Louisiana	312.57	0.08
203	179	H	10	5/12/2008	Bienville	Louisiana	312.57	0.08
204	180	H	10	6/24/2008	Bienville	Louisiana	312.57	0.08
206	181	H	10	7/30/2008	Bienville	Louisiana	312.57	0.08
207	182	H	10	9/10/2008	Bienville	Louisiana	312.57	0.08
208	183	H	10	10/20/2008	Bienville	Louisiana	312.57	0.08
208	184	H	10	6/2/2009	Bienville	Louisiana	312.57	0.08
209	185	H	10	6/11/2009	Bienville	Louisiana	312.57	0.08
210	186	H	10	6/2/2009	Bienville	Louisiana	312.57	0.08
211	187	H	10	4/29/2009	Vernon	Louisiana	312.57	0.08
212	188	H	10	6/23/2009	Vernon	Louisiana	312.57	0.08
213	189	M	200	6/2/1960	Caldwell	Texas	125581.04	31.03

Table 3. Definitions of SSURGO (2006) and other variables used in this analysis.

Variable	Definition
NUMERICAL	**(SSURGO 2006)**
hzdepb	The distance from the top of the soil to the upper boundary of the soil horizon.
sieveno4	Soil fraction passing a number 4 sieve (4.70mm square opening) as a weight percentage of the less than 3 inch (76.4mm) fraction.
sieveno10	Soil fraction passing a number 10 sieve (2.00mm square opening) as a weight percentage of the less than 3 inch (76.4mm) fraction.
sieveno40	Soil fraction passing a number 40 sieve (0.42mm square opening) as a weight percentage of the less than 3 inch (76.4mm) fraction.
sieveno200	Soil fraction passing a number 200 sieve (0.074mm square opening) as a weight percentage of the less than 3 inch (76.4mm) fraction.
sandtotal	Mineral particles 0.05mm to 2.0mm in equivalent diameter as a weight percentage of the less than 2 mm fraction.
sandvc	Mineral particles 1.0mm to 2.0mm in equivalent diameter as a weight percentage of the less than 2 mm fraction.
sandco	Mineral particles 0.5mm to 1.0mm in equivalent diameter as a weight percentage of the less than 2 mm fraction.
sandmed	Mineral particles 0.25mm to 0.5mm in equivalent diameter as a weight percentage of the less than 2 mm fraction.
sandfine	Mineral particles 0.10 to 0.25mm in equivalent diameter as a weight percentage of the less than 2 mm fraction.
sandvf	Mineral particles 0.05 to 0.10mm in equivalent diameter as a weight percentage of the less than 2 mm fraction.
silttotal	Mineral particles 0.002 to 0.05mm in equivalent diameter as a weight percentage of the less than 2.0mm fraction.
claytotal	Mineral particles less than 0.002mm in equivalent diameter as a weight percentage of the less than 2.0mm fraction.
om	The amount by weight of decomposed plant and animal residue expressed as a weight percentage of the less than 2 mm soil material.
dbthirdbar	The oven dry weight of the less than 2 mm soil material per unit volume of soil at a water tension of 1/3 bar.
dbfifteenbar	The oven dry weight of the less than 2 mm soil material per unit volume of soil at a water tension of 15 bar.
dbovendry	The oven dry weight of the less than 2 mm soil material per unit volume of soil exclusive of the desiccation cracks, measured on a coated clod.
ksat	The amount of water that would move vertically through a unit area of saturated soil in unit time under unit hydraulic gradient.
awc	The amount of water that an increment of soil depth, inclusive of fragments, can store that is available to plants. AWC is expressed as a volume fraction, and is commonly estimated as the difference between the water contents at 1/10 or 1/3 bar (field capacity) and 15 bars (permanent wilting point) tension and adjusted for salinity, and fragments.
wthirdbar	The volumetric content of soil water retained at a tension of 1/3 bar (33 kPa), expressed as a percentage of the whole soil.
wfifteenbar	The volumetric content of soil water retained at a tension of 15 bars (1500 kPa), expressed as a percentage of the whole soil.
wsatiated	The estimated volumetric soil water content at or near zero bar tension, expressed as a percentage of the whole soil.
lep	The linear expression of the volume difference of natural soil fabric at 1/3 or 1/10 bar water content and oven dryness. The volume change is reported as percent change for the whole soil.
ll	The water content of the soil at the change between the liquid and plastic states.
pi	The numerical difference between the liquid limit and plastic limit.
ec	The electrical conductivity of an extract from saturated soil paste.
cec7	The amount of readily exchangeable cations that can be electrically adsorbed to negative charges in the soil, soil constituent, or other material, at pH 7.0, as estimated by the ammonium acetate method.

ph1to1h2o	The negative logarithm to the base 10, of the hydrogen ion activity in the soil using the 1:1 soil-water ratio method. A numerical expression of the relative acidity or alkalinity of a soil sample. (SSM)
CATEGORI CAL	
hydricrating	A yes/no field that indicates whether or not a map unit component is classified as a "hydric soil". If rated as hydric, the specific criteria met are listed in the Component Hydric Criteria table.
drainagecl	Identifies the natural drainage conditions of the soil and refers to the frequency and duration of wet periods. An example of a drainage class is well drained.
geomdesc	A narrative description of the geomorphic setting of a component. The description may incorporate multiple geomorphic features as well as their relationship to each other. The individual parts of the description are recorded in the Component Geomorphic Description table.
hydgrp	A group of soils having similar runoff potential under similar storm and cover conditions. Examples are A and A/D.
taxorder	The highest level in Soil Taxonomy.
taxsuborde	The second level of Soil Taxonomy. The suborder is below the order and above the great group.
taxgrtgrop	The third level of Soil Taxonomy. The category is below the suborder and above the subgroup.
taxsubgrp	The fourth level of Soil Taxonomy. The subgroup is below great group and above family.
taxpartsiz	Particle-size classes are used as family differentiae. Particle-size refers to grain-size distribution of the whole soil and is not the same as texture. (Soil Taxonomy).
OTHER DATA	**DEFINITIONS**
Slope (NED)	the amount of inclination of that surface to the horizontal expressed as a percent
Aspect (NED)	the horizontal direction to which a slope faces.
drain_dist (NHD)	Distance from an actual or random polygon to the nearest drainage

Table 4. Correlation Matrix of numerical variables from the SSURGO (2006) dataset.

	HZDEPB	SIEVENO4	SIEVENO10	SIEVENO40	SIEVENO200	SANDTOTAL	SANDVC	SANDCO	SANDMED	SANDFINE	SANDVF	SILTTOTAL	CLAYTOTAL	OM	DBTHIRDBAR	DBOVENDRY	KSAT	AWC	WTHIRDBAR	WFIFTEENBA	WSATIATED	LEP	LL	PI	EC	CEC7	PH1TO1H2O	Slope	Aspect	Drain_dist
HZDEPB	1.00	0.01	0.02	-0.24	-0.26	0.15	0.60	0.78	0.41	-0.08	-0.15	-0.08	-0.26	-0.33	0.14	0.12	0.37	-0.21	-0.24	-0.29	-0.16	-0.10	-0.23	-0.26	0.19	-0.17	-0.04	0.26	0.16	-0.24
SIEVENO4	0.01	1.00	1.00	0.90	0.44	0.47	-0.08	-0.06	0.24	0.44	0.54	0.37	0.32	0.51	0.93	0.93	0.23	0.56	0.60	0.41	0.93	0.20	0.52	0.26	-0.21	0.17	0.91	0.10	0.25	0.15
SIEVENO10	0.02	1.00	1.00	0.90	0.44	0.46	-0.07	-0.05	0.24	0.43	0.53	0.38	0.32	0.51	0.94	0.93	0.23	0.56	0.60	0.41	0.93	0.19	0.52	0.26	-0.20	0.16	0.90	0.10	0.25	0.15
SIEVENO40	-0.24	0.90	0.90	1.00	0.53	0.26	-0.30	-0.41	-0.09	0.34	0.52	0.47	0.39	0.51	0.75	0.76	0.15	0.60	0.64	0.46	0.89	0.25	0.54	0.34	-0.33	0.25	0.81	-0.09	0.15	0.17
SIEVENO200	-0.26	0.44	0.44	0.53	1.00	-0.50	-0.02	-0.34	-0.55	-0.47	-0.19	0.80	0.81	0.61	0.38	0.47	-0.65	0.92	0.92	0.85	0.41	0.52	0.74	0.74	-0.14	0.53	0.49	-0.17	-0.01	-0.23
SANDTOTAL	0.15	0.47	0.46	0.26	-0.50	1.00	-0.13	0.24	0.83	0.95	0.76	-0.57	-0.43	-0.11	0.49	0.41	0.68	-0.38	-0.32	-0.38	0.45	-0.29	-0.20	-0.43	-0.07	-0.26	0.41	0.27	0.23	0.38
SANDVC	0.60	-0.08	-0.07	-0.30	-0.02	-0.13	1.00	0.81	0.20	-0.38	-0.43	0.06	0.03	-0.11	0.01	0.04	0.03	-0.03	0.02	0.00	-0.19	0.14	-0.02	0.03	0.48	0.06	-0.05	0.20	0.10	-0.29
SANDCO	0.78	-0.06	-0.05	-0.41	-0.34	0.24	0.81	1.00	0.64	-0.03	-0.24	-0.25	-0.27	-0.31	0.09	0.07	0.27	-0.30	-0.30	-0.30	-0.20	-0.10	-0.24	-0.27	0.44	-0.16	-0.06	0.36	0.17	-0.21
SANDMED	0.41	0.24	0.24	-0.09	-0.55	0.83	0.20	0.64	1.00	0.70	0.29	-0.58	-0.42	-0.21	0.35	0.28	0.52	-0.45	-0.39	-0.40	0.19	-0.25	-0.23	-0.41	0.08	-0.27	0.22	0.39	0.22	0.19
SANDFINE	-0.08	0.44	0.43	0.34	-0.47	0.95	-0.38	-0.03	0.70	1.00	0.75	-0.56	-0.37	-0.04	0.43	0.36	0.64	-0.36	-0.27	-0.31	0.46	-0.26	-0.13	-0.35	-0.23	-0.21	0.40	0.17	0.17	0.47
SANDVF	-0.15	0.54	0.53	0.52	-0.19	0.76	-0.43	-0.24	0.29	0.75	1.00	-0.27	-0.28	0.05	0.46	0.39	0.50	-0.07	-0.11	-0.21	0.56	-0.24	-0.11	-0.30	-0.18	-0.18	0.45	0.05	0.16	0.36
SILTTOTAL	-0.08	0.37	0.38	0.47	0.80	-0.57	0.06	-0.25	-0.58	-0.56	-0.27	1.00	0.45	0.50	0.33	0.35	-0.46	0.86	0.70	0.50	0.32	0.17	0.43	0.41	-0.09	0.15	0.29	-0.14	-0.01	-0.24
CLAYTOTAL	-0.26	0.32	0.32	0.39	0.81	-0.43	0.03	-0.27	-0.42	-0.37	-0.28	0.45	1.00	0.59	0.25	0.41	-0.53	0.63	0.89	0.98	0.34	0.83	0.90	0.95	-0.12	0.70	0.46	-0.14	0.00	-0.14
OM	-0.33	0.51	0.51	0.51	0.61	-0.11	-0.11	-0.31	-0.21	-0.04	0.05	0.50	0.59	1.00	0.45	0.52	-0.32	0.66	0.74	0.68	0.55	0.39	0.70	0.61	-0.27	0.33	0.52	-0.07	0.03	0.06
DBTHIRDBAR	0.14	0.93	0.94	0.75	0.38	0.49	0.01	0.09	0.35	0.43	0.46	0.33	0.25	0.45	1.00	0.98	0.22	0.53	0.55	0.37	0.80	0.11	0.46	0.20	-0.15	0.13	0.86	0.17	0.26	0.10
DBOVENDRY	0.12	0.93	0.93	0.76	0.47	0.41	0.04	0.07	0.28	0.36	0.39	0.35	0.41	0.52	0.98	1.00	0.16	0.57	0.66	0.51	0.81	0.28	0.60	0.36	-0.15	0.25	0.89	0.14	0.25	0.08
KSAT	0.37	0.23	0.23	0.15	-0.65	0.68	0.03	0.27	0.52	0.64	0.50	-0.46	-0.53	-0.32	0.22	0.16	1.00	-0.57	-0.46	-0.54	0.17	-0.23	-0.35	-0.47	0.04	-0.25	0.13	0.13	0.17	0.29
AWC	-0.21	0.56	0.56	0.60	0.92	-0.38	-0.03	-0.30	-0.45	-0.36	-0.07	0.86	0.63	0.66	0.53	0.57	-0.57	1.00	0.86	0.72	0.49	0.28	0.62	0.55	-0.18	0.31	0.52	-0.11	0.02	-0.21
WTHIRDBAR	-0.24	0.60	0.60	0.64	0.92	-0.32	0.02	-0.30	-0.39	-0.27	-0.11	0.70	0.89	0.74	0.55	0.66	-0.46	0.86	1.00	0.94	0.58	0.64	0.88	0.83	-0.19	0.56	0.65	-0.11	0.05	-0.11
WFIFTEENBA	-0.29	0.41	0.41	0.46	0.85	-0.38	0.00	-0.30	-0.40	-0.31	-0.21	0.50	0.98	0.68	0.37	0.51	-0.54	0.72	0.94	1.00	0.41	0.75	0.92	0.94	-0.17	0.67	0.52	-0.13	0.01	-0.13
WSATIATED	-0.16	0.93	0.93	0.89	0.41	0.45	-0.19	-0.20	0.19	0.46	0.56	0.32	0.34	0.55	0.80	0.81	0.17	0.49	0.58	0.41	1.00	0.24	0.53	0.30	-0.24	0.15	0.86	0.07	0.22	0.26
LEP	-0.10	0.20	0.19	0.25	0.52	-0.29	0.14	-0.10	-0.25	-0.26	-0.24	0.17	0.83	0.39	0.11	0.28	-0.23	0.28	0.64	0.75	0.24	1.00	0.79	0.84	-0.03	0.73	0.39	-0.11	0.02	-0.08
LL	-0.23	0.52	0.52	0.54	0.74	-0.20	-0.02	-0.24	-0.23	-0.13	-0.11	0.43	0.90	0.70	0.46	0.60	-0.35	0.62	0.88	0.92	0.53	0.79	1.00	0.93	-0.22	0.65	0.63	-0.07	0.05	-0.01
PI	-0.26	0.26	0.26	0.34	0.74	-0.43	0.03	-0.27	-0.41	-0.35	-0.30	0.41	0.95	0.61	0.20	0.36	-0.47	0.55	0.83	0.94	0.30	0.84	0.93	1.00	-0.13	0.70	0.41	-0.14	-0.02	-0.09
EC	0.19	-0.21	-0.20	-0.33	-0.14	-0.07	0.48	0.44	0.08	-0.23	-0.18	-0.09	-0.12	-0.27	-0.15	-0.15	0.04	-0.18	-0.19	-0.17	-0.24	-0.03	-0.22	-0.13	1.00	-0.12	-0.21	0.11	0.07	-0.14
CEC7	-0.17	0.17	0.16	0.25	0.53	-0.26	0.06	-0.16	-0.27	-0.21	-0.18	0.15	0.70	0.33	0.13	0.25	-0.25	0.31	0.56	0.67	0.15	0.73	0.65	0.70	-0.12	1.00	0.44	-0.15	-0.02	-0.12
PH1TO1H2O	-0.04	0.91	0.90	0.81	0.49	0.41	-0.05	-0.06	0.22	0.40	0.45	0.29	0.46	0.52	0.86	0.89	0.13	0.52	0.65	0.52	0.86	0.39	0.63	0.41	-0.21	0.44	1.00	0.08	0.23	0.14
Slope	0.26	0.10	0.10	-0.09	-0.17	0.27	0.20	0.36	0.39	0.17	0.05	-0.14	-0.14	-0.07	0.17	0.14	0.13	-0.11	-0.11	-0.13	0.07	-0.11	-0.07	-0.14	0.11	-0.15	0.08	1.00	0.16	0.02
Aspect	0.16	0.25	0.25	0.15	-0.01	0.23	0.10	0.17	0.22	0.17	0.16	-0.01	0.00	0.03	0.26	0.25	0.17	0.02	0.05	0.01	0.22	0.02	0.05	-0.02	0.07	-0.02	0.23	0.16	1.00	0.06
Drain_dist	-0.24	0.15	0.15	0.17	-0.23	0.38	-0.29	-0.21	0.19	0.47	0.36	-0.24	-0.14	0.06	0.10	0.08	0.29	-0.21	-0.11	-0.13	0.26	-0.08	-0.01	-0.09	-0.14	-0.12	0.14	0.02	0.06	1.00

Table 5. Chi-square Statistics for Taxsubgrp parameters from Transmittered Snake Dataset

Term		Estimate	L-R ChiSquare	Prob>ChiSq
Intercept		14.18555	243.93481	<.0001*
Aeric Fluvaquents		-13.15772	21.156126	<.0001*
Albaquic Hapludalfs		-13.74947	40.718181	<.0001*
Aquic Hapludults		-13.4478	109.20154	<.0001*
Arenic Paleudults		-15.26798	336.29287	<.0001*
Chromic Dystraquerts		-11.3636	3.4839545	0.0620
Grossarenic Paleudults		-15.83081	383.24763	<.0001*
Humaqueptic Psammaquents		-15.00985	55.63689	<.0001*
Lamellic Paleudults		-16.47425	459.38939	<.0001*
Plinthic Paleudults		-12.40969	26.629165	<.0001*
Typic Glossaqualfs		-11.37024	10.966405	0.0009*
Typic Hapludalfs		-12.49825	32.080909	<.0001*
Typic Hapludults		-13.81484	84.023621	<.0001*
Typic Paleudults		-12.47572	29.17804	<.0001*
Vertic Hapludalfs		-12.94473	51.715849	<.0001*

Table 6. Contingency Table Taxsubgrp by Present from the Transmittered Snake Dataset

Count Total % Col % Row %	Absent	Present	
Aeric Fluvaquents	14 0.46 0.82 73.65	5 0.16 0.37 26.35	19 0.62
Albaquic Hapludalfs	15 0.49 0.88 60.73	10 0.32 0.72 39.27	25 0.81
Aquic Hapludults	191 6.29 11.25 67.65	91 3.01 6.83 32.35	283 9.30
Arenic Paleudults	114 3.74 6.69 25.30	336 11.05 25.07 74.70	449 14.79
Chromic Dystraquerts P = .0620	17 0.55 0.99 94.39	1 0.03 0.07 5.61	18 0.59
Grossarenic Paleudults	57 1.88 3.36 16.18	296 9.75 22.13 83.82	353 11.64
Humaqueptic Psammaquents	4 0.14 0.25 30.49	10 0.32 0.72 69.51	14 0.46
Lamellic Paleudults	47 1.56 2.79 9.21	467 15.37 34.87 90.79	514 16.93
Plinthic Paleudults	86 2.84 5.07 85.52	15 0.48 1.09 14.48	101 3.32

Count Total % Col % Row %	Absent	Present	
Typic Glossaqualfs	205 6.75 12.07 94.35	12 0.40 0.92 5.65	217 7.15
Typic Hapludalfs	106 3.49 6.24 84.39	20 0.65 1.46 15.61	126 4.13
Typic Hapludults	44 1.46 2.61 59.16	31 1.01 2.29 40.84	75 2.47
Typic Paleudults	90 2.96 5.29 84.68	16 0.53 1.21 15.32	106 3.49
Vertic Hapludalfs	104 3.41 6.09 77.57	30 0.99 2.24 22.43	133 4.39
	1699 55.93	1339 44.07	3038

Tables 7 & 8. Tests for fit of TXSUBGRP by Present

N	DF	-LogLike	RSquare (U)
3038	60	987.58153	0.4738

Test	ChiSquare	Prob>ChiSq
Likelihood Ratio	1975.163	0.0000*
Pearson	1630.879	<.0001*

Table 13. Landowners with >1000 acres of priority LPS soils in eight priority counties summarized (Note: this is total acreage, regardless the size of the parcels in which it occurs.)

Owner	Acres of Potential LPS

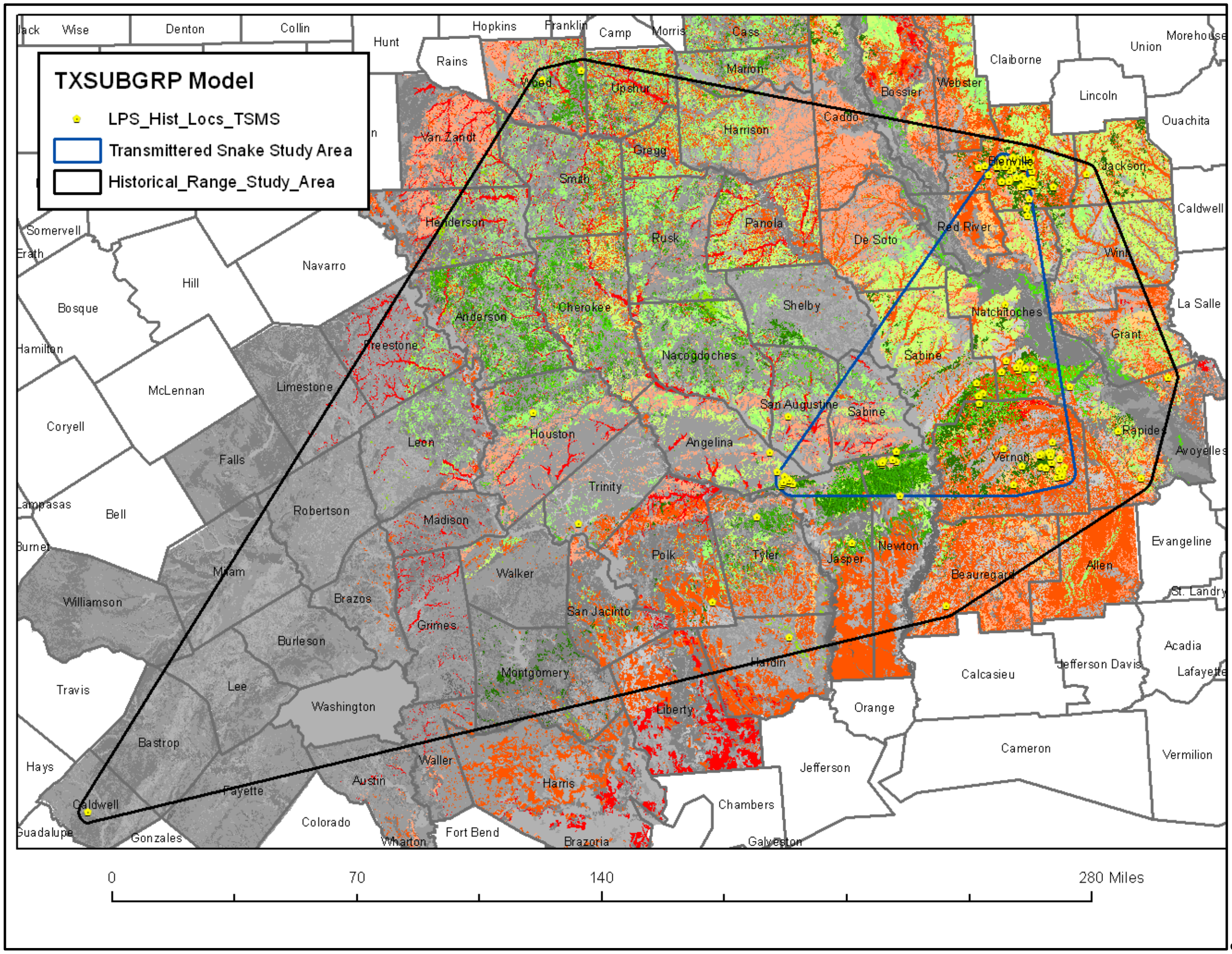
	Habitat (Hydgrp A+B)
HODGES, A. J. & NONA TRIGG	1010.661
ARBORGEN LLC	1086.868
CITIZENS LAND CORP	1087.066
RAYONIER TEXAS, LP	1099.149
PINE ISLAND PARTNERS	1140.935
HSH PROPERTIES PARTNERSHIP LP	1215.067
NORTH AMERICAN PROCUREMENT CO	1225.494
WOODARD VILLA, INC.	1237.145
ROCK CREEK RANCH we, LTD	1299.898
EPC HOLDINGS RAYONIER GMO LLC	1387.101
NECHES RIVER CORRIDOR LP	1406.400
STANLEY JASPER PAUL JR	1419.255
UMPHREY FAMILY LTD PARTNERSHIP	1444.702
DAVIS WIRT TRUSTS	1511.914
WEED JANE C MRS	1537.816
Tin Inc	1539.763
FORESTAR USA REAL ESTATE GROUP INC	1595.955
MARTINDALE LAND & CATTLE	1649.030
DUBEA INVESTMENTS LP	1899.746
RAYONIER FOREST RESOURCES LP	1990.187
UMPHREY WALTER	2152.683
421 Development LTD	2208.331
SFG HCK TEXAS LP	2288.509
H T VII TEXAS LP	2337.146
CAMBIUM CORRIGAN LP	2475.502
ALABAMA-COUSHATTA INDIAN RES	2492.997
EFG BALANCED L P	2499.496
BURNS FOREST PRODUCTS, INC.	2605.629
DAVIS, WIRT TRUSTS & KATE DAVIS	2869.066
RAYONIER FOREST REOURCES LP	2953.502
BOSQUES DEL NORTE LP	3003.319
PACES CREEK WOODLANDS LP	3627.458
MERIWETHER LAND & TIMBER LLC	3740.780
RMK SELECT TMBR INVST FUND II LLC	4126.734
MARTIN TIMBER CO., INC.	4540.440
LABOKAY CORPORATION	5558.981
MANULIFE INSURANCE CO, ET AL	5998.038
ADIRONDACK TIMBER CO INC	6178.461
TIMBERSTAR LOUISIANA we LP	6500.552
BIG THICKET NATIONAL PRESERVE	6628.973
HANCOCK TIMBERLAND VII TX LP	6904.495
HT VII TEXAS LP & HT VII TRS INC	7135.934
TEXAS TIMBERLANDS II, LTD	13123.184
TEMPLE-INLAND FPC	14863.519
WEYERHAEUSER COMPANY	15389.761
LA. MINERALS, LTD.	18181.410
CROWN PINE TIMBER 1 LP	24704.286
SUSTAINABLE FORESTS, LLC	28689.953
JOHN HANCOCK LIFE INS.	67546.028
TEXAS TIMBERLANDS we LP	111771.027
CROWN PINE TIMBER 3 LP	120989.389
Total	**531869.738**

Table 14. Landowners with >1000 acres of priority LPS soils by county.

Owner	County/Parish	Acres of Potential LPS Habitat (Hydgrp A+B)
421 Development LTD	Sabine_Co	2208.331369
ADIRONDACK TIMBER CO INC	Jasper	6178.460845
ALABAMA-COUSHATTA INDIAN RES	Polk	2492.996768
BOSQUES DEL NORTE LP	Polk	3003.3188
BURNS FOREST PRODUCTS, INC.	Bienville	2605.629374
CAMBIUM CORRIGAN LP	Polk	2475.501707
CITIZENS LAND CORP	Tyler	1087.065992
CROWN PINE TIMBER 1 LP	Angelina	24704.28634
CROWN PINE TIMBER 3 LP	Polk	12894.9472
CROWN PINE TIMBER 3 LP	Tyler	48737.53329
CROWN PINE TIMBER 3 LP	Jasper	59356.90854
DAVIS WIRT TRUSTS	Tyler	1511.914274
DAVIS, WIRT TRUSTS & KATE DAVIS	Polk	2869.066448
DUBEA INVESTMENTS LP	Polk	1899.746169
EFG BALANCED L P	Tyler	2499.495639
EPC HOLDINGS RAYONIER GMO LLC	Angelina	1387.101345
FORESTAR USA REAL ESTATE GROUP INC	Angelina	1595.954812
H T VII TEXAS LP	Jasper	2337.145676
HANCOCK TIMBERLAND VII TX LP	Tyler	6904.495004
HODGES, A. J. & NONA TRIGG	Sabine_Par	1010.661008
HSH PROPERTIES PARTNERSHIP LP	Angelina	1215.066579
HT VII TEXAS LP & HT VII TRS INC	Polk	7135.933904
JOHN HANCOCK LIFE INS.	Polk	2503.276353
JOHN HANCOCK LIFE INS.	Jasper	4183.982628
JOHN HANCOCK LIFE INS.	Tyler	60858.76884
LA. MINERALS, LTD.	Bienville	18181.40976
LABOKAY CORPORATION	Sabine_Par	5558.981493
MANULIFE INSURANCE CO, ET AL	Polk	5998.038332
MARTIN TIMBER CO., INC.	Bienville	4540.440292
MARTINDALE LAND & CATTLE	Jasper	1649.030331
MERIWETHER LAND & TIMBER LLC	Sabine_Par	3740.7801
NECHES RIVER CORRIDOR LP	Angelina	1406.400277
NORTH AMERICAN PROCUREMENT CO	Tyler	1225.494426
PACES CREEK WOODLANDS LP	Polk	3627.457575
PINE ISLAND PARTNERS	Angelina	1140.934965
RAYONIER FOREST REOURCES LP	Angelina	2953.502358
RAYONIER FOREST RESOURCES LP	Tyler	1990.186739
RAYONIER TEXAS, LP	Polk	1099.149447
RMK SELECT TMBR INVST FUND II LLC	Polk	4126.733997
ROCK CREEK RANCH we, LTD	Polk	1299.897857
SFG HCK TEXAS LP	Jasper	2016.841749
STANLEY JASPER PAUL JR	Jasper	1419.255439
SUSTAINABLE FORESTS, LLC	Bienville	28689.9533
TEMPLE-INLAND FPC	Jasper	14863.51939
TEXAS TIMBERLANDS II, LTD	Jasper	1439.893187
TEXAS TIMBERLANDS II, LTD	Polk	5106.976331
TEXAS TIMBERLANDS II, LTD	Tyler	6576.314348
TEXAS TIMBERLANDS we LP	Tyler	23714.30805
TEXAS TIMBERLANDS we LP	Polk	88056.71913
TIMBERSTAR LOUISIANA we LP	Sabine_Par	6500.551837
TIN INC	Angelina	1319.98753
UMPHREY FAMILY LTD PARTNERSHIP	Tyler	1444.70161
UMPHREY WALTER	Tyler	2152.683237
WEED JANE C MRS	Jasper	1537.815613
WEYERHAEUSER COMPANY	Bienville	15114.38694
WOODARD VILLA, INC.	Bienville	1237.145198
Total Potential LPS Habitat by owners w/>1000 ac	**ALL**	**523387.0797**

Figures

Figure 3 - Graphical representation of a model based on the SSURGO categorical variable TAXSBGRP which is the finest level of soil taxonomy in the SSURGO dataset. The legend for TXSUBGRP contains 68 categories and is therefore not included. 14 of the 68 parameters were found to explain significant amounts of the variation in LPS occurrence ($r^2 = 45$). The greener subgroups show areas predicted to contain LPS habit; the redder subgroups were avoided or selected at a lower frequency by Louisiana Pine Snakes. The grayer polygons represent subgroups that had few or no intersections with either actual occurrences or pseudo-absent polygons.



a

Figure 4. Graphical illustration of the LPS habitat model based on taxonomic subgroups (TAXSBGRP) with actual occurrences of the LPS (yellow markers) in eastern Texas. Note the abrupt change in some TXSUBGRP polygons at the border between Sabine and Newton counties. Surveyors in one county sometimes classify soils or mapunits differently from those in the adjacent county or parishes—this variation increases as number of parameters increase—one reason that we eventually rejected this model.

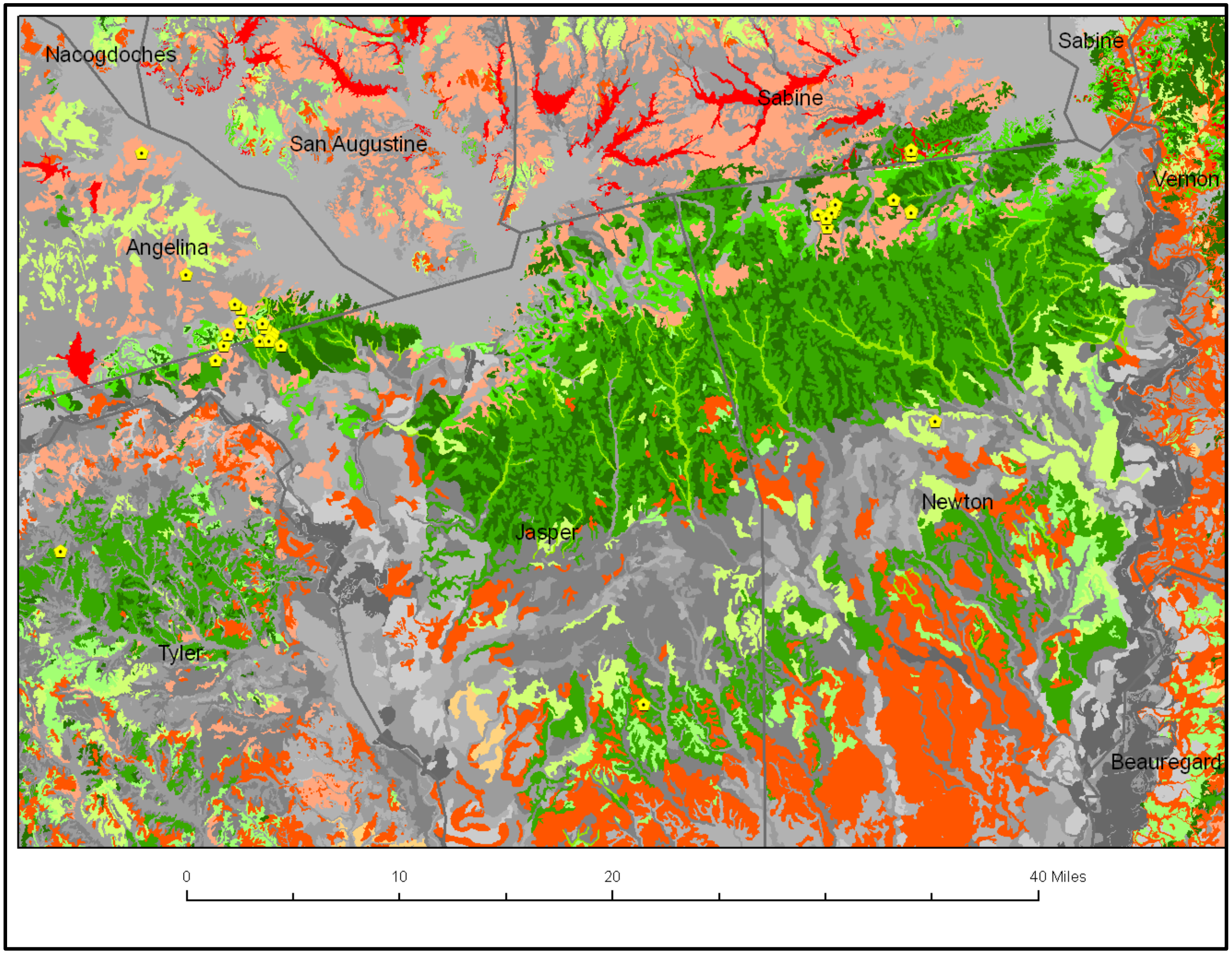


Figure 5. Graphical illustration of the LPS habitat model based on the SSURGO variable TXSUBGRPS with actual occurrences the LPS (yellow markers). Note the abrupt change in some TXSUBGRP polygons at the border between Bienville and Natchitoches parishes. Surveyors in one county sometimes classify soils or mapunits differently from those in the adjacent county or parish—this variation increases as number of parameters increase—one reason that we eventually rejected this model.

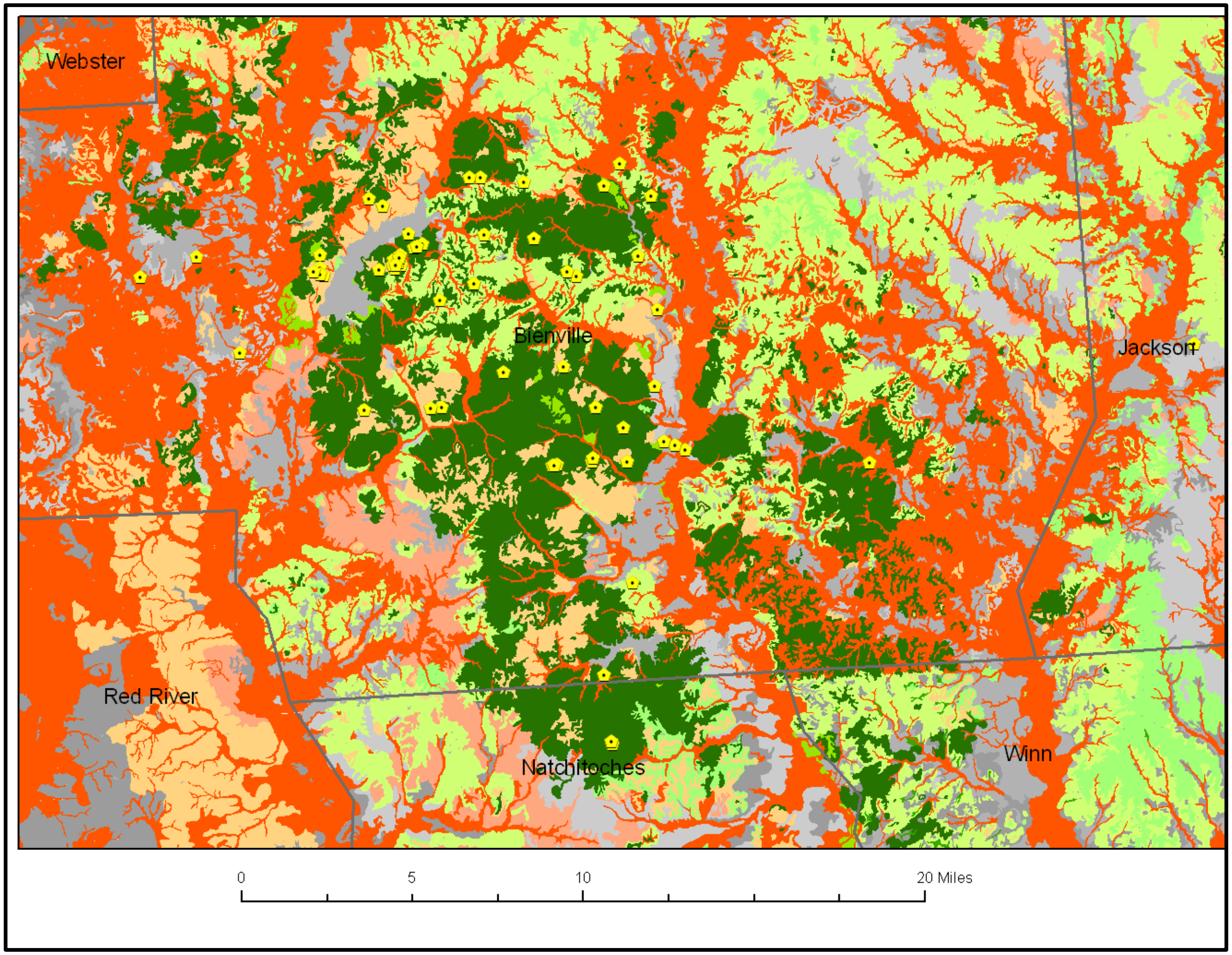


Figure 8. Graphical Illustration of LPS habitat model selected using the transmittered snake dataset by KSAT. (Ksat: The amount of water that would move vertically through a unit area of saturated soil in unit time under unit hydraulic gradient). The mean KSAT value for actual localities was 74.21; the mean KSAT value for random polygons was 19.76. The model explained about 45% of the variation in LPS occurrence.

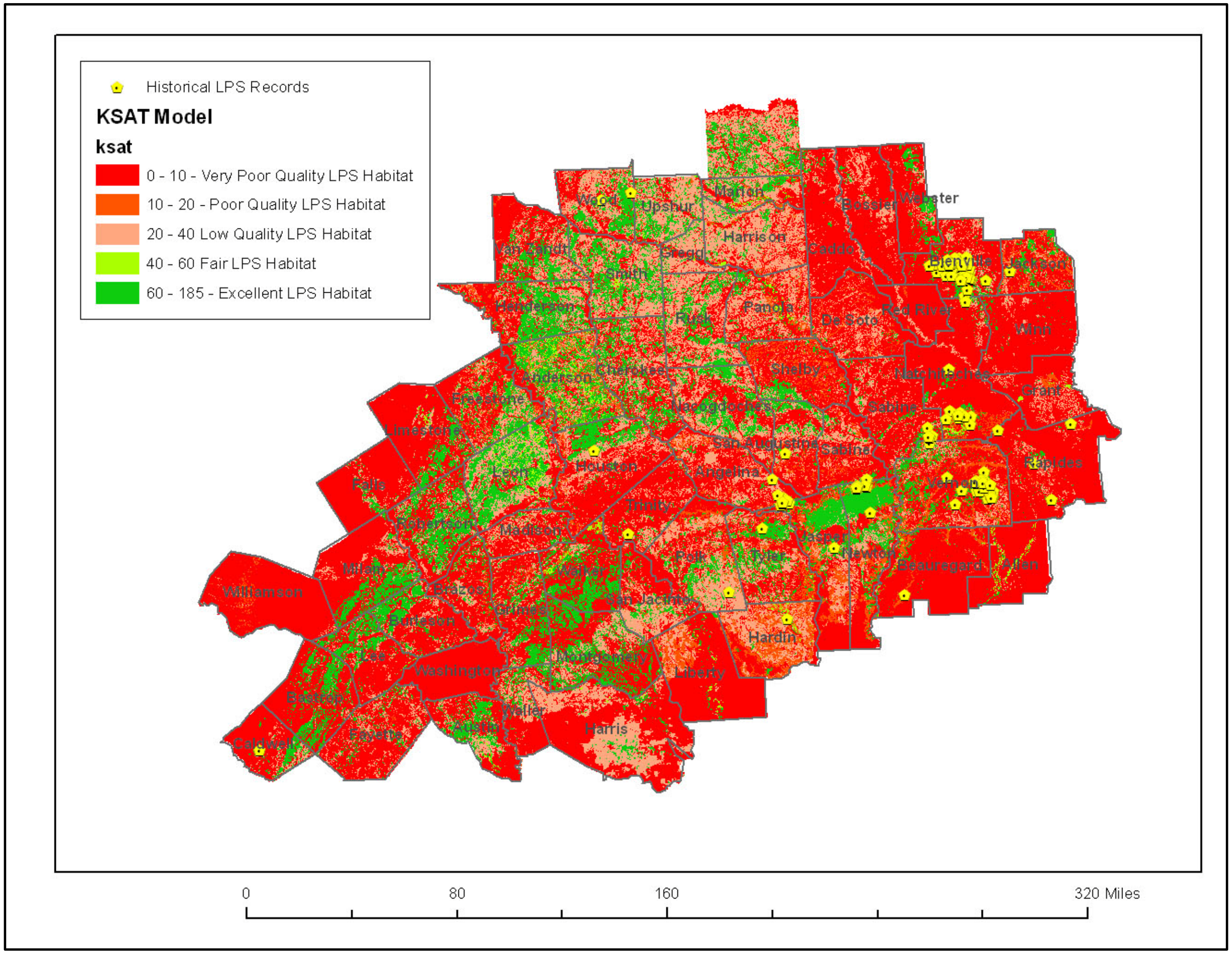


Figure 9. Predicted Louisiana Pine Snake habitat based on the KSAT Model with actual occurrences of Louisiana Pine Snakes.

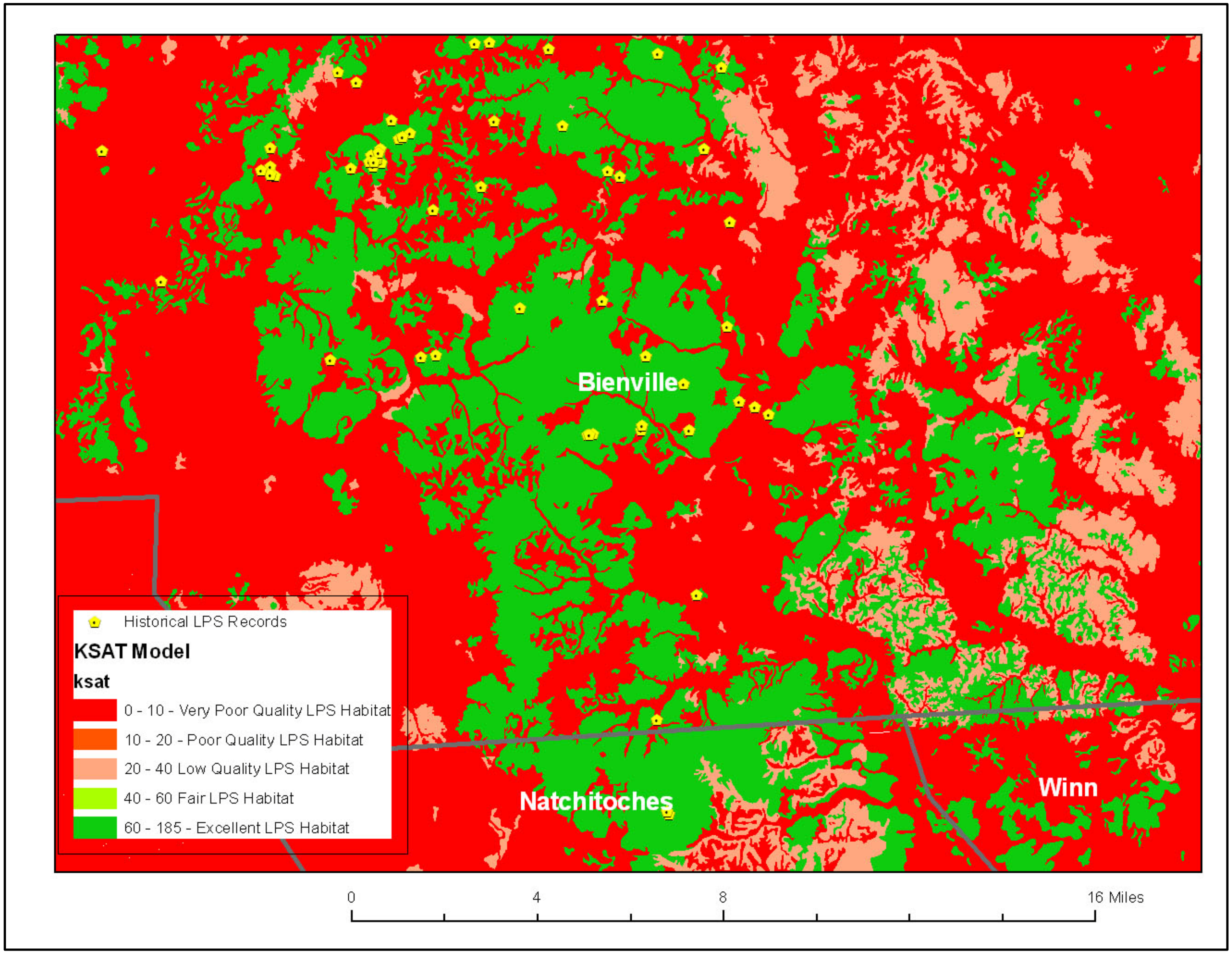


Figure 11. Graphical illustration of the LPS habitat model based on the SSURGO categorical variable HYDRGRP. The only parameter that was significantly preferred by the LPS was Hydrogroup “A”. Hydrogroup “B” intersected LPS polygons somewhat less than they did random polygons but 35% of LPS occurrences in the transmittered snake study area occurred on the “B” hydrogroup while 50% of snakes with high precision locality data from the historical dataset occurred on HYDGRP B.

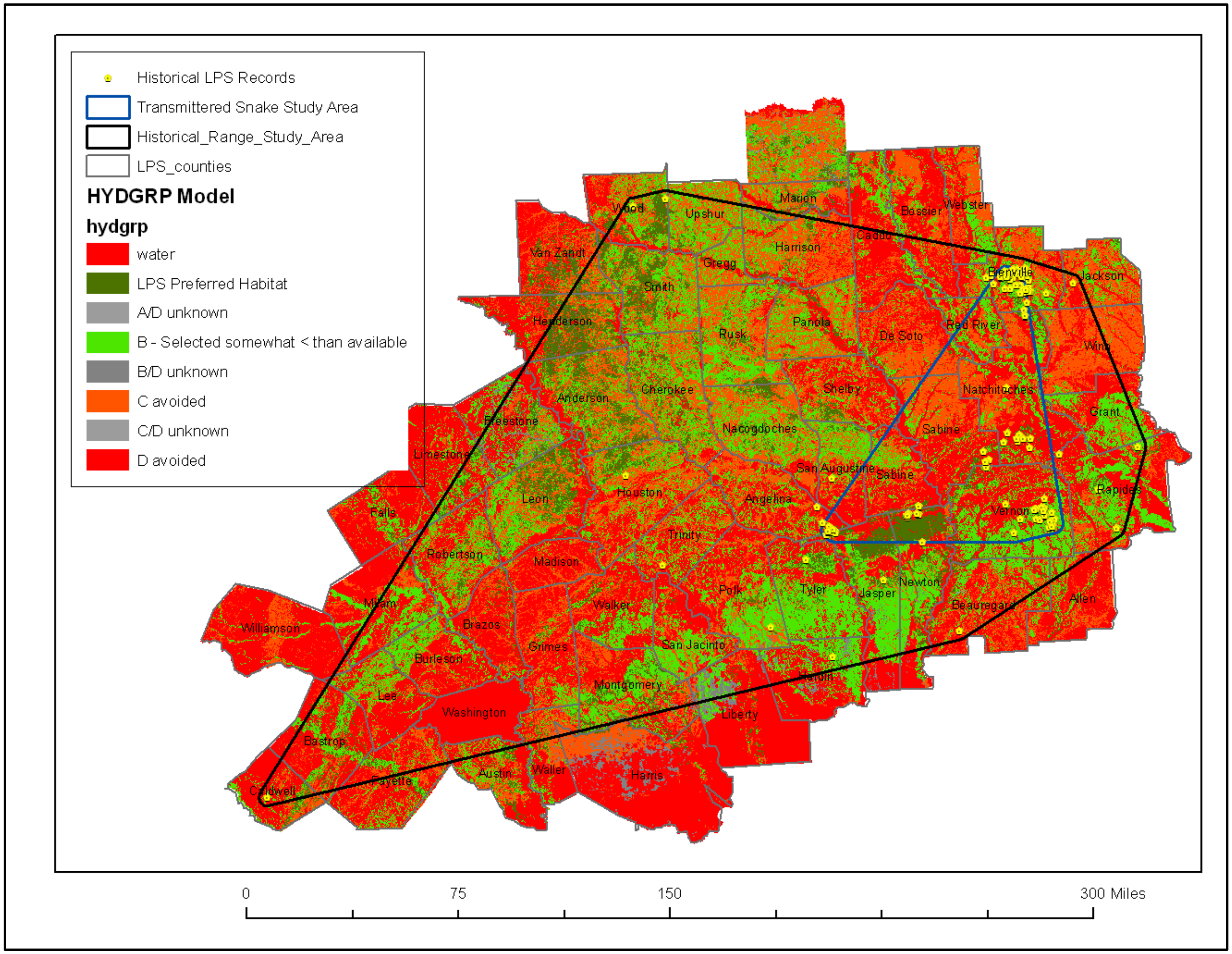


Figure 12. Predicted habitat based on a HYDGRP Model and actual occurrences of the Louisiana Pine Snake far eastern Texas.

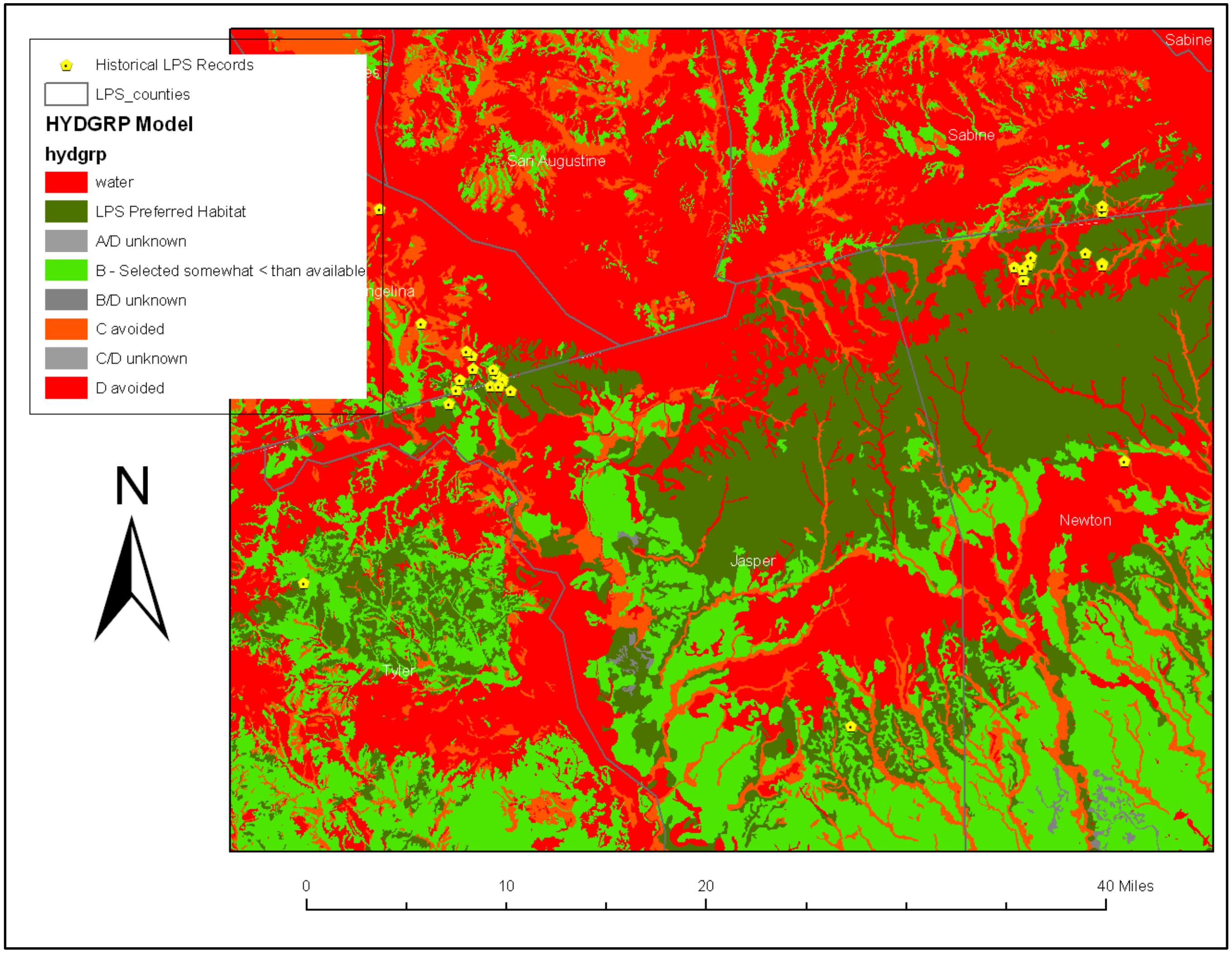


Figure 13. Predicted LPS potential habitat based on the HYDGRP Model and actual occurrences of the Louisiana Pine Snake in Angelina and Jasper counties, Texas.

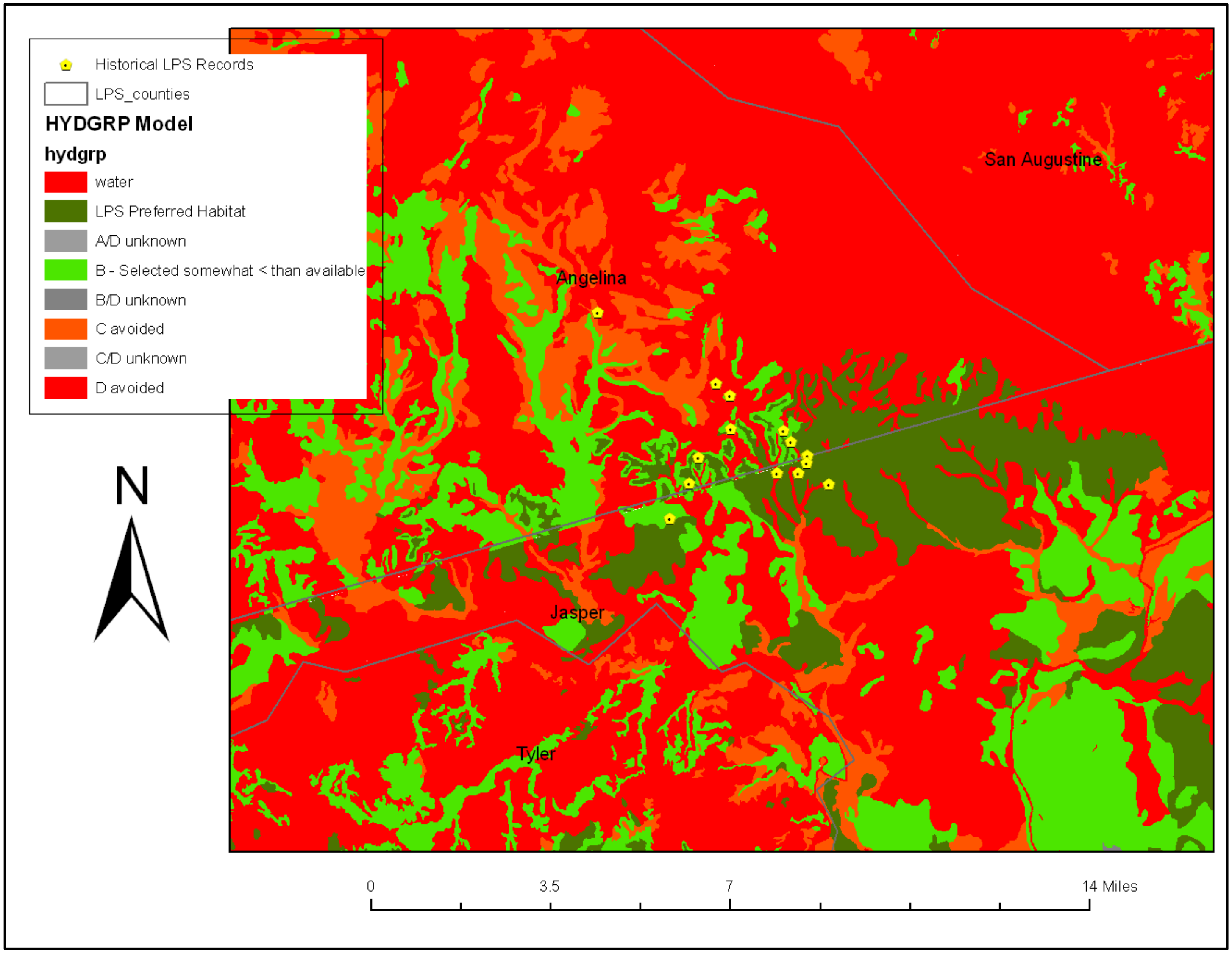


Figure 14. Predicted habitat based on the HYDGRP Model and actual occurrences of the Louisiana Pine Snake in and around Bienville Parish, Louisiana.

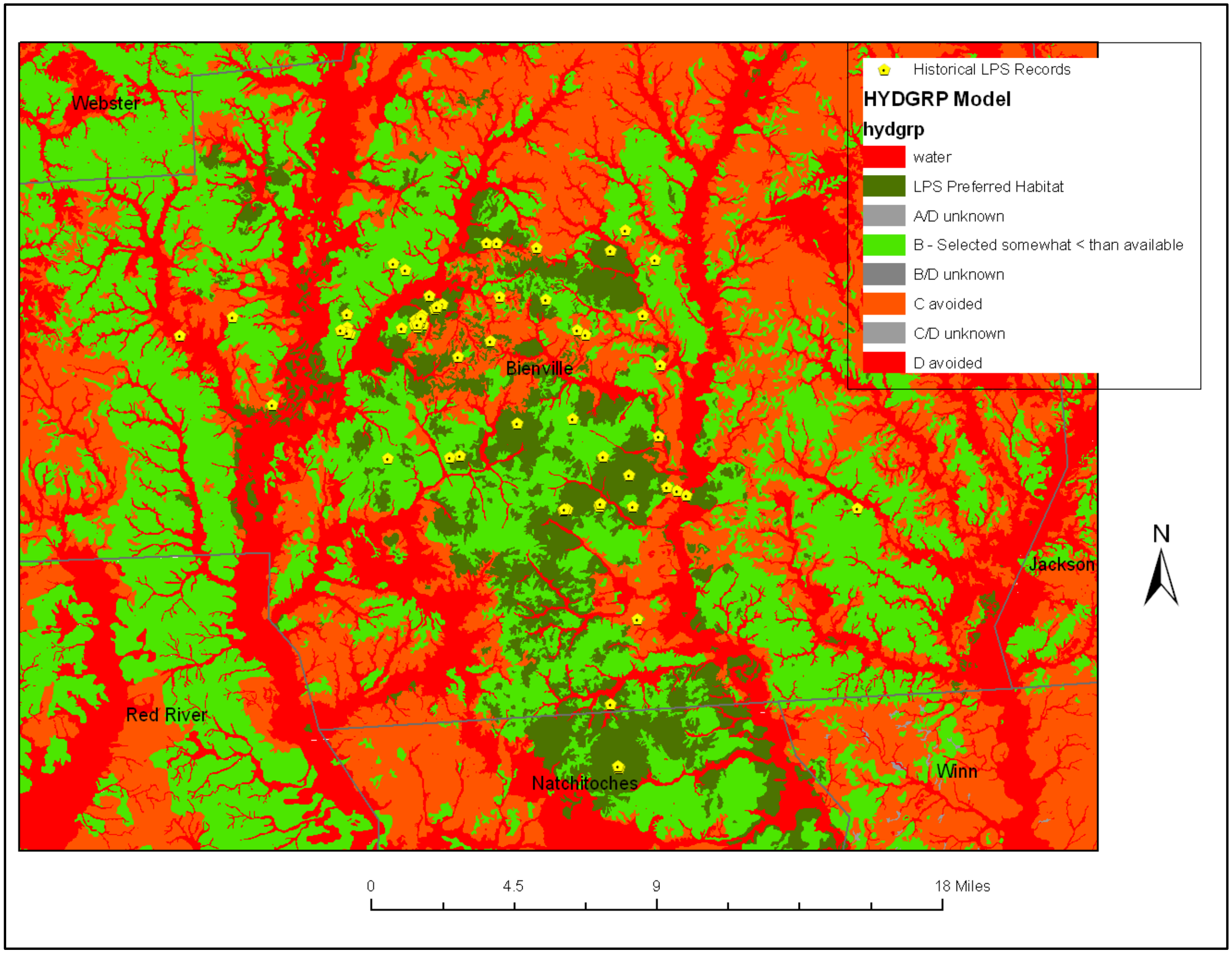


Figure 15. Vernon Parish with preferred Louisiana pine snake habitat and protected land.

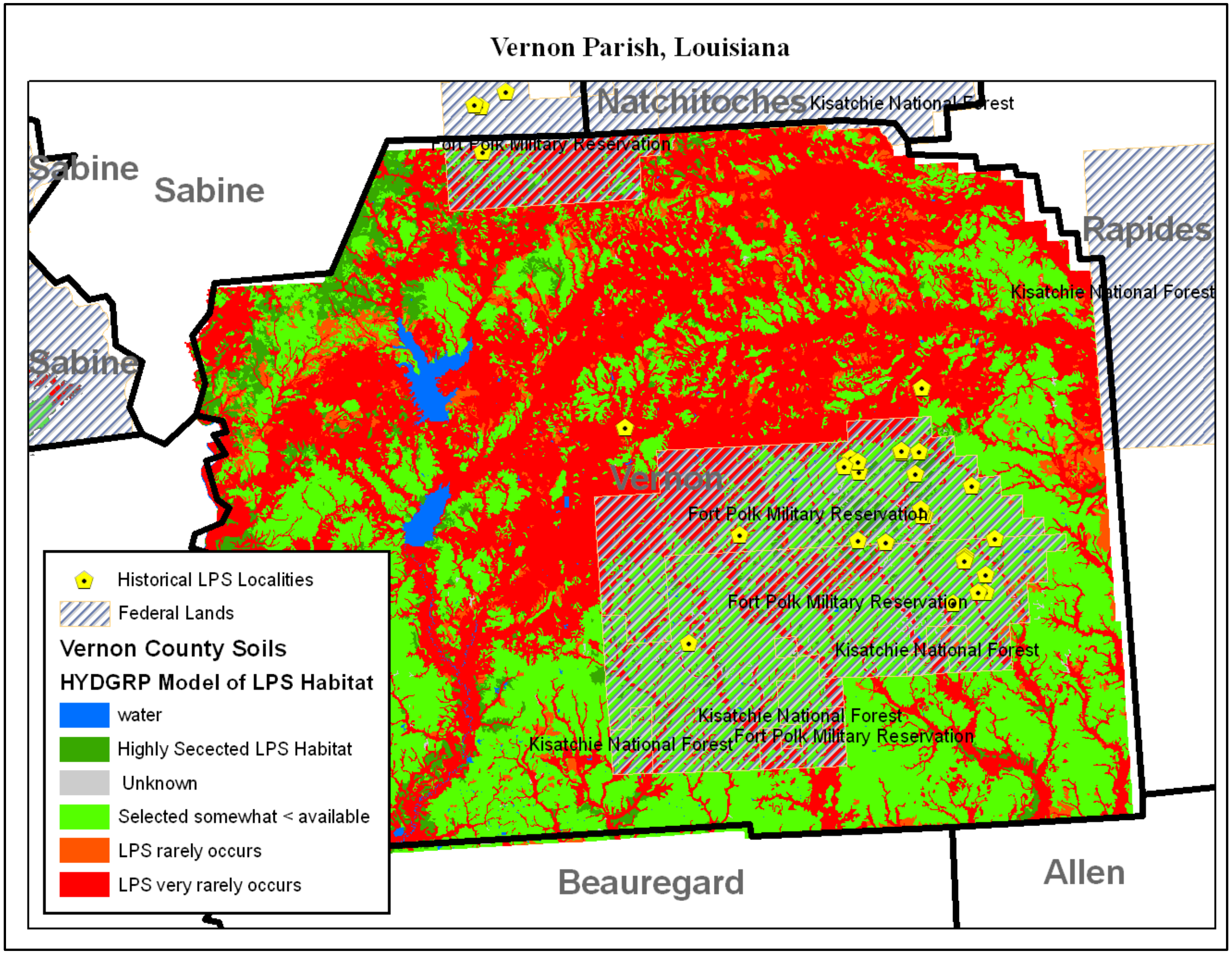


Figure 16. Bienville Parish ownership parcels delineated by acreage of LPS priority soils.

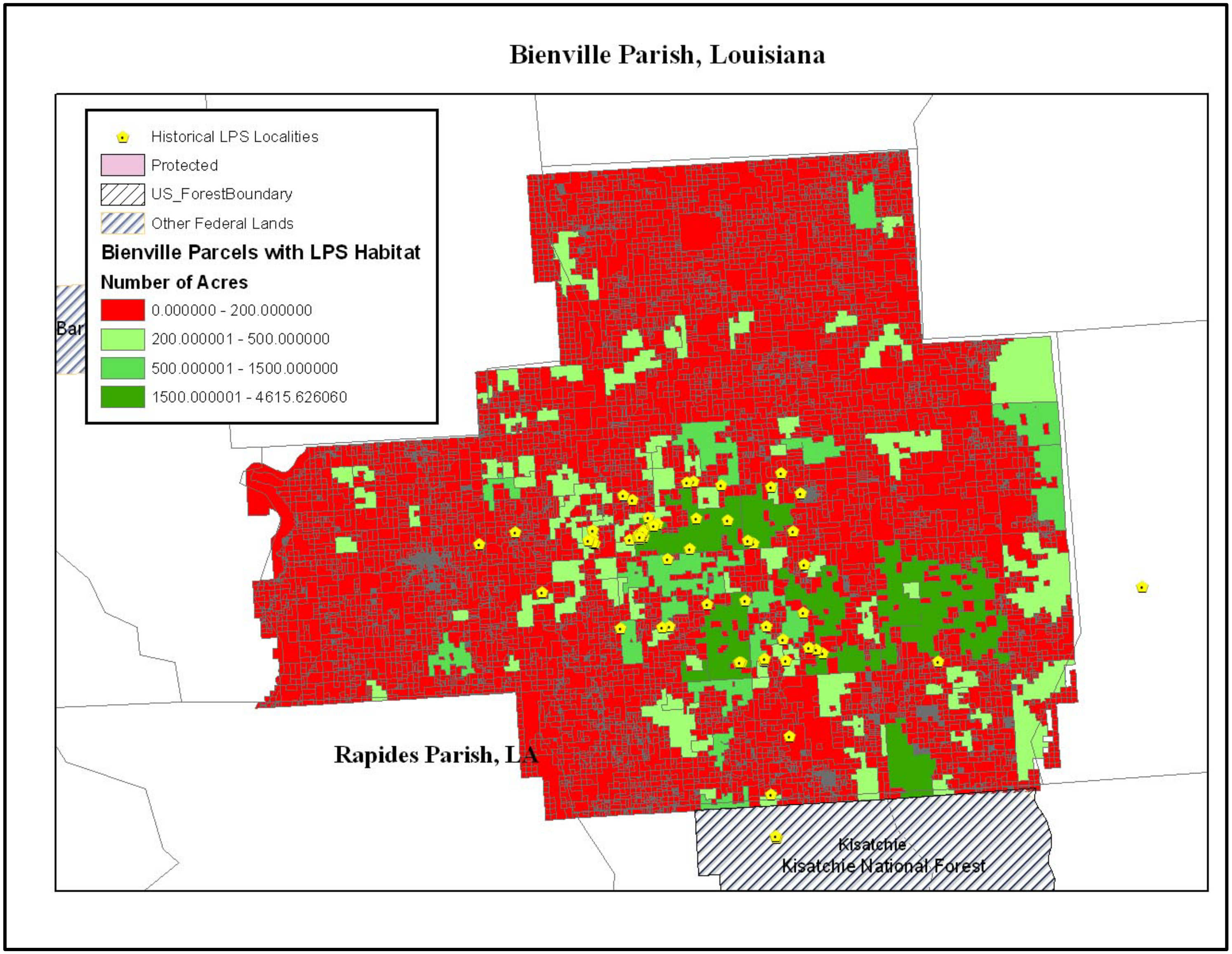


Figure 17. Tyler County ownership parcels delineated by acreage of LPS priority soils.

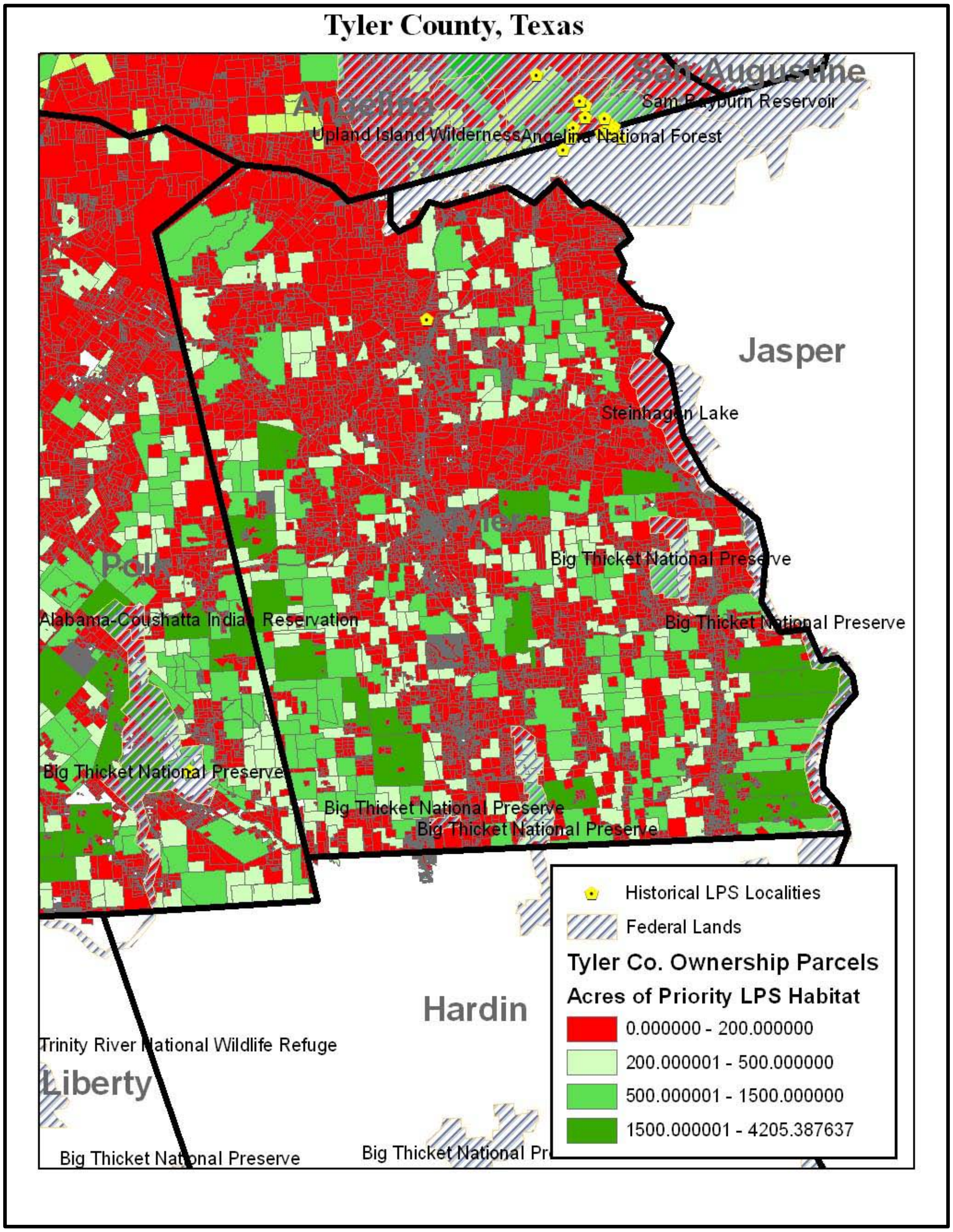


Figure 18. Polk County ownership parcels delineated by acreage of LPS priority soils.

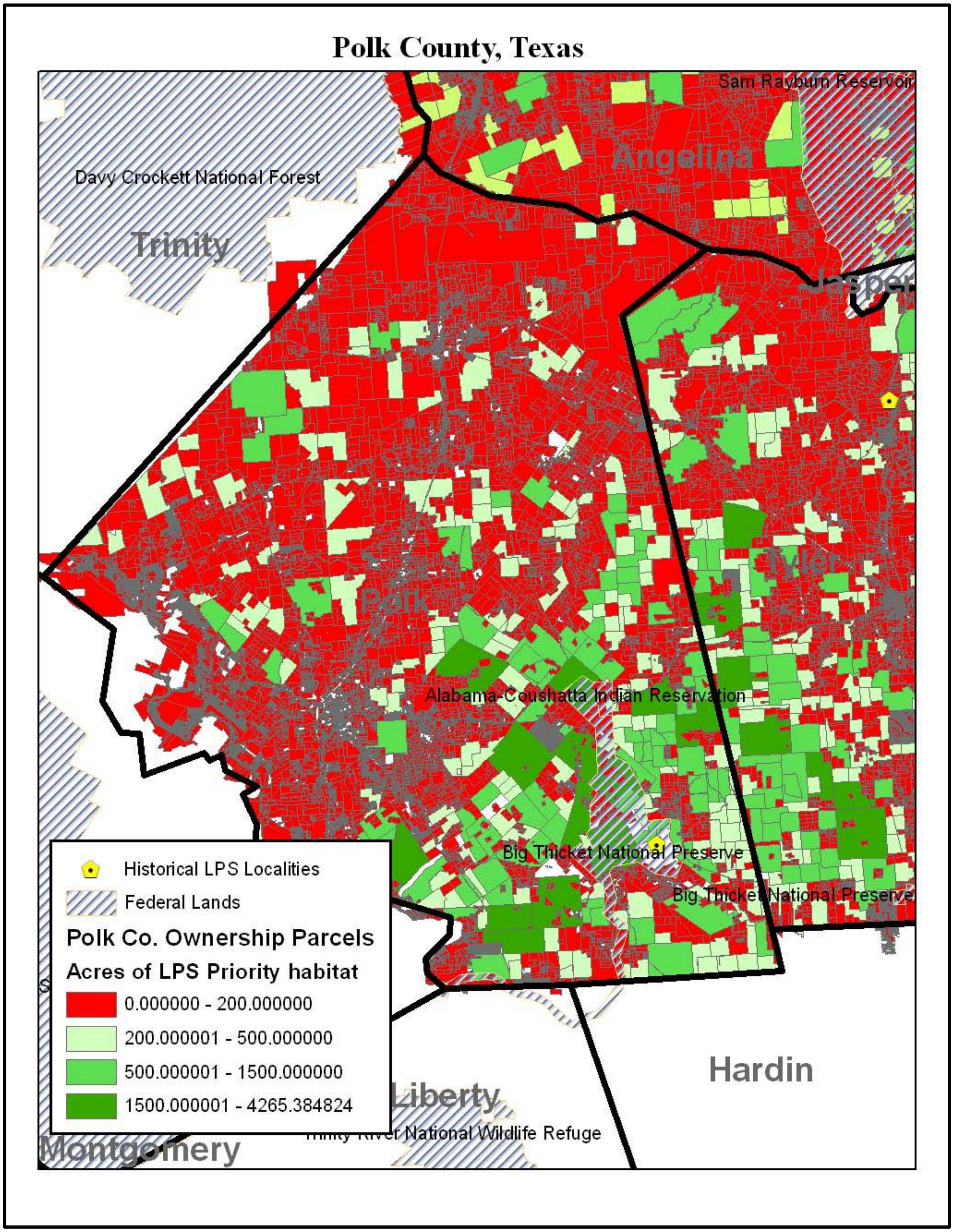


Figure 19. Jasper County ownership parcels delineated by acreage of LPS priority soils.

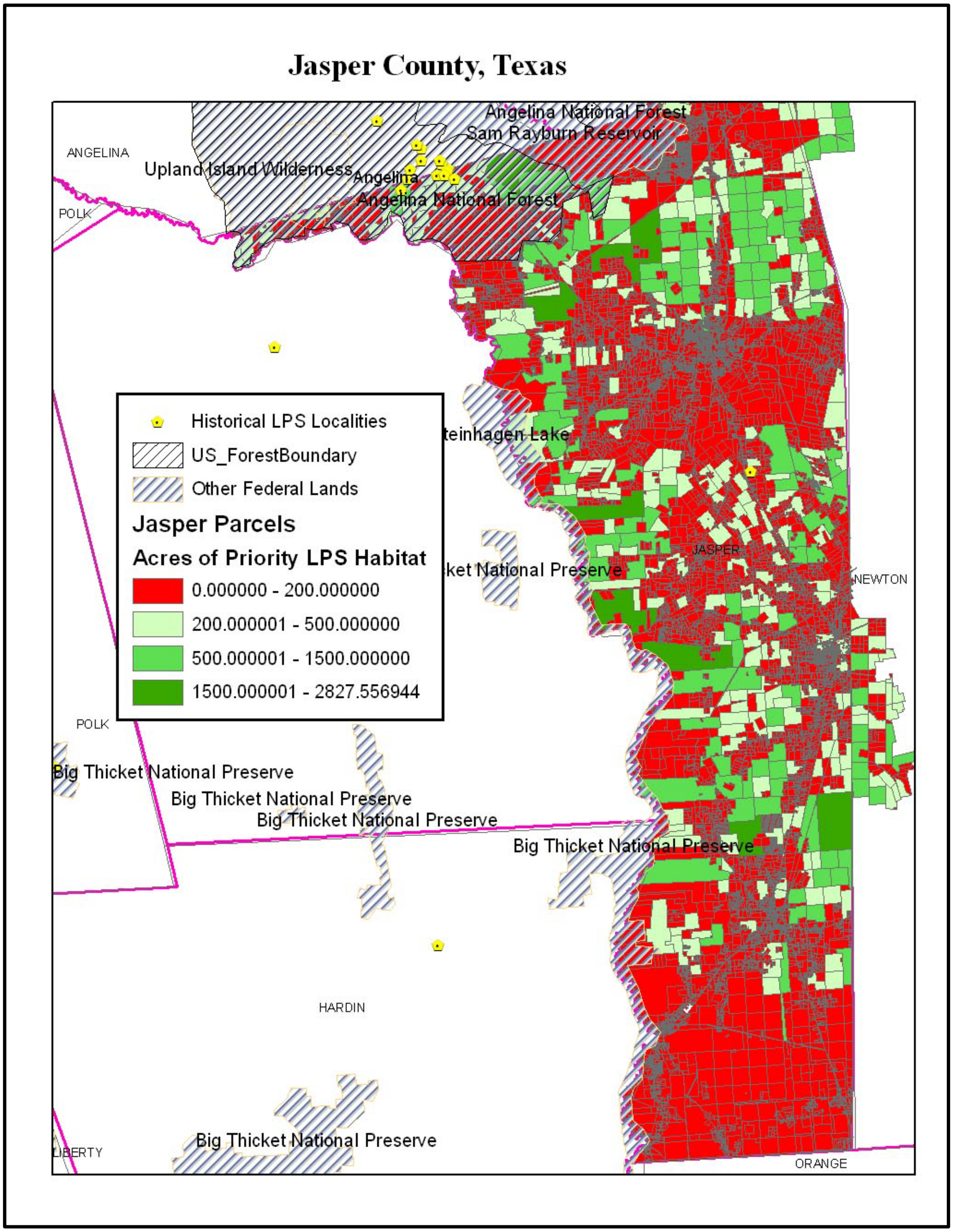


Figure 20. Sabine County ownership parcels delineated by acreage of LPS priority soils.

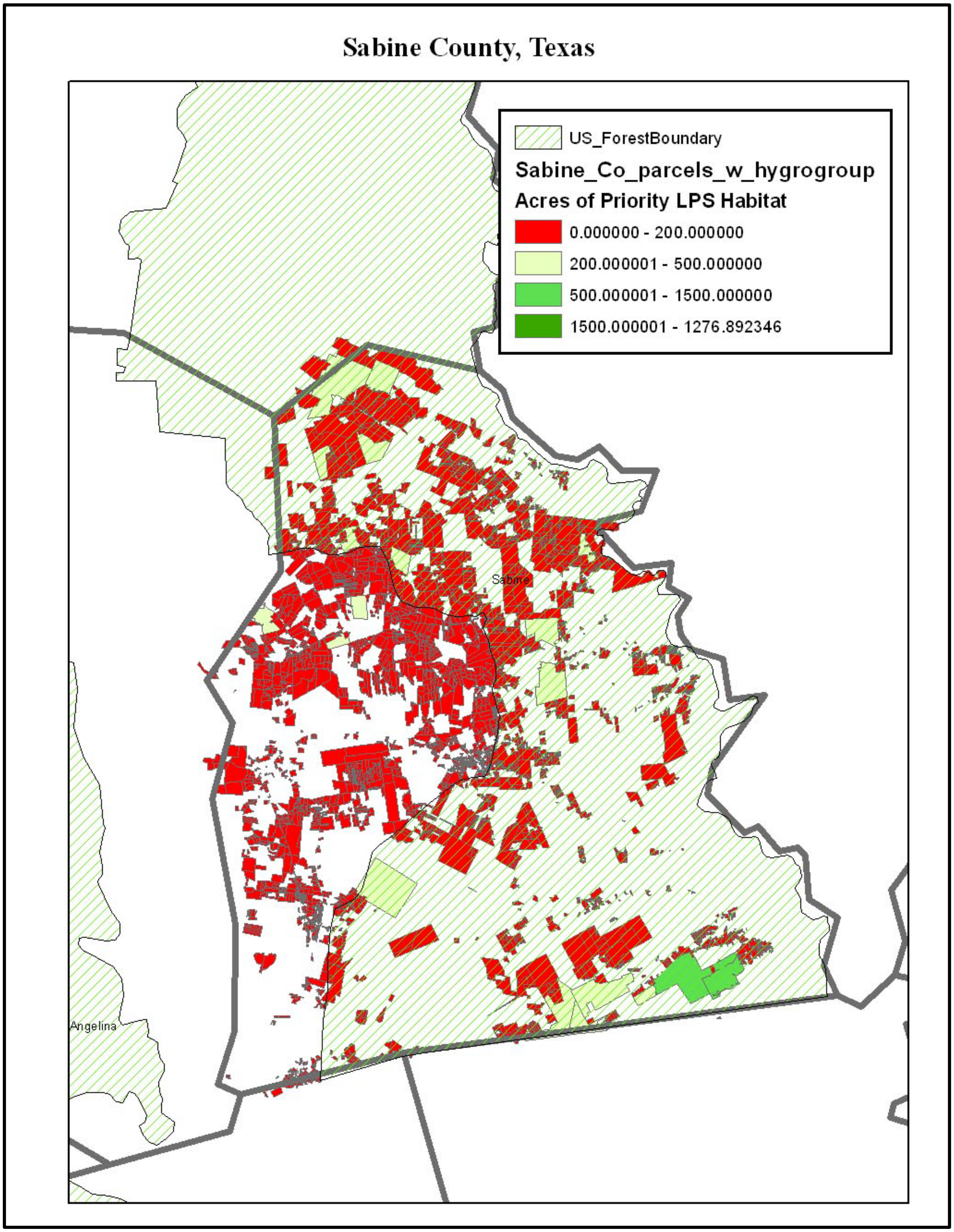


Figure 21. Angelina County ownership parcels delineated by acreage of LPS priority soils.

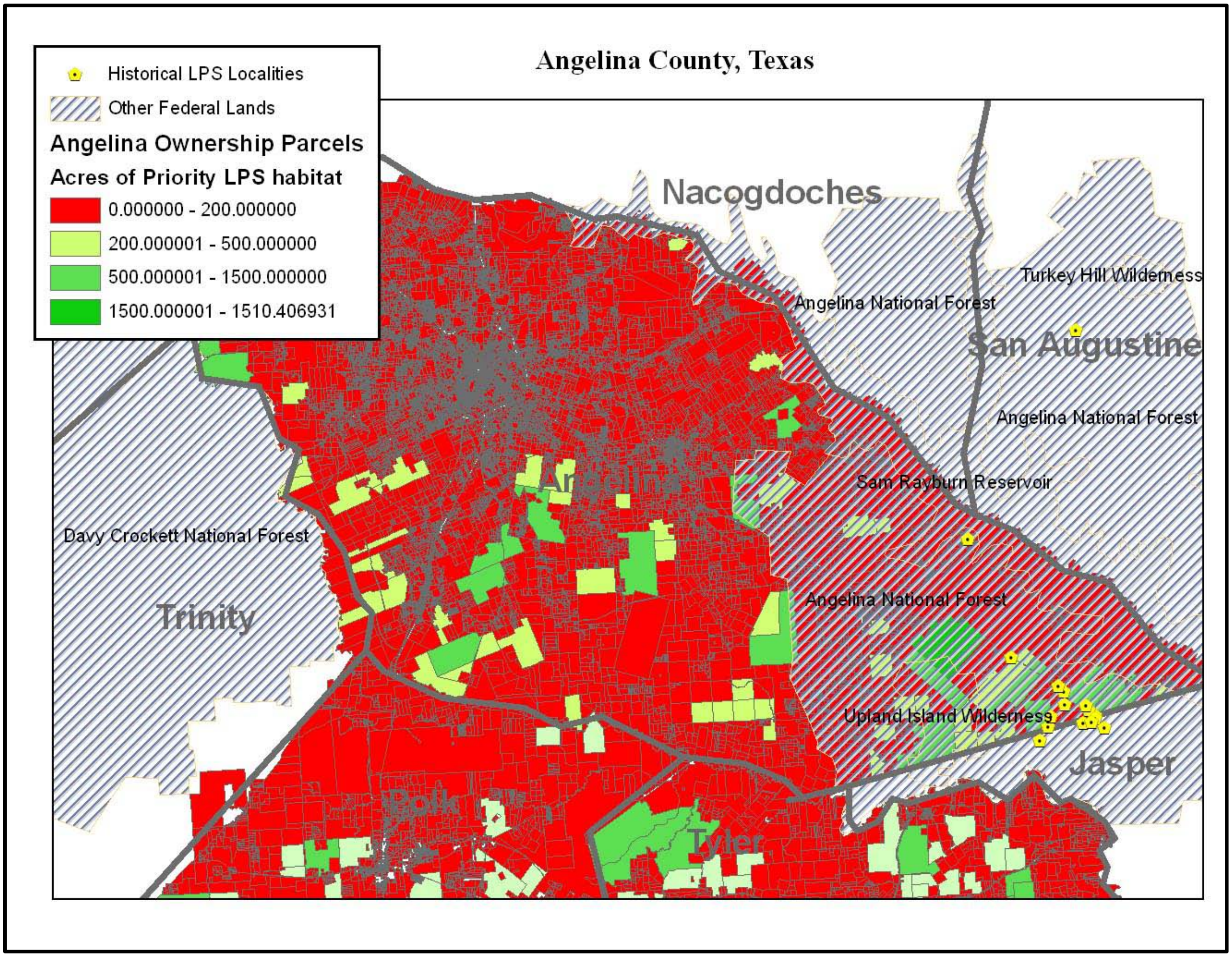


Figure 22. Sabine Parish ownership parcels delineated by acreage of LPS priority soils.

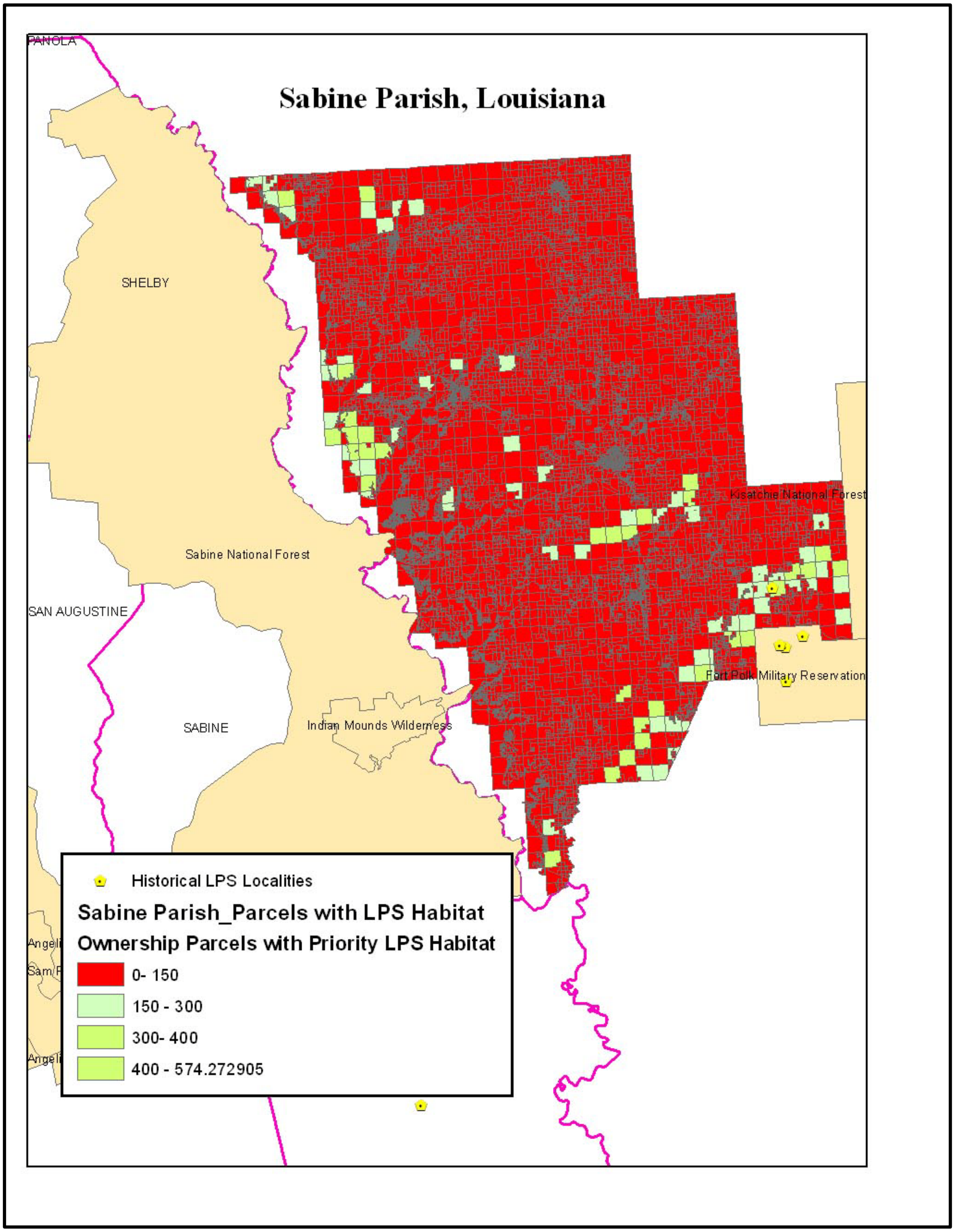


Figure 23. Rapides Parish ownership parcels delineated by acreage of LPS priority soils.

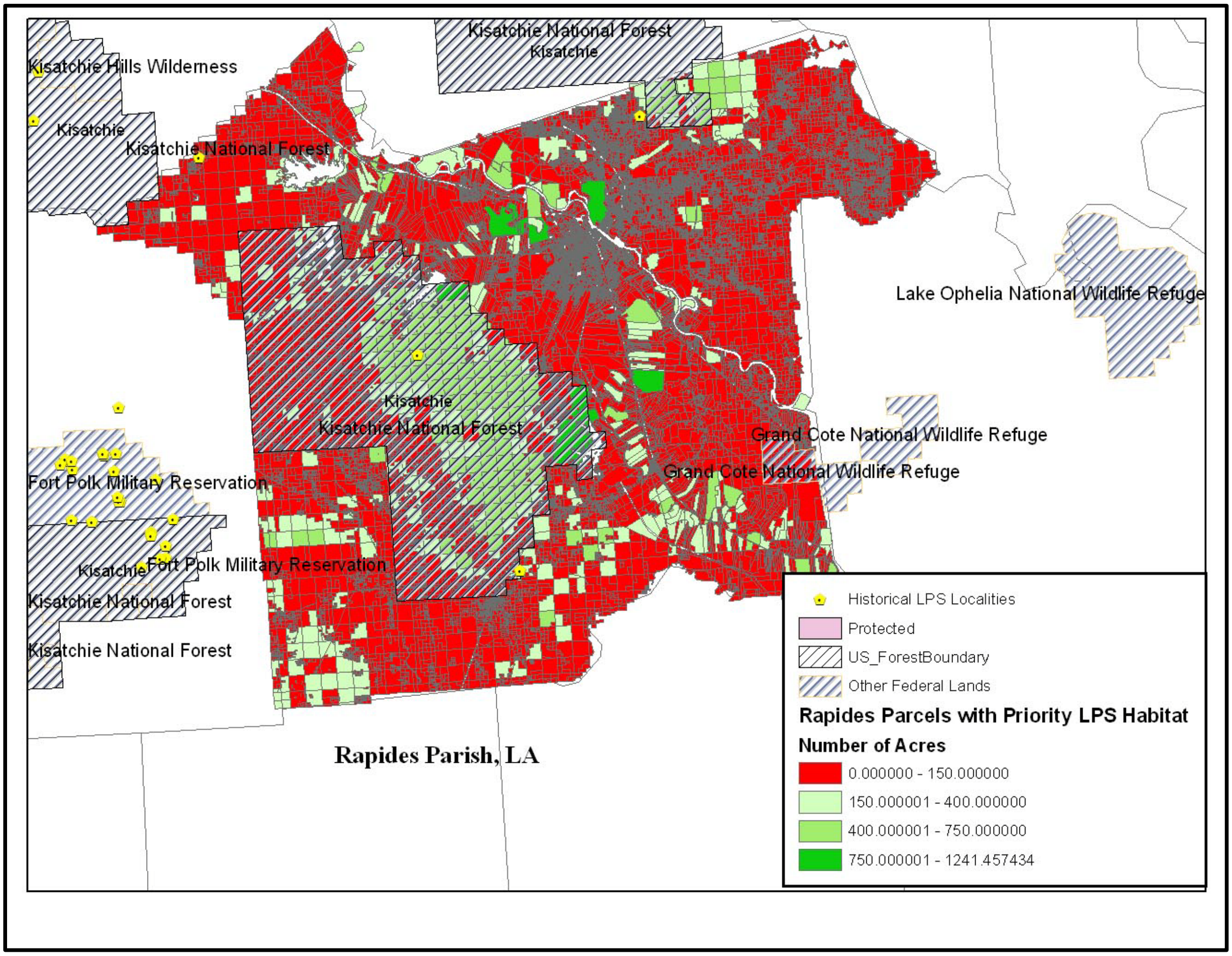


Figure 24. Natchitoches Parish soils by Hydrogroup with heads-up digitization of some parcels with > 1000 ac of LPS priority soils.

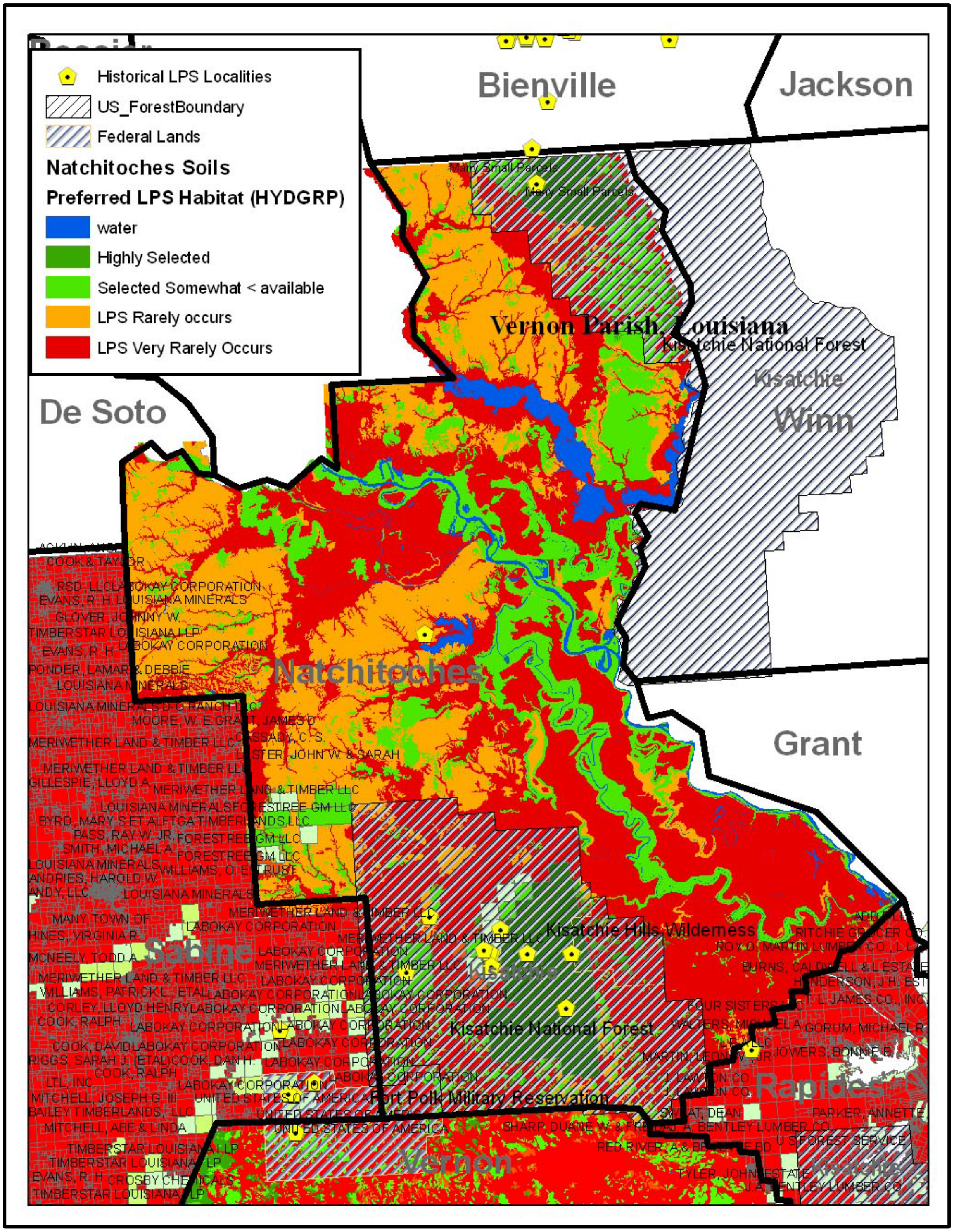


Figure 25. Newton County parcels classified by acreage of potential LPS habitat contained within individual ownership parcels.