Environmental assessment survey of the vegetation surrounding a Lower Wilcox Group coal gas well site

By John W. McCoy

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Contents

Figures

Tables

Appendices

Environmental Assessment Survey of the Vegetation Surrounding a Lower Wilcox Group Coal Gas Well Site, North Louisiana

By John W. McCoy[1]

Overview

Objectives

This environmental assessment was conducted to examine the impacts on vegetation of the drilling and operation of a coal gas well located along Hwy 134 about 5 miles (8 km) east of Fairbanks, La. The drill site is 85 meters north of Hwy 134 (figs. 1, 2, and 3) and operations at the well were performed by EnerVest Operating LLC. The site (privately owned) was formerly a mixed hardwood/pine forest that was clear-cut in 1998 and planted with loblolly pine (table 1). Once completed, the well site, with its associated pipeline covered about 1,560 m^2 (11.5 percent of the survey area) (fig. 4). This survey was conducted in coordination with Peter D. Warwick, Research Geologist, U.S. Geological Survey, and Jim York, contract geologist for EnerVest Operating, LLC. For details on the coal gas well, please refer to Warwick and others (2004).

Site Descriptions

I visited the site in late winter (March 11, 2003), summer (August 1, 2003), and fall (October 24, 2003) to capture seasonal variation of the vegetation and to note any specific environmental effects of the drilling and coal gas operation. Thirty-two 1-m^2 plots were used to assess baseline vegetation. Plot placement was at intervals up to 55 m on either side of the well site (up to 120 m from Hwy 134). The location of the plots made the surveyed area about 110 x 120 m or about 1.3 ha in size. Additional plots were placed to describe interesting habitats or important changes in vegetation structure within the study site. The field surrounding the well site was homogenous due to site preparation for planting loblolly pines. Typical plants throughout the survey site were similar to plants across the entire field (based on my observations); soils were also similar across the field (based on USDA soil surveys).

March 2003

I conducted the first visit (March 2003) prior to well or pipeline construction. The site was very wet and muddy because of recent rain. Pooled water and mud were assumed to be artifacts of site preparation for the loblolly pine plantation. The pine trees were planted in rows about 2 m apart, with water pooled in the deep furrows between rows. However, the Frizzell-Guyton-Providence soil association found on this site characteristically floods naturally partially due to lack of slope. The pooled water adjacent to the higher rows permitted obligate wetland to facultative wetland plants to coexist.

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The well was drilled in early spring, and the pipeline was constructed so that it connected the well to a distribution pipeline near the highway. Pits adjacent to the well site were excavated for the mud and liquids used during the drilling operation. Additional fill dirt was trucked in and laid as a foundation for the road to the well site (a protective cloth was laid down before the fill dirt was placed). Limestone rock was then laid on the surface of the fill dirt. The fill dirt was most likely of subsoil origin (not topsoil) and not high in mineral content. The surface limestone could have possibly buffered some of the acidity the new soil may contain. The poor mineral content of the freshly disturbed fill dirt may help to explain an abundance of hogwort and hairy crab grass near the well site since these species of plants require less soil nutrients and compete successfully against other plant species in disturbed sites.

August 2003

In contrast to spring conditions, the site was hot and dry during the summer visit in August: two of the three springtime mud pits (2-3 ft, 51–76 cm deep) nearest to the well site were nearly dry, and the vegetation adjacent to the well site was found to be different from vegetation farther away. As mentioned above, the vegetation nearest the well site consisted primarily of hogwort and hairy crab grass. Additional plant species included St. Andrew’s cross, ovate false fiddleleaf, mountain mint, seedbox, Indian heliotrope, panic grass, sedges, and beak sedge, which were in various stages of flowering, fruiting or seeding. There were some noticeable differences between vegetation closer and farther from the well site. Just east of the well site and adjacent to the produced waters tank (6,000 gallon [26,400 liter]; no levee was around it at this time) was an irregular shaped zone of about 1,500 m^2 containing a few, short, pine trees and other vegetation that was stunted and shorter than similar vegetation within the survey site.

October 2003

In October, the site was still somewhat dry. Although there had been a recent rain, there were only a few puddles of water. Conditions were not nearly so wet as during the March visit. New earthwork had been conducted near the well site: the mud pits had been filled and a low levee had been built around the produced water tank. The wellpad had been enlarged, leveled and lowered from its former 1-m height to the height of the surrounding area. The well had also been partially cemented in. A large pit about 3 x 3 x 3 m in size was in place of previously observed mud pits. The vegetation nearest to the produced water tank showed diminished height growth, as it did during the August visit. Some additional plants were in bloom, including the swamp sunflower, giant plume grass, bluemist flower, late-flowering thoroughwort, and helmet-flower. Various plants were also in fruit or seed, including narrow plume grass, hogwort, American beauty-berry, groundseltree, climbing hempvine, dog-fennel, dwarf palmetto, and some sedges.

Another preexisting well site, about 100 m to the northeast, was being prepared for operation. Preparations included construction of a dirt road from Hwy 134 and additional clearing around the new well site.

Soil, Water, Drought, Temperature, and Animals

Soil

Soils of the study area (fig. 1) are of the Frizzell-Guyton-Providence association, which is acidic and poorly drained silty soil. The field is nearly flat in the survey area and, because of the deep furrows between the plowed rows, standing water at the well site can be a problem in the winter or spring. Standing water was clouded with sediment and frequently covered by a reddish-brown colored scum (presumed to be “iron oxide”). The soil was alkaline with pH ranging from 7.1 to 9.3, mean = 7.9 (n=8) throughout the survey area during the spring visit. This alkaline pH maybe attributed to the deep tilling and exposure of the subsoil in preparation for the loblolly pine tree plantation.

Water and Drought

Rainfall is usually abundant during the spring and winter months but can be low during the summer months (fig. 5A and B). Monthly precipitation totals over the last 100 years normally range from 3 to 9 inches (7.6 to 22.9 cm), with occasional monthly totals up to 18 inches (45.7 cm) (fig. 5A). These large amounts of rainfall have usually been limited to very short time periods and have only occurred sporadically. Conversely, less than 3 inches (7.6 cm) of rainfall per month is more common than higher amounts of rainfall.

It is not advisable to drain the area other than to keep water from pooling unnaturally during the hot summer months (pooled warm or hot water may harm trees). The site is slow to drain, but the vegetation common to this type of site is generally capable of surviving short-term flooding. Long periods of pooled water, however, are not considered to be normal conditions and should be prevented from occurring, especially during the hot months.

Drought, as measured by NOAA Palmer drought severity index (http://www.drought.noaa.gov/palmer.html) (fig. 6), is less predictable than temperature or precipitation (fig. 5 and 7). Wet periods tend to be of greater intensity but shorter duration than droughts. Long periods of drought as well as wet periods affect plant growth considerably. Trees may only show reduced growth or increased growth depending on water availability, whereas the species composition of annuals may change with water availability.

Temperature

Temperature is highly predictable (fig. 7) and can be expected to attain 90°F (32.2°C) and above during the summer months with lows near 30°F (-1.1°C) during the winter months (fig. 5B). However, there can be years with extreme low temperatures that can kill or severely damage vegetation. Slight deviations from normal temperatures occur every few years. Although a natural occurrence, low temperatures that produce killing frosts and freezing weather ultimately modify the species composition. Ice storms that can occur during these low temperature extremes will damage trees severely.

Animals and Insects

I found tadpoles and aquatic beetles in the puddles, and I noted spiders near the edge of the puddles during at least one of the visits. I also noted one tree frog, but I heard numerous frog calls during the March visit. I observed a small rodent at one plot near the edge of the field, and I observed one hawk in the field during the March visit. I noted other birds, but they were few in numbers during all three visits. I observed bees during the summer and fall visits when swamp sunflowers and groundseltrees were in bloom. I detected no evidence of snakes or turtles during the site visits but the area likely supports these species. I observed paw prints of raccoon and hoof prints of deer along the edges of puddles near the well. Although no special effort was made to record the presence or absence of fire ants these insects should be present at this site.

Human-induced Changes

Soil Disturbance

The most obvious disturbance associated with well operations is the moving of soil. There was evidence of a cleared area beyond the well site that was not in use at the time of this study. This cleared area only accounts for 0.247 acres (1000 m^2); however, if this kind of clearing were common at all well sites, avoidable impacts would be significant. The area disturbed in conjunction with this drill site and associated pipeline of this size could destroy about 105 planted pine trees (based on a planting density of about 1 tree/10 m^2 and a cleared area of 1000 m^2). The number of naturally occurring woody tree species destroyed could be as many as the pine (based on previous studies of naturally occurring trees invading onto fields).

As mentioned previously, an area downslope and near the produced water tank supported fewer loblolly pines, and the pines growing in that area were less than half the height of nearby pines. In addition, other plant species in this area were stunted. The stunted nature of the vegetation in this area will probably persist until conditions become dryer in that area. Construction of levees around produced water tanks at sites such as this can help reduce the possibility of spills and any potential impacts to vegetation, but the produced water tank at this site did not have a levee around it until sometime after the summer visit.

Fire

Although there is no indication that any catastrophic event will occur in the future, the impact of such an event could be devastating to the vegetation at this site. One catastrophic event that could affect the site is fire or even an explosion at the well site. The vegetation surrounding the well site is likely to be very dry during the summer months, enhancing the chances of wildfire. Because of the enhanced possibility of fire around well operations, it is prudent to establish fire breaks within the area, especially if the density of wells in the area is increased.

Roads

Roads leading to well sites, public access roads, or hunting roads can also be used as fire breaks. These roads may, however, also restrict the movement of water throughout the field; therefore, the construction of any roads should be carefully planned. In the event that routine trips to a well site are needed, it is important to simply keep the existing roads in place and do minimal maintenance through time rather than installing a new road that would cause more soil erosion and other impacts to the vegetation. New construction will most likely cause erosion, destruction of additional trees that other plant species and wildlife dependent on, and disturbances that will allow for invasive species to become established.

Vegetation

Flora

I found a total of 50 species or plant groups at this site (table 1), but not all species were found during each site visit. The relative abundance, as well as the wetland indicator status of each species, is presented in table 1. The wetland indicator status places each species along a scale of ability to tolerate wet or dry conditions. The abundance and wetland indicator status of individual species helps to assess a site for current and, to some degree, past site conditions. Photos of the same general area taken during each of the three visits to the site indicate some idea of vegetation changes (fig. 8). Additional photographs from the site are in appendixes A and B.

None of the commonly found springtime plant species were present during the March visit. The greatest variety of species was found on the rows (out of the water and mud) with the planted loblolly pine. Sedges and rushes were the most common plant species found in the low areas, but herbaceous plants such as seedbox, ovate false fiddleleaf, and Virginia buttonweed were also present. Other herbaceous plants that were present but not in abundance were Greater water-starwort, meadow beauty, and peatree. The most common grass was broom-sedge, followed by rosette grass.

Woody species at the site included winged elm, Carolina ash, sweetgum, American elm, willow oak, water oak, and red oak. Some of these saplings grew from root sprouts that were generated when the site was prepared for planting with pine, but other saplings and seedlings grew from the seed provided by the tree lines surrounding the site. The majority of woody plants growing on the rows with the loblolly pine (out of the water and mud) were groundseltree, St. Andrew's cross, and blackberry (most likely a single species of blackberry).

In March, the planted loblolly pine ranged in size from 28 to 63 inches (70 to 160 cm) tall, with a mean height of 44 inches (113 cm). The pines were light green at the growing tips. This coloration could be caused by increased availability of water; however, loblolly pines are also described in plant keys as having a needle that is light green in color. The alkaline pH may have precipitated minerals in the soil essential to the growth of these pines and other plants. By October these same pines were 79 to 118 inches (200 to 300 cm) tall. This height growth, although not measured, was observed to be similar in the other woody vegetation present in the area.

The more unusual plants found at the site were nonvascular, such as mosses and liverworts. All of these species were abundant throughout the site and were actively producing spores, especially during the March visit. Liverworts and mosses were not noted during the October visit, possibly because of the high vegetation density or perhaps because of mortality related to less abundant water during the summer months. These species can regenerate from spores during wet conditions.

Violets, bluets, buttercups, or other common springtime herbs were not noted during any of the visits to the site. Typically, these common herbs do not initially grow in such highly disturbed areas. The lack of these common species may be the result of soil disturbance or other anthropogenic effects. For example, application of herbicides is a common practice in tree plantations (Dr. R. Dale Thomas, Botanist, University of Louisiana at Monroe, oral commun., 2003); the use of herbicides at the loblolly pine plantation may have eliminated the early spring-blooming species from the site. One plant in particular, St. Andrew’s cross, responds to herbicide by being more bushy after herbicide application, and I observed that individuals at this site were more bushy than normal.

The primary species of woody plants included groundseltree, St. Andrew’s cross, and loblolly pine. Additional species of woody or semiwoody plants that were occasionally encountered included blackberry, Carolina ash, American elm, winged elm, willow oak, water oak, sugar-berry, and Chinese tallowtree. Black willow and winged sumac were infrequent. Most trees and shrubs were not actually counted in the 1 m^2 square plots; these woody plants showed a clumped distribution throughout the site and may have higher densities than those shown in table 1. Proximity to a seed source will determine the ability of many of these species to regenerate naturally. Since there are tree lines and forests that produce seed surrounding this site there will be many new trees present in the future. These new trees will become established and grow until the larger, more dominant trees either from the planted pine plantation or naturally occurring trees form a closed canopy and begin to shade out and out-compete the smaller trees and shrubs as well as other herbaceous vegetation.

Herbaceous plants at the site include a host of predominantly wetland plant species (table 1). Nonwoody perennial plants that persist throughout the year include broomsedge, beak-sedge, mountain-mint and white oldfield aster. The primary grass in the field was broomsedge on the higher elevations and rosette grasses on the lower elevations, although not necessarily in water. The primary plants found near the freshly disturbed edge of the well site and road, as well as near the pipeline, were hairy crab grass and hogwort. Some individuals of these species were present away from the well site but not in the abundance noted near the well site. Both of these plant species are known to be primary successional species and will not likely persist once the forest of the area begins to mature.

During the March survey, species diversity was low. Only two or three species were observed per square meter. Of the species encountered, groundseltree and St. Andrew’s cross, with an occasional planted loblolly pine, were the most common. During the August visit, additional study plots were set in the area closer to the produced-waters tank where stunted vegetation was observed. Lower areas were dominated by prostrate or crawling vegetation such as seedbox, Virginia buttonweed, and ovate false fiddleleaf. Species diversity of the herbaceous layer will probably diminish naturally as the pine forest matures. The reasons for this include light to the forest floor diminishing, water availability decreasing due to the increased use by the trees, and nutrient availability changes from changes in the characteristics of the soil from the additional organic materials added from tree litter fall.

Areas with atypical vegetation were sporadic throughout the site. These areas usually had very few trees and were not as wet as adjacent areas. Furthermore, the vegetation in these areas was noticeably shorter than other vegetation in other areas. It is unknown if these areas had been previously disturbed or somehow affected by operations before the well site was constructed.

Changes in Vegetation

Changes to the composition of the vegetative community were noted along the edges of the well site as well as along the pipeline. The most important changes were in the dense stands of hogwort and hairy crab grass that developed along the edges of these disturbed areas. These plants are typically associated with disturbed areas. Since these plants are a direct response to the disturbance that the site endured during well site construction, these species will likely be replaced by a more diverse group of species as the site matures.

Normal plant succession on this site has been upset by site preparation for tree planting and, more recently and to a lesser degree, by disturbance from well site operations. Periodic disturbance, such as from well site operations, can drastically affect plant succession and may affect species diversity. Disturbances can allow for undesirable species such as hogwort, hairy crab grass, groundseltree, and Chinese tallowtree to thrive. Diversity of both the number of species and the number of habitats will help this site to function like the undisturbed sites found in this general area. This vegetative diversity will help to ensure habitats that will promote wildlife.

Invasive and Nuisance Species

The most prominent invasive species at the site is the Chinese tallowtree. A native of Asia, it is an aggressive invader that has become a major problem on disturbed sites during the last 30 years. The tree produces seeds that are eaten and distributed by birds. The seed can remain dormant until the soil is disturbed and then will germinate and grow very fast. The soils at this site should be disturbed as little as possible so that a minimum of these trees and other nuisance disturbance-related species become established. Clumps of Chinese tallowtrees were observed throughout the site. These trees will begin to produce seed in the next few years, and a seed bank will become established. Because of the current low density of Chinese tallowtrees on this site, it is feasible to control this invasive species with the use of a herbicide; cutting of individual trees without the use of a herbicide will only encourage root sprouting. Control of these trees includes a regime of cutting and applying herbicide at the proper time of year, usually spring. The herbicides triclopyr or imazapyr (Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.) can be used for control of Chinese tallowtree.

Groundseltree is a nuisance shrub species that is very common at this site. There is little that can be done about the number of these plants within this site. As the other trees mature, the groundseltrees will begin to die back and eventually disappear from most of the site, except in the area maintained around the wellhead. In the short term, these shrubs will continue to use valuable water and nutrients from the soil.

Conclusion

Soil disturbances such as ditching, clearing for the well site, and clearing for road construction account for the bulk of the damage and impacts to the Lower Wilcox well site. However, impacts including the maintenance of the field edges (brush cutting) and building and maintenance of the dirt roads for other purposes are at least as great as the impacts from the building of this one well site, its associated access road, and pipeline.

The impacts to the vegetative community near the well site are hard to determine since the site was already highly disturbed because of loblolly pine planting. As the site matures, the vegetation composition will become more stable and develop into a mature stand of pine with a mix of hardwood species in the understory. The most likely mature forest that will develop will be similar to the mixed pine/hardwood forest adjacent to this site. Operation and maintenance of the well site will affect species composition and will probably allow invasive and undesirable plant species to become more widespread within the site. The worst of the invaders at this time is Chinese tallowtree that also has the potential to become a dominant tree species if given opportunity. However, it is difficult to assess impacts by invasive species to the vegetation since the area was previously disturbed to plant a pine plantation and more recently disturbed for the well operation. Similar wells in recently established pine plantations may respond somewhat the same, at least for the general area in which this site is located.

Approximate direct impact area of the well operation was about 1,600 m^2. This is a conservative estimate for the area that was bulldozed, overlaid by fill dirt, and excavated for pits at the well site. Collateral impacts to the areas near well sites will generally increase with the number of wells. Partitioning of the landscape by roads to the well can influence the hydrology and ultimately the vegetation; minimizing the size of well operations will eventually help to minimize environmental impacts. Most of these environmental impacts have occurred adjacent to and directly connected to the well site. Proper use of erosion control fences and containment levees can help to minimize runoff that would affect vegetation farther from the well site. Using local topsoil to fill holes and recondition disturbed areas can help promote growth of naturally occurring plant species rather than invasive or undesirable plant species.

More vegetation and environmental monitoring in a variety of habitats over a longer time period (at least 3 years) is required to get sufficient data for statistical interpretation of environmental impacts by well site operations.

Literature Cited

Warwick, P.D., Breland, F.C., Jr., Clark, A.C., and Willett, J.C., 2004, Preliminary Results from Coal-Bed Methane Drilling in Ouachita Parish, Louisiana: U.S. Geological Survey Open-File Report 2004-1239, 4 p. http://pubs.usgs.gov/of/2004/1239/

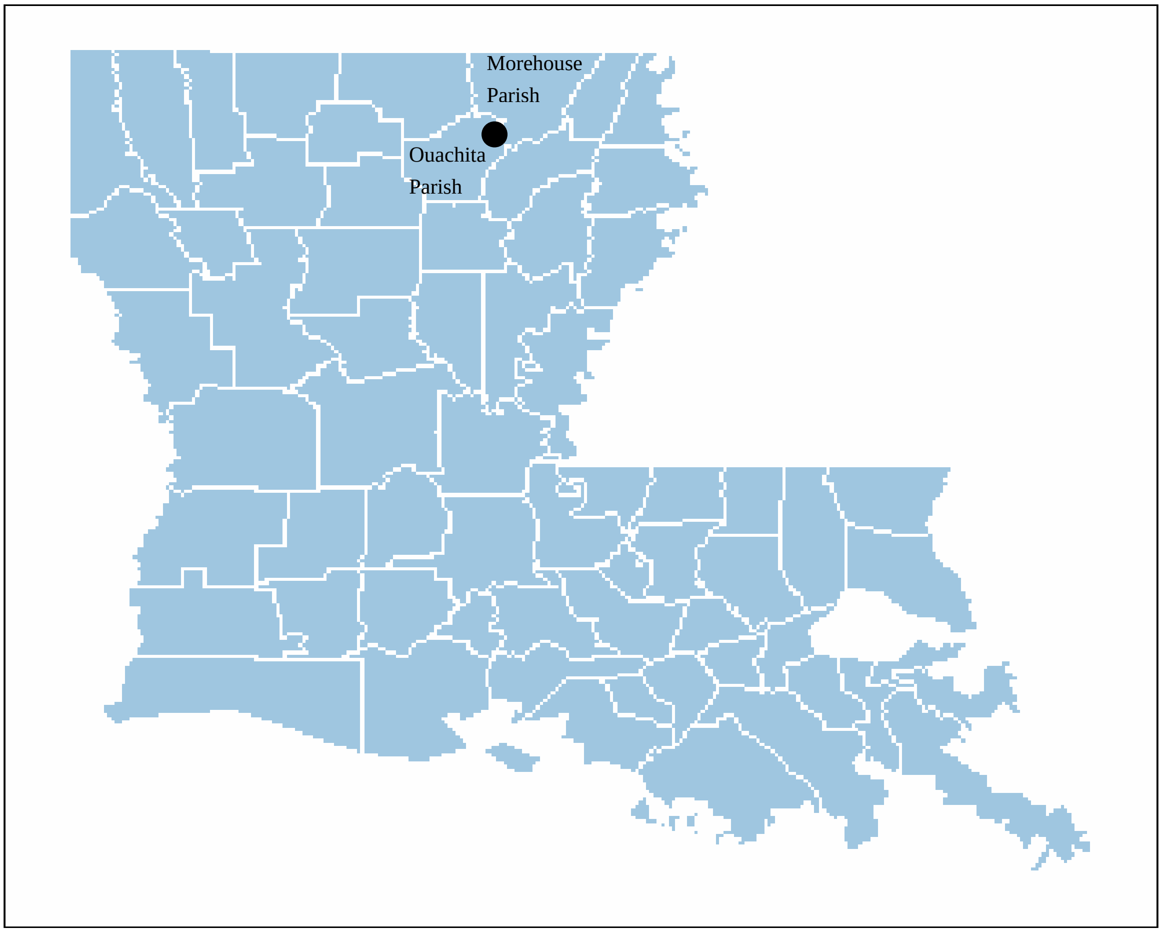


Figure 1. General location (black dot) of Lower Wilcox site within Louisiana. In the northeast section of Ouachita Parish near the border of Morehouse Parish.

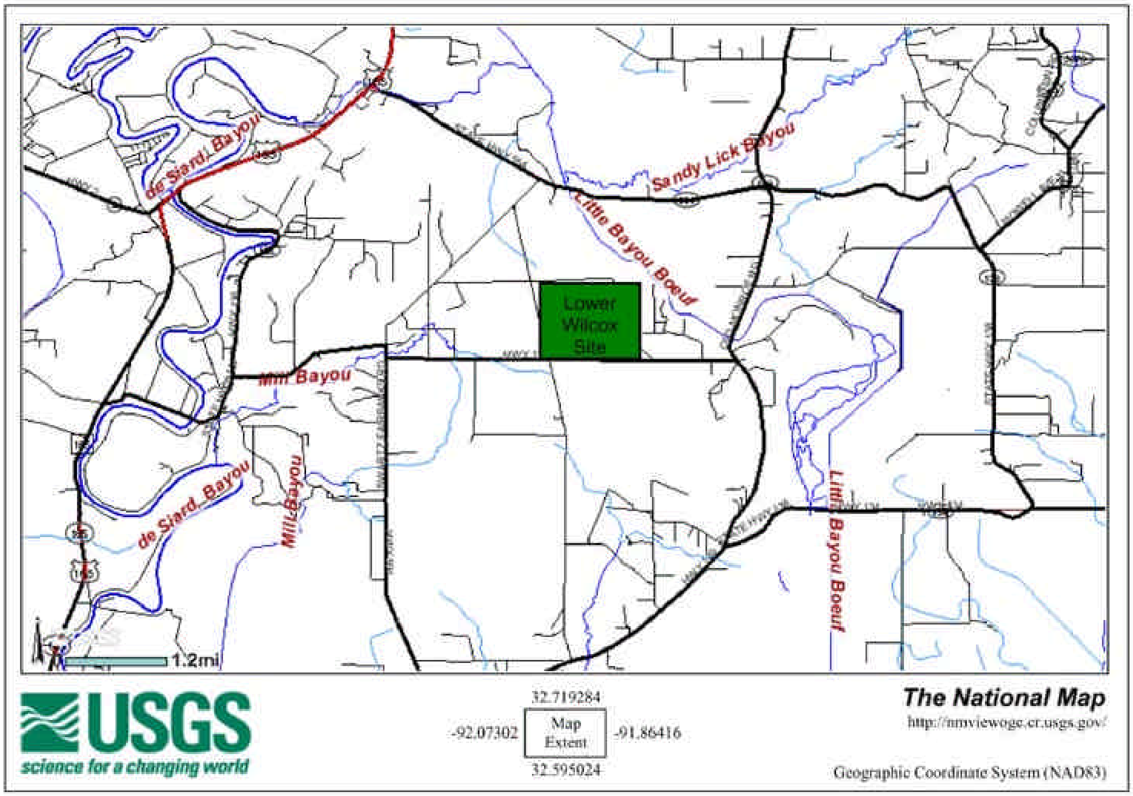


Figure 2. Location of the Lower Wilcox site showing roads (black and red lines) and proximity to water courses (blue lines).

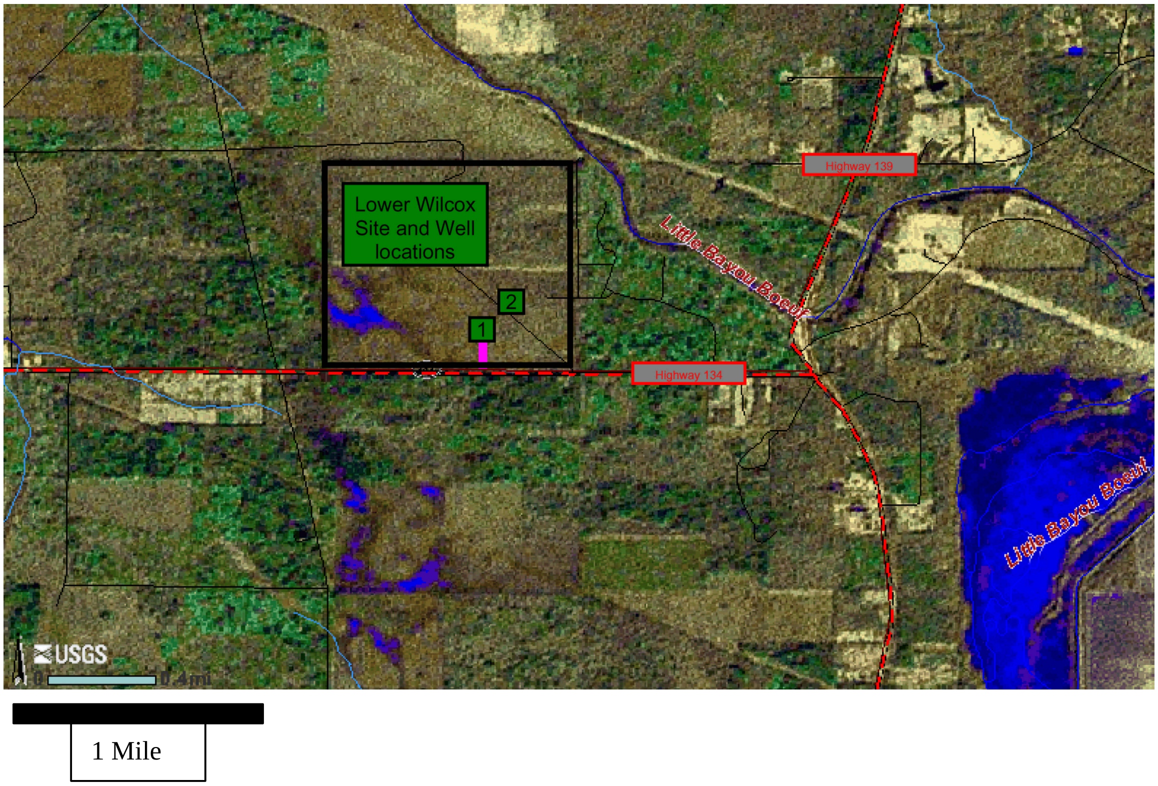


Figure 3. Aerial photo of the site. Boxes 1 (focus of this study) and 2 indicate well sites.

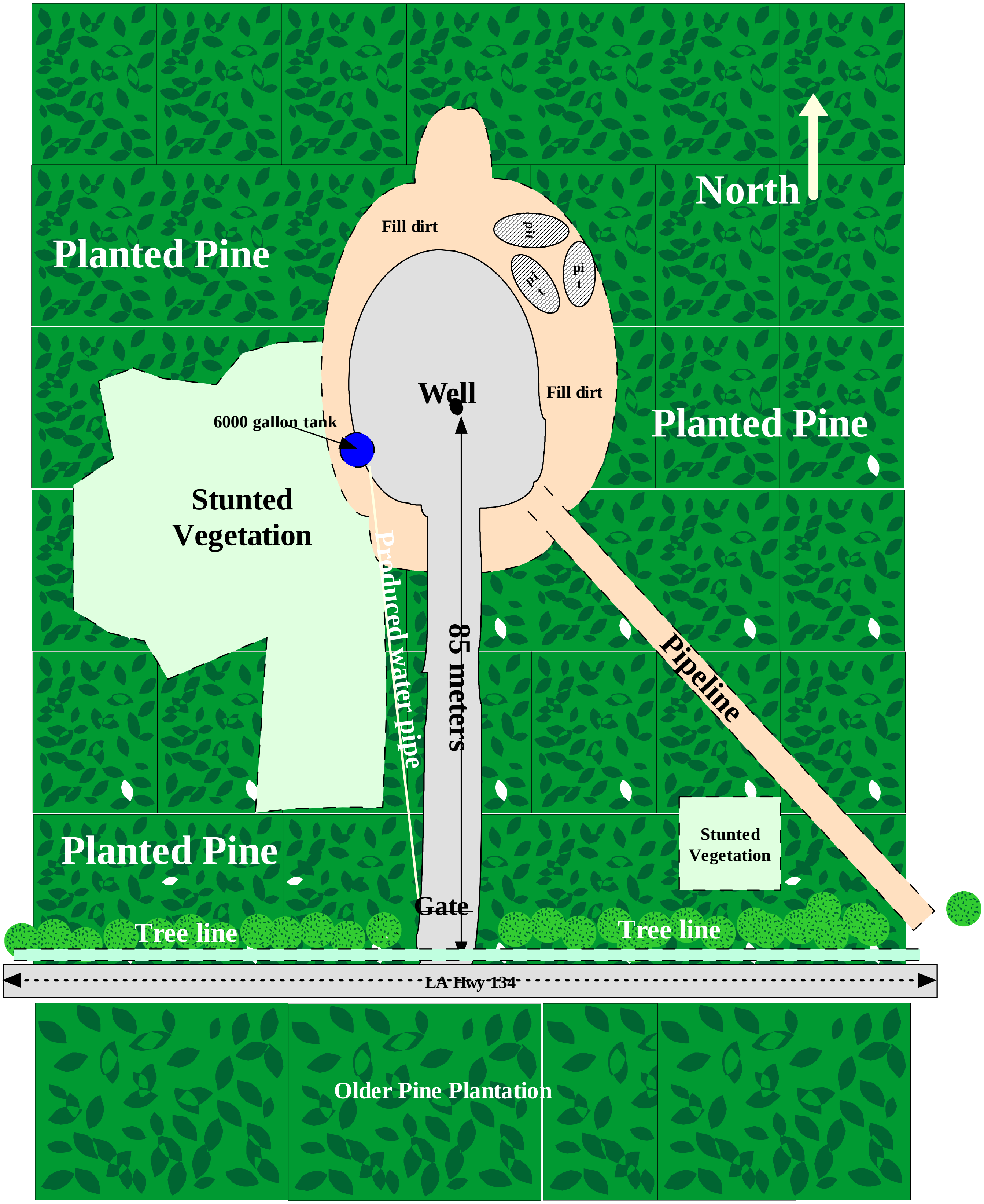
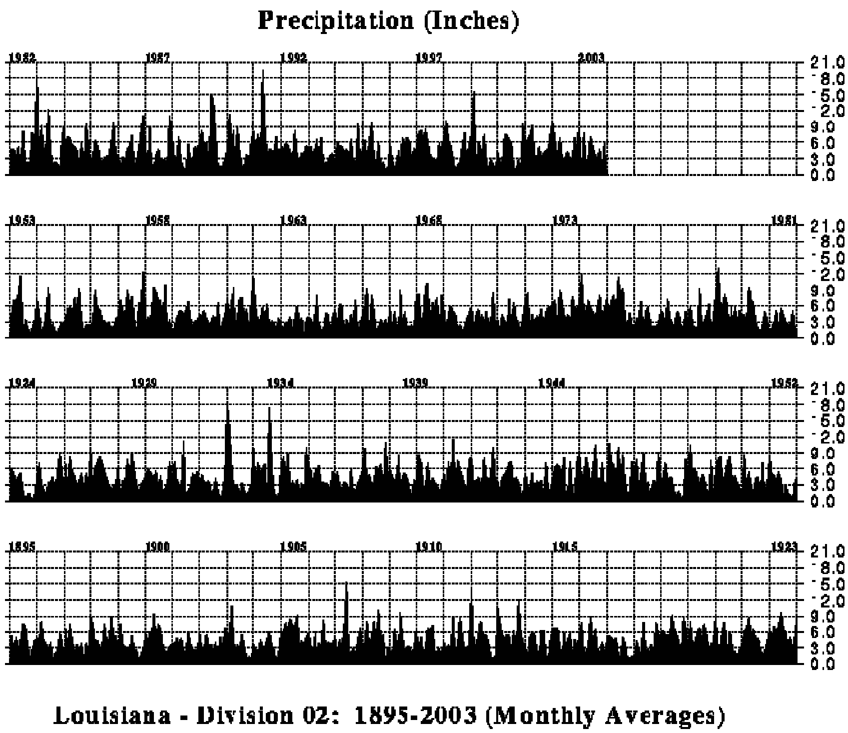


Figure 4. Diagram of well site layout during the summer visit.

A



B

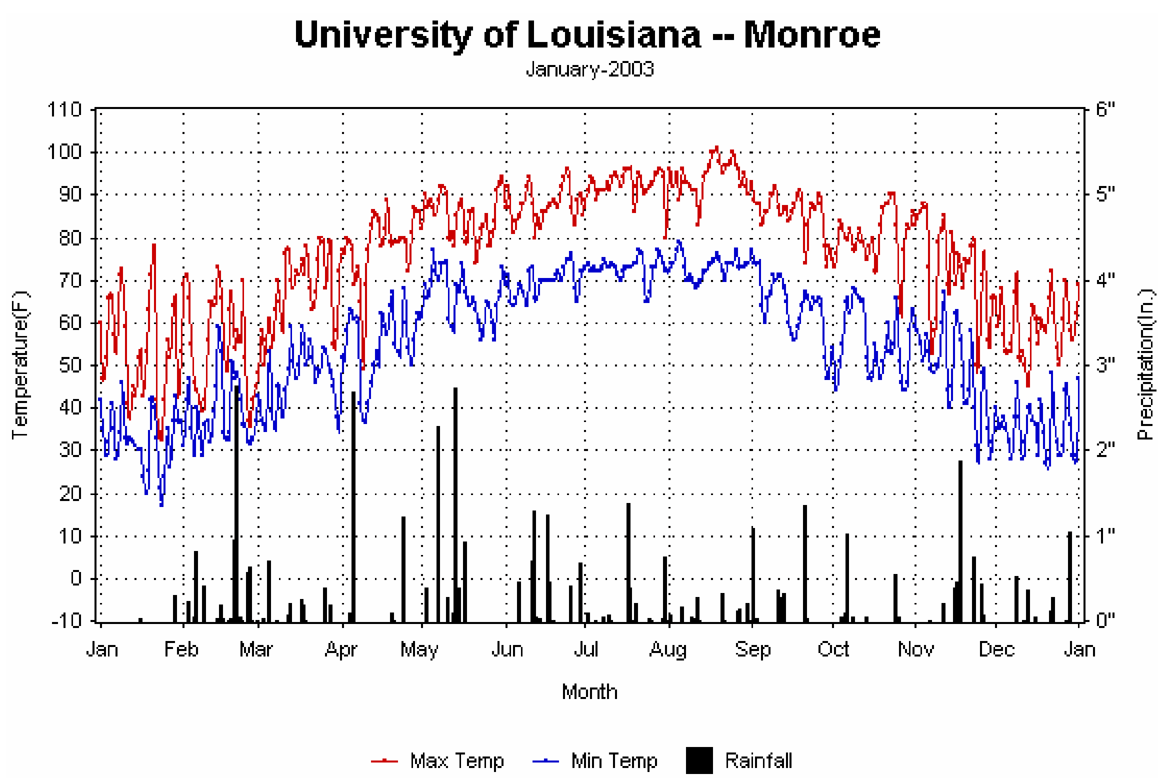


Figure 5. (A) Monthly average precipitation of division 2 Louisiana (1895 - 2003), which includes the Lower Wilcox site. Data prepared from Climate Division of the National Climatic Data Center, December 22, 2003. (B) Maximum precipitation, maximum temperature, and minimum temperature for 2003 at University of Louisiana at Monroe, LA.

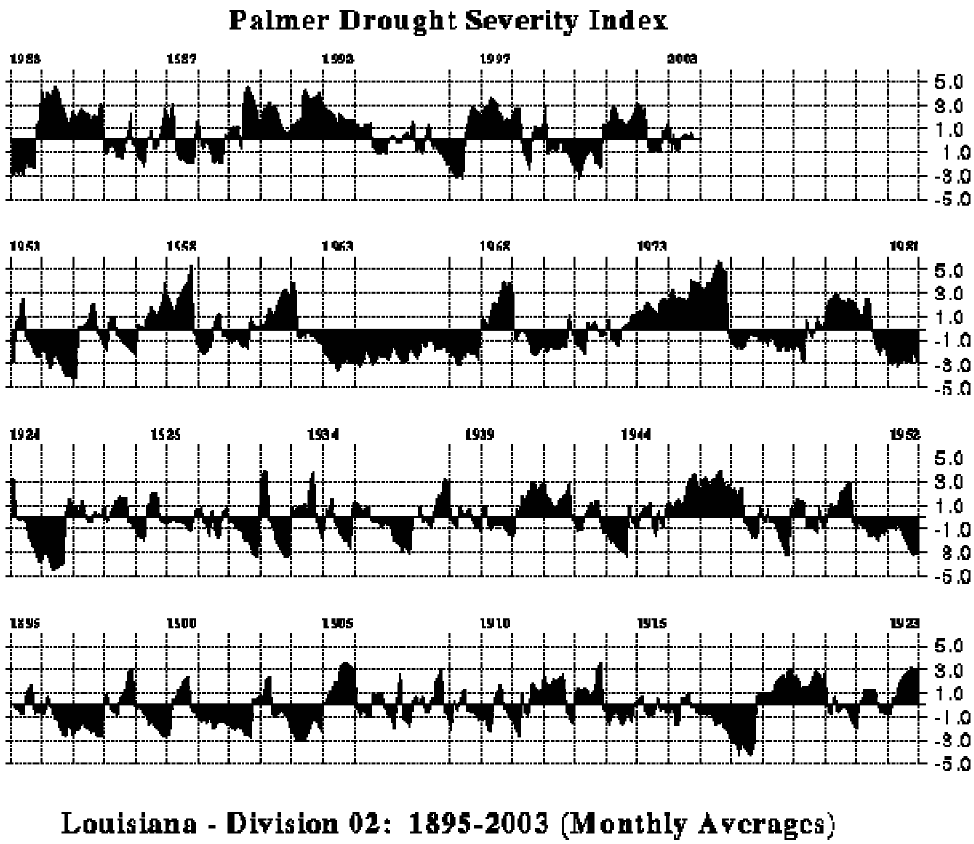


Figure 6. Monthly average Palmer drought severity index of Division 2, Louisiana, which includes the Lower Wilcox site. Zero is normal and drought is shown in terms of minus numbers. Data prepared from Climate Division of the National Climatic Data Center, December 22, 2003.

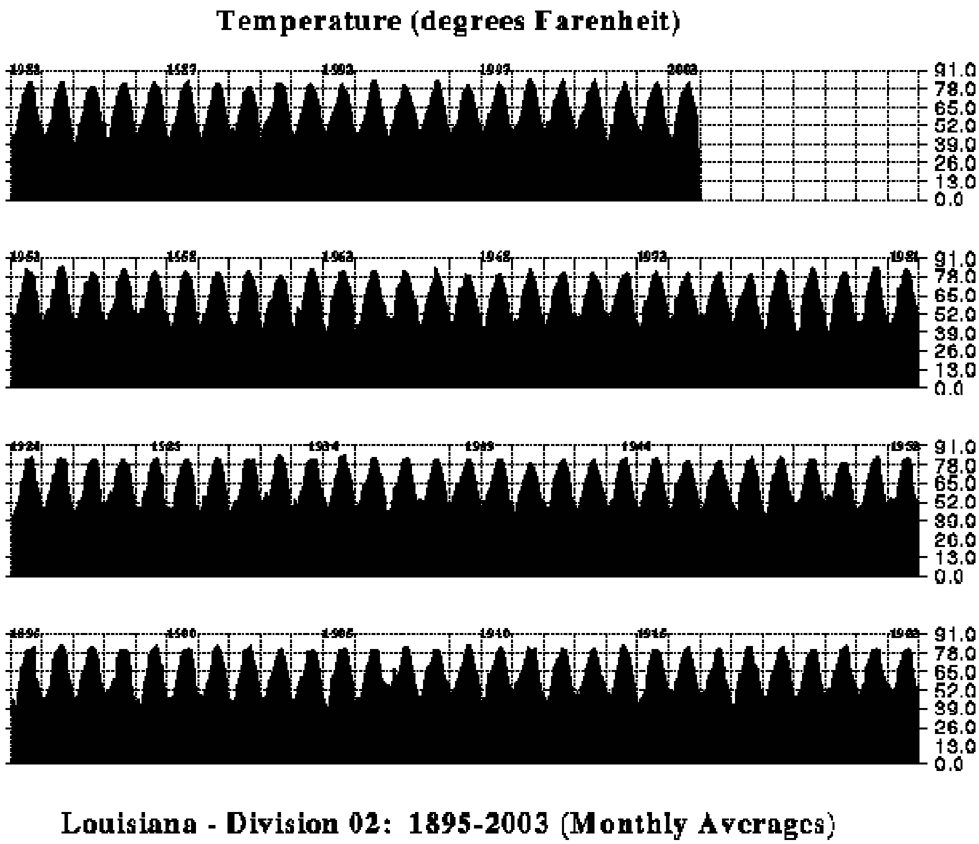


Figure 7. Monthly average temperature of Division 2, Louisiana, (1895 - 2003) which includes the Lower Wilcox site. Data prepared from Climate Division of the National Climatic Data Center, December 22, 2003.

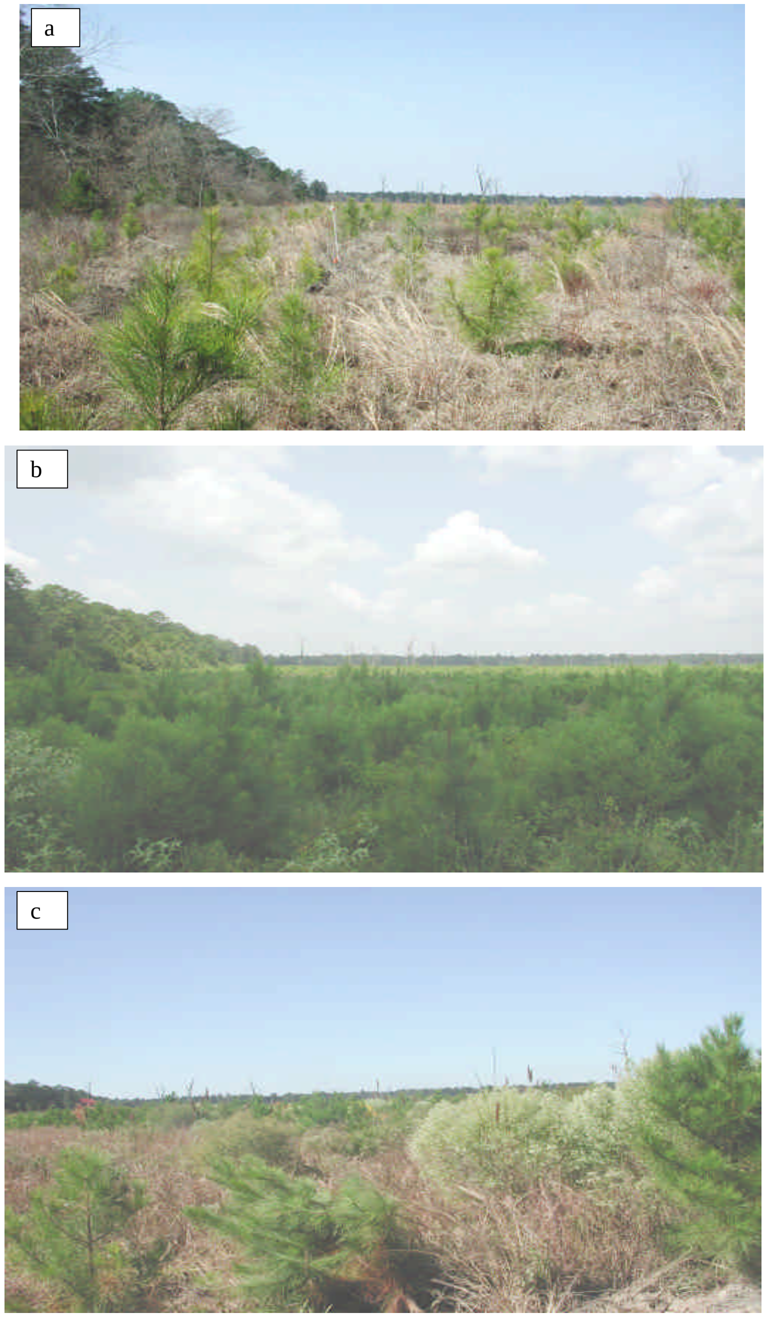


Figure 8. Comparison photos for the (a) March, (b) August, and (c) October visits to the Lower Wilcox site. All views are looking to the west from the area of the road that leads to the well. The photos were not all taken from the exact same location: The March photo (a) was taken from a lower perspective since there was no elevated road at that time.

Table 1. A list of plant species and groups, sorted by plant type, found at the Lower Wilcox site during three visits in 2003. These species represent the most common plants at this site. Scientific and common names, wetland indicator status (WET)[1], and percent frequency[2] are noted for each species. Type indicates the functional group to which each species belongs. "Forb" indicates an herbaceous plant other than a grass or sedge.

Species	**Type**	**WET**	**%**	**Common name**
Callitriche heterophylla Pursh	Forb	OBL	<1	Greater water-starwort
Cirsium horridulum Michx.	Forb	FAC	<1	Yellow Thistle
Conoclinium coelestinum L.	Forb	FACU	<1	Blue mistflower
Croton capitatus Michx.	Forb	FACW+	3	Hogwort
Diodia virginiana L.	Forb	FACW	11	Virginia buttonweed
Eupatorium capillifolium (Lam.)	Forb	FACU	14	Dog-fennel
Eupatorium serotinum Michx.	Forb	FAC-	12	Late-flowering thoroughwort
Helianthus angustifolius L.	Forb	FAC+	<1	Swamp sunflower
Heliotropium indicum L.	Forb	FAC+	<1	Indian heliotrope
Houstonia L.	Forb	FAC	-	Bluet
Hydrolea ovata Nutt. Ex Choisy	Forb	OBL	<1	Ovate false fiddleleaf
Ludwigia alternifolia L.	Forb	OBL	6	Seedbox
Mikania scandens (L.) Willd.	Forb	FACW+	<1	Climbing hempvine
Pycnanthemum Michx.	Forb	FAC	6	Mountain-mint
Ranunculus L.	Forb	FACW	-	Buttercup
Rhexia mariana var. *Mariana* L.	Forb	FACW+	3	Meadow-beauty
Scutellaria integrifolia L.	Forb	FAC	<1	Helmet flower
Sesbania herbacea (P. Mill.) McVaugh	Forb	FACW	3	Peatree
Solidago altissima L.	Forb	FACU	12	Tall goldenrod
Symphyotrichum pilosum (Willd.) Nesom	Forb	FAC-	<1	White oldfield American-aster
Viola L.	Forb	FAC	-	Violet
Andropogon virginicus L.	Grass	FAC-	34	Broomsedge
Dichanthelium (A.S. Hitchc. & Chase) Gould	Grass	FAC	4	Rosette grass
Digitaria sanguinalis (L.) Scop.	Grass	FAC-	3	Hairy crab grass
Panicum L.	Grass	FACW	<1	Panicgrass
Saccharum baldwinii Spreng.	Grass	OBL	<1	Narrow plume grass
Saccharum giganteum (Walt.) Pers.	Grass	FACW	<1	Giant plume grass
Mosses and Liverworts	Moss	OBL	.	Mosses and Liverworts
Carex L.	Sedge	FAC	2	Sedge
Cyperus L.	Sedge	FACW	2	Flat sedge
Eleocharis R. Br.	Sedge	FACW	31	Spike rush
Juncus L.	Sedge	FACW	<1	Rush
Rhynchospora Vahl	Sedge	FACW	12	Beak sedge
Baccharis halimifolia L.	Shrub	FACW+	22	Groundseltree
Callicarpa americana L.	Shrub	FACU-	<1	American beauty-berry
Hypericum hypericoides (L.) Crantz	Shrub	FAC	38	St. Andrew's-cross
Rhus copallinum L.	Shrub	FACU-	<1	Winged sumac
Sabal minor (Jacq.) Pers.	Shrub	FACW	3	Dwarf palmetto
Celtis laevigata Willd.	Tree	FACW	<1	Sugar-berry
Fraxinus caroliniana P. Mill.	Tree	OBL	1	Carolina ash
Liquidambar styraciflua L.	Tree	FACW	<1	Sweetgum
Pinus L.	Tree	FAC	7	Pine
Pinus taeda L.	Tree	FAC	7	Loblolly pine
Quercus falcata Michx.	Tree	FACU-	2	Southern red oak
Quercus nigra L.	Tree	FAC	2	Water oak
Quercus phellos L.	Tree	FACW-	2	Willow oak
Salix nigra Marsh.	Tree	OBL	<1	Black willow
Triadica sebifera (L.) Small	Tree	FAC	<1	Chinese tallowtree
Ulmus alata Michx.	Tree	FACU+	<1	Winged elm
Ulmus americana L.	Tree	FACU+	<1	American elm

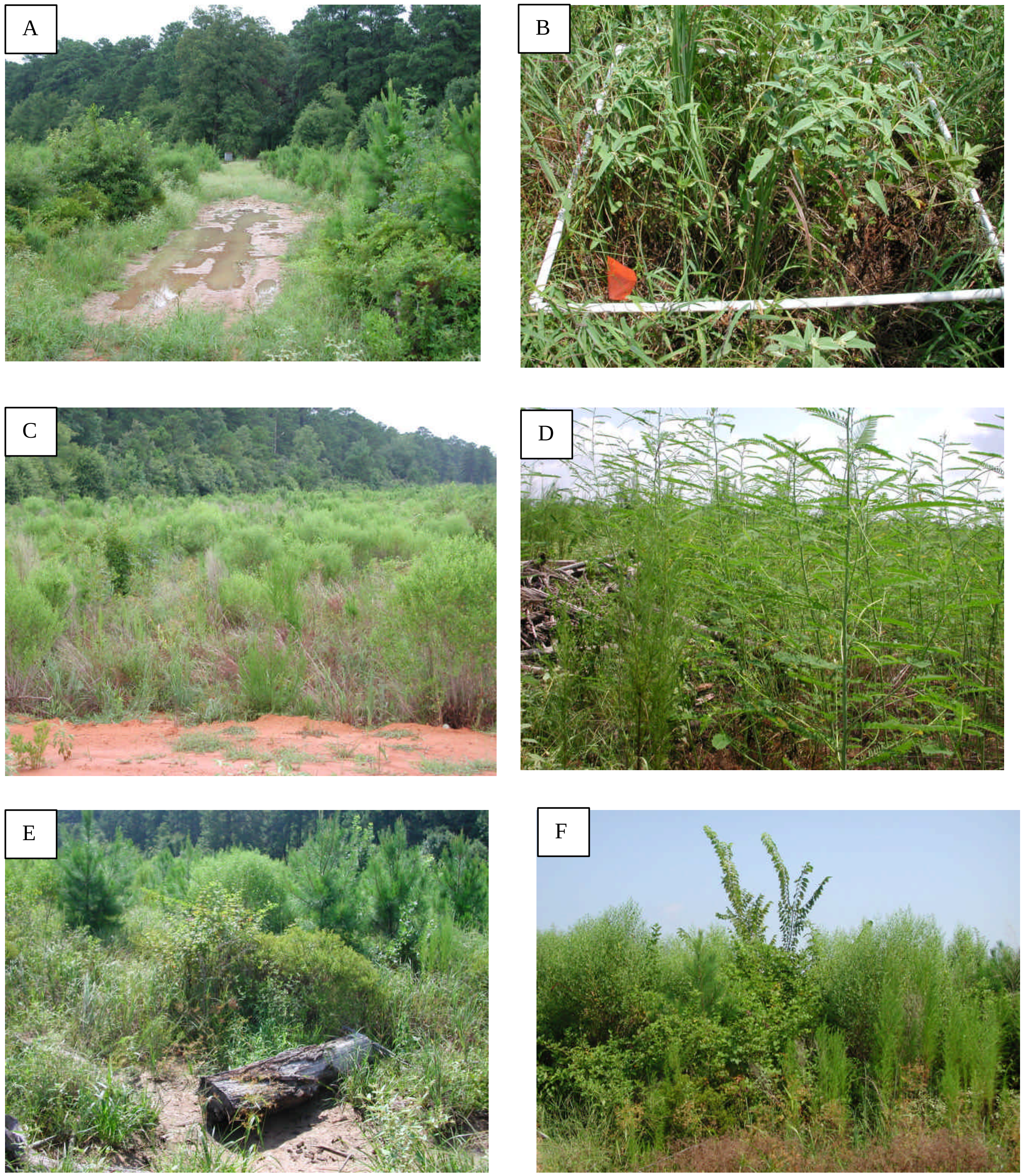
Rubis L.	Vine	FAC	9	Blackberry
Trachelospermum difforme (Walter) Gray	Vine	FACW	1	Climbing dogbane
Vitis aestivalis Michx.	Vine	FAC-	<1	Summer grape

[1]Wetland Indicator Status definition (http://www.nwi.fws.gov/bha). A plus sign (+) indicates a frequency towards the wetter end of the category (more frequently found in wetlands) and a minus sign (-) indicates a frequency towards the drier end of the category (less frequently found in wetlands).

OBL	Obligate Wetland	Occurs almost always (estimated probability 99%) under natural conditions in wetlands.
FACW	Facultative Wetland	Usually occurs in wetlands (estimated probability 67%-99%), but occasionally found in non-wetlands.
FAC	Facultative	Equally likely to occur in wetlands or non-wetlands (estimated probability 34%-66%).
FACU	Facultative	Upland usually occurs in non-wetlands (estimated probability 67%-99%), but occasionally found on wetlands (estimated probability 1%-33%).
UPL	Obligate Upland	Occurs in wetlands in another region but occurs almost always (estimated probability 99%) under natural conditions in non-wetlands.

[2]Percentages indicate the frequency that a species would be encountered within an area of 100 m^2. Some species such as grasses, sedges, and the smaller herbaceous plants can grow under the larger species of woody plants and will therefore have a large number. Species with minus sign (-) were not found at this site but included since they are mentioned in the text.

Appendix A. Photos of the site from the July visit. Including a view of the (A) pipeline (looking SE from the well), (B) a herbaceous sampling plot (1 m^2) with the pvc quadrate, (C) a dense groundseltree patch SW of the well, (D) a dense peatree stand SE of the well (only location noted at site), (E) a 0.5-m diameter log (remnants of previous intact forest), and (F) an American elm, a natural invading woody species common to this area that is outgrowing the adjacent pines.



Appendix B. These photos were taken during the October visit they show (A) the well site, tank (6000 gal), and red clay fill. Most of the vegetation in these photos (A, B) is hairy crab grass, hogwort, groundseltree, and loblolly pine. Looking SW to wellsite (C), is vegetated with loblolly pine, giant plume grass, groundseltrees, an ash and a willow oak.