

# **Final project report to the National Commission on Science for Sustainable Forestry (NCSSF)**

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## **NCSSF Project C.1 Extension: Phase 2 Report**

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## Abstract

In the southeastern United States there is increased pressure on forest managers of privately managed lands to produce, in addition to forest products, other values such as wildlife habitat and bio-diversity. Longleaf pine forests were historically prevalent across the coastal plain and were regarded for their diversity but today have been largely replaced by monoculture pine plantations (loblolly, slash, or longleaf).

The purpose of Phase II of the Project C1 extension was to enhance the understanding of how species diversity changes with time as a result of dynamic stand development. Six stands were identified and ranged in age from 11 – 15 years old in 2005. In 1995 four of the stands had been designated as having benchmark characteristics and two of the stands had non-benchmark characteristics. In 2005, it appeared that the stands had similar herbaceous composition and condition regardless of their prior designation. This report summarizes the findings of the field data collected and the subsequent seed bank study conducted on these six stands.

In all cases the herbaceous and woody understory percent cover decreased and the overstory basal area increased during the 10 year period between 1995 and 2005. For herbaceous cover, reductions averaged ~43% and ranged from ~18%.to as high as ~77%. Understory woody cover also declined in all stands and ranged from ~3% to as high as 27% with the average of ~11%. In two of the stands the midstory basal area increased and in the remaining four stands the midstory basal area decreased. In general there were ~50% fewer total species identified in 2005 than were found in 1995 (123 vs. 64) and in particular, the number of herbaceous species declined by nearly 60% (87 vs. 35). The number of understory woody species declined while the number of midstory and overstory species increased in the same time period. This is to be expected as the smaller woody vegetation grew into larger size classes and some shade intolerant species were out competed as crowns closed and overstory basal area increased.

From the seed bank samples 2910 individuals germinated representing 56 unique species. Approximately 50% of the total individual germinants were two species of *Gnaphalium* (*G. falcatum* (28%), *G. pensilvanicum* (22%). Nearly 45% of the remaining germinates were from 15 species with a minimum of 1% representation. The intent for this study was to assist in understanding the potential role that the seed bank could play during stand development. If thinning to reduce basal area increases the potential for biodiversity as our modeling effort suggests (Zobrist, Hinckley et al. 2005), then these results will be important to understand whether the vegetative response is primarily from the seed bank or some other source.

Deliverables for this project include this summary report as well as two manuscripts that will be submitted for publication to refereed journals. These manuscripts will address the findings from the re-measurement of the vegetation plots since 1995 and the findings from the seed bank study respectively. Finally, one extension publication will be submitted with the illustration of herbaceous seedling development from germination to flowering/fruitletting.

## **I. Introduction**

In the southeastern United States there is increased pressure on forest managers of privately managed lands to produce, in addition to forest products, other values such as wildlife habitat and bio-diversity. Longleaf pine forests were historically prevalent across the coastal plain and were regarded for their diversity but today have been largely replaced by monoculture pine plantations (loblolly, slash, or longleaf). Silvicultural practices to optimize and maximize plantation production are often perceived to be at odds with sustaining biodiversity. Hedman et al. (2000) addressed this issue in a study describing the relationship between understory plant species diversity and stands of different ages of loblolly, slash, and longleaf pine. They found that one significant (and negative) factor influencing understory species diversity and richness was if the stand had a history of being used for agriculture.

Stands in the Hedman et al. (2000) study were classified into two categories, benchmark and non-benchmark. Benchmark stands were those that contained species characteristic of relic longleaf pine/wiregrass communities. Non-benchmark stands were characterized as having fewer species of the relic longleaf pine/wiregrass communities and tended to have species more common to ruderal or disturbed sites. The authors suggested that plantation forestry “has the potential” to maintain a suite of native groundcover species on sites without a history of agriculture. They further suggested that manipulative experiments to evaluate the impacts of silvicultural practices on native vegetation persistence should be conducted.

Ten years after their study was completed we are now able to examine the impacts of silvicultural practices on native vegetation persistence. Of their 49 stands from the Hedman et al. study in 1995, 14 ranged in age from 1 to 5 years. Ten of those were classified as being benchmark stands and four were considered to be non-benchmark stands. We located and re-established plots in six of those stands (four benchmark and two non-benchmark); all of the stands comprising these plots had been subjected to typical, scheduled management practices since 1995. cursory observations indicated that the four stands originally classified as benchmark now appeared devoid of many of the plant species characteristic of benchmark sites such that the herbaceous component seemed to be similar in composition and abundance to non-benchmark stands.

The six stands with re-established plots were designated for operational thinning in 2006. For Phase II of the NCSSF Project C1 extension, we sampled these stands using the same plots and methodology as Hedman et. al, prior to thinning operations occurring. It is our intention to remeasure these plots post thinning to quantify the herbaceous and woody response to thinning. This sampling effort will enable us to (1) understand the response of understory species in benchmark and non-benchmark stands to ten growing seasons of overstory development and (2) document the response of herbaceous species to thinning in benchmark and non benchmark stands.

In addition to sampling understory species on the six stands, we sampled the soil seed bank from these stands and germinated the samples to determine potential species composition and abundance. The rationale for taking these samples was to assist in understanding the potential role that the seed bank could play during stand development with and without operational mitigation (Oliver and Larson 1996). If thinning to reduce basal area increases the potential for biodiversity as our modeling effort suggests (Zobrist, Hinckley et al. 2005), then it will be important to understand whether the vegetative response is primarily from the seed bank, existing understory vegetation, the sprouting of roots and rhizomes, and/or the influx of material from surrounding stands.

## **II. Purpose**

The purpose of Phase II of the Project C1 extension was to enhance the understanding of how species diversity changes with time as a result of dynamic stand development. The six stands were identified and ranged in age from 11 – 15 years old in 2005. In 1995 four of the stands had been designated as having benchmark characteristics and two of the stands had non-benchmark characteristics. In 2005, it appeared that the stands had similar herbaceous composition and condition regardless of their prior designation. This report summarizes the findings of the field data collected and the subsequent seed bank study conducted on these six stands. In the late -winter and spring of 2006 these six stands were commercially thinned and a prescribed burn will follow in the winter of 2007. It is our intention to utilize the findings from this study as baseline information for subsequent monitoring to compare the vegetation response to these treatments between the stands originally identified as benchmark or non benchmark.

The specific objectives of this study were to:

1. Provide quantitative data about the species composition and abundance from six stands in the stem exclusion (canopy closure) stage of development which, in the previous study (1995) had different understory characteristics (benchmark or non-benchmark), but today (2005) have similar herbaceous understory conditions.
2. Determine the composition of the seed bank of these six stands.
3. Provide baseline data from these results to be used in future post thinning studies.

This study was not designed to make conclusive inferences about dynamics of the understory vegetation but rather to provide a baseline for future research efforts and as such, our report will only provide summary statistics of the field and seed bank sampling efforts.

### III. Summary of Results

In 2005, there were between 9 and 17 different understory species found in each of the six different stands (Table 1). The mean for the benchmark (n = 4) and non-benchmark (n=2) were 12.75 and 14, respectively. Values for the seed bank ranged from 14 to 32 and the means were 22 and 29.5, respectively. In general, formerly benchmark stands had fewer understory and seed bank species than non-benchmark though the difference is likely not statistically significant.

**Table 1. Summary of stand attributes of 1m<sup>2</sup> sampled stands in 2005. BM = benchmark conditions in 1995 and NBM = non benchmark in 1995.**

Stand Attributes				
Stand #	Age 1995	Status 1995	Total # Species 2005 (1m <sup>2</sup> )	
			Field Study	Seed bank Study
30001001	4	BM	13	24
40001201	2	BM	11	22
40001601	4	BM	10	14
40004401	5	BM	8	28
40000602	4	NBM	11	27
40002401	1	NBM	11	32

#### 1. Findings of the field study

In all cases the herbaceous and woody understory percent cover decreased and the overstory basal area increased during the 10 year period between 1995 and 2005 (Table 4). For herbaceous cover, reductions averaged ~43% and ranged from ~18%.to as high as ~77% and. Understory woody cover also declined in all stands and ranged from ~3% to as high as 27% with the average of ~11%. In two of the stands the midstory basal area increased and in the remaining four stands the midstory basal area decreased. It is interesting to note that the greatest losses in herbaceous cover (>35%) were in the stands that were classified as “benchmark in 1995. This is not unexpected though as the average stand overstory basal area (28 m<sup>2</sup>/Ha), which is a function of average diameter and number of trees per hectare, values indicate that these stands near or are at crown closure and therefore there is very little sunlight reaching the forest floor. The actual values measured for each stand in 1995 and 2005 can be found in Appendix VI.

**Table 2. Summary of the change in cover and basal area measurements between 1995 & 2005 by plot per stand. Highlighted stands were classified as NBM in 1995.**

Stand Number	Herbaceous Δ Avg. % Cover 1m <sup>2</sup>	Understory Δ Avg. % Cover 10m <sup>2</sup>	Midstory Δ Avg. BA /100m <sup>2</sup>	Overstory Δ Total BA/ Ha
30001001	-77.1	-2.6	-0.0016	21.9
40000602	-17.6	-5.7	0.0066	28.7
40001201	-53.7	-6.7	0.0123	20.9
40001601	-46.6	-17.0	-0.0058	27.1
40002401	-24.1	-4.8	-0.0051	27.3
40004401	-38.5	-26.8	-0.0237	23.9

In addition stand structural changes in terms of abundances and density of species there were also notable changes in the numbers of species found between 1995 and 2005. Tables 3 & 4 list the number of species found in each stand by plot size and in general there were ~50% fewer total species identified in 2005 than were found in 1995 (123 vs. 64) and in particular, the number of herbaceous species declined by nearly 60% (87 vs. 35). The number of understory woody species declined while the number of midstory and overstory species increased in the same time period. This is to be expected as the smaller woody vegetation grew into larger size classes and some shade intolerant species were out competed as crowns closed and basal area increased.

**Table 3. Total number of unique species in all plots and number of species in each stand, 1995.**

	<b>Herbaceous # Species 1m<sup>2</sup></b>	<b>Understory # Species 10m<sup>2</sup></b>	<b>Midstory # Species 100m<sup>2</sup></b>	<b>Overstory # Species 1000m<sup>2</sup></b>	<b>Total # Individual Species</b>
<b>Total # Individual sp.</b>	<b>87</b>	<b>29</b>	<b>19</b>	<b>8</b>	<b>123</b>
Stand Number					
30001001	20	7	4	3	30
40000602	29	8	1	2	37
40001201	33	14	6	0	46
40001601	26	13	5	2	42
40002401	25	5	2	1	30
40004401	31	10	15	6	53

**Table 4. Total number of unique species in all plots and number of species in each stand, 2005.**

	<b>Herbaceous # Species 1m<sup>2</sup></b>	<b>Understory # Species 10m<sup>2</sup></b>	<b>Midstory # Species 100m<sup>2</sup></b>	<b>Overstory # Species 1000m<sup>2</sup></b>	<b>Total # Individual Species</b>
<b>Total # Individual sp.</b>	<b>35</b>	<b>16</b>	<b>20</b>	<b>17</b>	<b>64</b>
Stand Number					
30001001	13	10	4	5	26
40000602	11	7	8	6	26
40001201	11	9	7	5	24
40001601	10	10	5	4	22
40002401	11	6	8	9	26
40004401	8	7	8	8	24

The changes found in both the number of species and the abundances of species are not unexpected, however they do provide quantitative evidence that species biodiversity is dynamic and fluctuates on a temporal scale as the stand structure changes.

## 2. Findings of the seed bank study

To our knowledge there are only two other published seed bank studies from pine sites in the southeastern U.S. (Carrington 1997; Cohen, Braham et al. 2004). Carrington's study sites were in pine scrub in central Florida and Cohen et al.'s study sites were in longleaf stands (disturbed and undisturbed) of the Croatan National Forest in North Carolina. Because seed bank dynamics are poorly studied and understood, our study will help to establish a baseline of the seed bank under pine plantations in southwestern Georgia and the Florida panhandle.

From the seed bank samples 2910 individuals germinated representing 56 unique species. Approximately 50% of the total individual germinants were two species of *Gnaphalium* (*G. falcatum* (28%), *G. pensilvanicum* (22%)) (Table 5). These species are considered to be ruderal and while *G. falcatum* is native, *G. pensilvanicum* is not native. It should be noted in Table 5 the two non-benchmark stands, as classified by Hedman et. al in 1995, contained ~73% of the germinates (2131 individual seedlings).

**Table 5. Total number of germinants and species in the current 2005-2006 study.**

Stand Number	# Germinants	# Species
<b>Benchmark 1995</b>		
30001001	125	24
40001201	133	22
40001601	50	13
40004401	471	28
<b>Total BM</b>	<b>779</b>	<b>42</b>
<b>Non-Benchmark 1995</b>		
40000602	609	27
40002401	1522	32
<b>Total NBM</b>	<b>2131</b>	<b>42</b>
<b>Total (BM &amp; NBM)</b>	<b>2910</b>	<b>56</b>

Nearly 45% of the remaining germinates were from 15 species with a minimum of 1% representation (Table 6). Three individual germinates representing three species emerged from the 14 control trays. Of those three species, only one, *Carex atlantica*, was found in a sample tray. This germinant and species was excluded from the final data analyses as is a standard practice with seed bank studies (Cohen, Braham et al. 2004).

**Table 6. Number of germinants and percentage of total germinants by species from 120 soil seed bank samples. Note: species highlighted in green represent ~50% of all germinants and species highlighted in yellow represent ~45% of all germinants.**

Species	# Germinants	%	Species	# Germinants	%
<i>Acalypha gracilens</i>	32	1.1	<i>Helianthus angustifolius</i>	1	0.0
<i>Andropogon virginicus</i>	4	0.1	<i>Hypericum gentianoides</i>	48	1.6
<i>Asteraceae family</i>	2	0.1	<i>Hypericum hypericoides</i>	26	0.9
<i>Baccharis hamilifolia</i>	3	0.1	<i>Hypericum sp.</i>	5	0.2
<i>Bulbostylis ciliatifolia</i>	1	0.0	<i>Juncus dichotomus</i>	1	0.0
<i>Cassia fasciculata</i>	1	0.0	<i>Lactuca floridana</i>	2	0.1
<i>Conyza canadensis</i>	4	0.1	<i>Liatris sp.</i>	33	1.1
<i>Cyperus globulosus</i>	38	1.3	<i>Linaria canadensis</i>	111	3.8
<i>Cyperus retrorsus</i>	1	0.0	<i>Myrica cerifera</i>	1	0.0
<i>Cyperus sp. 1</i>	1	0.0	<i>Oxalis corniculata</i>	3	0.1
<i>Veronica peregrina</i>	1	0.0	<i>Panicum capillare</i>	2	0.1
<i>Dichanthelium acuminatum</i>	110	3.8	<i>Paspalum setaceum</i>	4	0.1
<i>Dichanthelium dichotomum</i>	28	1.0	<i>Phyllanthus urinaria</i>	2	0.1
<i>Dichanthelium ovale</i>	44	1.5	<i>Pinus sp.</i>	1	0.0
<i>Dichanthelium sp. 1</i>	3	0.1	<i>Polypremum procumbens</i>	34	1.2
<i>Dichanthelium sp. 2</i>	1	0.0	<i>Rhus copallina</i>	2	0.1
<i>Dichanthelium spaerocarpon</i>	49	1.7	<i>Richardia scabra</i>	1	0.0
<i>Digitaria ciliaris</i>	6	0.2	<i>Rubus sp.</i>	87	3.0
<i>Digitaria filiformis</i>	10	0.3	<i>Scirpus cyperinus</i>	2	0.1
<i>Erechtites hieracifolia</i>	1	0.0	<i>Scripus sp.</i>	1	0.0
<i>Erugrostis hirsuta</i>	2	0.1	<i>Solanum nigrescens</i>	2	0.1
<i>Eupatorium capillifolium</i>	140	4.8	<i>Solidago sp.</i>	1	0.0
<i>Eupatorium compositifolium</i>	141	4.8	<i>Trichostema dichotomum</i>	5	0.2
<i>Gnaphalium falcatum</i>	812	27.9	<i>Trichostema setaceum</i>	1	0.0
<i>Gnaphalium pensilvanicum</i>	649	22.3	<i>Triodanis perfoliata</i>	2	0.1
<i>Gnaphalium purpureum</i>	132	4.5	<i>Typha angustifolia</i>	1	0.0
<i>Gnaphalium spicatum</i>	11	0.4	UNK D	24	0.8
<i>Hedyotis bosicii</i>	1	0.0	UNK M	1	0.0
<i>Hedyotis procumbens</i>	10	0.3	<i>Whalengergia marginata</i>	268	9.2
			<b>TOTAL</b>	<b>2910</b>	<b>100.0</b>

## **IV. Approach**

### **Study Area**

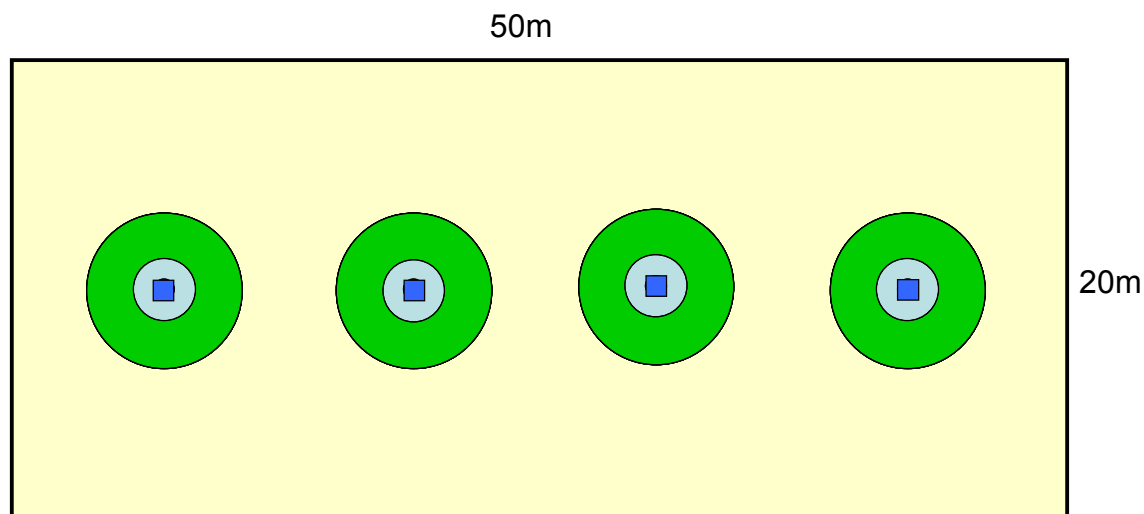
This study was conducted at International Paper's 6500-ha Southlands Experiment Forest (SEF) located in southwest Georgia and falls into the broad geographical area of the Gulf Coastal Plain. The study plots were located within the Dougherty Plain geologic formation which is characterized by soils that primarily belong to the Ultisol order (Hedman, Grace et al. 2000).

### **1. Field study**

Six plots from the Hedman et al. study in 1995 were located, re-established, and re-measured in November & December of 2005. It was a concern that the timing of this re-measurement was too late in the year and might not reflect the species composition and abundances found during the 1995 sampling which took place during the summer and fall of that same year. However, due to warm weather conditions and the fact that species numbers and abundances were low throughout the year because of stand conditions (crown closure), this concern appears to be unwarranted.

The plot design (Figure 1.) consisted of:

- 20 x 50 meter overstory plot – all trees > 2 cm DBH were measured (yellow). Within the overstory plot, there are four nested plots (4/plot) and within each there are three sampling scales:
  - 1 m<sup>2</sup> herbaceous plot – presence/absence herbaceous plants – visual estimates of % cover (blue)
  - 10 m<sup>2</sup> understory plot – presence/absence of all woody species < 1.4 m tall – visual estimate of % cover (light blue)
  - 100 m<sup>2</sup> midstory plot – presence/absence of all woody species < 2.5 cm DBH and ≥ 1.4 m tall – basal diameters measured. (green).



**Figure 1. Plot design for the 1000 m<sup>2</sup> overstory plots with nested plots for 1m<sup>2</sup> herbaceous (blue), 10m<sup>2</sup> understory (light blue) and 100m<sup>2</sup> midstory (green) strata.**

## 2. Seed bank study

Soil seed bank samples were collected in December 2005 and early January 2006 from the six permanent plots discussed above. Each plot contained four permanent nested plots spaced evenly (~12.5m) along the length of a 50m transect (Figure 1). Soil seed bank samples were collected using a soil profiler that extracted a 10cm x 2.5cm x 15cm section of soil. Soil seed bank samples were taken at the center point as well as in the four cardinal directions (3m from center), totaling five samples per nested plot, yielding 20 samples per plot for a total of 120 soil seed bank samples. Each seed bank sample was placed in a separate plastic bag, sealed, and brought back to the University of Florida-IFAS Plant City campus. All samples were stratified in a refrigerator (3.3° C) for one month to break dormancy (Whipple 1978; Leck 1989; Gross 1990)

In early February, soil samples were removed from the refrigerator and each one was placed in a 25cm x 25cm, 36 celled insert. The inserts were lined with ~2.5cm of sterilized soilless potting media consisting of 70% peat and 30% vermiculite. Each soil sample was distributed evenly across an insert at ~1cm in depth and care was taken to remove large vegetative matter (larger roots and leaves) and rocks. Fourteen control inserts were set up containing only potting media to track any seed contamination in the soil or greenhouse.

All samples and controls were placed randomly in a greenhouse (Cohen, Braham et al. 2004) and for optimal germination, greenhouse temperatures were set for a range of 15.5-26.6° C with day and night fluctuation (Young 1995; Hartman 1997). The greenhouse was equipped with an automatic temperature control system that utilized a 65% shade cloth as an energy conservation resource. Samples were kept moist by watering with a 1 gpm mist nozzle head attached to a hose.

All sample and control trays were monitored weekly, starting in February and monitoring ended after new germinates ceased to appear for one month. New germinates ceased to appear in late May and the study was terminated in late June. This five month observation period has been shown to be a suitable duration for seed bank studies since the majority of seeds will have germinated after two months (Warr, Thompson et al. 1993). When monitoring, colored toothpicks and code names were assigned to a germinant to: (1) distinguish between types of plants (monocots, dicots, and gymnosperms) and species, (2) acquire accurate counts of live and dead individuals per species, and (3) distinguish between old and new germinates. Seedlings were removed after they were positively identified or were transplanted for later identification and to free up space for new germinates. A representative of each species was photographed and pressed at several different stages for documentation of ontogenesis and for use as a reference guide to distinguish between species. All data were recorded and entered into an electronic database.

## **V. Deliverables**

As a result of the re-measurement of these stands and with additional analysis, we will submit the following manuscripts for publication:

- 1) The seed bank study manuscript will most likely be submitted to the journal *Restoration Ecology*. As there are so few publications describing the seed banks of pine stands in the southeastern U.S. this work will contribute to our understanding of the potential seed bank composition and how it might be managed as a source of herbaceous biodiversity.
- 2) The vegetation re-measurement will be submitted to the journal *Forest Ecology & Management* as a 10 year follow up to the original study. This publication and its research also provide the foundation for a study to be conducted in the future addressing vegetative response to thinning and burning on these same 6 stands. This will be a unique set of publications due to the fact that it is a long term ecological dataset occurring on intensively managed plantations.
- 3) Seedling development pictorial guide. As a result of the seed bank study, we photo-documented and tracked the development of many of the plant species from emergence of cotyledons to flower and in some cases fruit. Such a pictorial guide will benefit researchers and managers attempting to identify plants in their early developmental stages, as well as when they are not flowering and therefore are poorly addressed by existing dichotomous keys. This pictorial guide will be submitted for publication through the University of Florida's Electronic Document Information System (EDIS) and will be available for download via the internet.

The National Commission on the Science of Sustainable Forestry will be acknowledged on all publications as a result of the funding in support of this research effort.

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## VII. Appendices

### Appendix I. List of Participants: Field Crew

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## Appendix II. List of anticipated publications

1. The seed bank study manuscript will most likely be submitted to the journal *Restoration Ecology* by October 31, 2006.
2. The vegetation re-measurement will be submitted to the journal *Forest Ecology & Management* by December 31, 2006.
3. Seedling development pictorial guide will be submitted for publication through the University of Florida's Electronic Digital Information Source (EDIS) by the end of September 2006.

Appendix III. Presence of Vegetative Species Occurrence by Stand 1995.

Note: this species list is inclusive of all species found in 1000m<sup>2</sup> plots regardless if they met the measurement criteria of a given subplot.

Species Names	30001001	40000602	40001201	40001601	40002401	40004401
<i>Acalypha gracilens</i>		X				X
<i>Agalinis fasciculata</i>						X
<i>Agalinis sp</i>					X	
<i>Agratina aromatica</i>			X	X		X
<i>Ambrosia artemisiifolia</i>	X				X	X
<i>Ampelopsis arborea</i>						X
<i>Andropogon virginicus</i>	X	X	X		X	X
<i>Aristolochia serpentaria</i>		X				X
<i>Aristida stricta</i>	X	X	X	X		X
<i>Asclepias verticillata</i>			X			
<i>Asimina longifolia</i>		X	X	X		X
<i>Asimina triloba</i>	X					
<i>Aster adnatus</i>	X		X	X		X
<i>Aster concolor</i>			X			
<i>Aster dumosus</i>	X			X	X	
<i>Aster patens</i>						X
<i>Aster phyllolepis</i>				X		
<i>Aster tortifolius</i>	X	X		X		
<i>Baccharis halimifolia</i>					X	
<i>Baerlandiera pumila</i>		X	X			X
<i>Callicarpa americana</i>						X
<i>Cassia fasciculata</i>		X	X	X	X	X
<i>Ceanothus microphyllus</i>				X		
<i>Celtis occidentalis</i>						X
<i>Centrosema virginianum</i>		X		X		X
<i>Chrysopsis mariana</i>	X		X	X		
<i>Clitoria mariana</i>				X		
<i>Cnidoscolus stimulosus</i>		X			X	
<i>Commelina communis</i>		X				
<i>Conyza bonariensis</i>						X
<i>Conyza canadensis</i>			X		X	
<i>Conyza sp.</i>		X			X	
<i>Cornus florida</i>	X	X				
<i>Crataegus sp</i>	X					
<i>Croton argyranthemus</i>		X	X	X		X
<i>Crotalaria purshii</i>			X	X	X	X
<i>Crotalaria rotundifolia</i>		X	X	X		
<i>Cyperus sp.</i>					X	
<i>Desmodium ciliare</i>				X	X	
<i>Desmodium glabellum</i>					X	X
<i>Desmodium laevigatum</i>					X	
<i>Desmodium lineatum</i>				X	X	X
<i>Desmodium sp.</i>						X

Desmodium nudiflorum			X			
Desmodium tenuifolium					X	
Dichantherium aciculare					X	
Dichantherium sp	X	X	X		X	
Dichondra carolinensis						X
Dichondra sphaerocarpon		X				
Diodia teres		X	X			X
Diospyros virginiana	X	X	X	X		X
Dyschoriste oblongifolia	X	X	X	X		X
Elephantopus tomentosus	X	X	X	X		X
Erigeron strigosus			X			
Erigonum tomentosum		X	X			X
Eupatorium album			X			X
Eupatirium capillifolium						X
Eupatorium compositifolium	X	X	X		X	X
Eupatorium hyssopifolium	X	X			X	
Euphorbia pubentissima		X		X		X
Galactia erecta			X	X		
Galium hispidulum			X			X
Galium sp				X		
Galactia mollis			X			
Galium pilosum	X	X		X		X
Galactia volubilis			X			
Gaura angustifolia		X	X	X		
Gaylussacia dumosa			X	X		X
Gaylussacia frondosa var. nana				X		
Gelsemium sempervirens						X
Gnaphalium pensilvanicum		X			X	
Gnaphalium sp		X		X	X	
Gnaphalium spicatum	X		X			X
Gymnopogon ambiguous			X	X		X
Haplopappus divaricatus					X	
Hedyotis procumbens		X	X	X		X
Helianthemum carolinianum		X	X		X	
Heterotheca subaxillaris		X			X	
Hypericum cisifolium				X		
Hypericum crux-andreae			X			
Hypericum sp	X					X
Hypericum gentianoides					X	X
Hypericum hypericoides		X	X			X
Ilex sp.			X			
Ipomea pandurata	X					X
Lactuca graminifolia					X	
Lactuca sp.		X				
Lechea sp.		X				
Lechea minor			X	X		
Lechea mucronata			X		X	
Lespedeza angustifolia			X	X		

Lespedeza sp.	X					
Lespedeza repens	X	X	X	X	X	X
Lespedeza virginica			X			
Liatris aspera	X	X				X
Linum medium	X					
Lobelia puberula						X
Lonicera sempervirens						X
Lupinus villosus		X		X		
Lygodesmia aphylla		X				
Nyssa sylvatica	X					
Oxalis sp.						X
Panicum sp.	X	X	X	X	X	X
Passiflora incarnata						X
Paspalum pubiflorum		X			X	
Petalostemon pinnatum			X			
Phlox sp.				X		
Phlox pilosa			X			
Physalis sp.						X
Physallis viscosa		X	X	X		
Pinus palustris	X					
Pinus taeda	X	X	X	X	X	X
Piriqueta caroliniana						X
Pityopsis adenolepis	X		X			X
Pityopsis graminifolia	X	X	X	X		
Pityopsis sp.					X	X
Polygala grandiflora			X			
Polygala incarnata			X			
Polygala nana	X					
Polygala polygama	X			X		
Prunus angustifolia		X		X		X
Prunus serotina	X					X
Prunus umbellata						X
Petridium aquilinum	X		X	X		X
Quercus falcata	X	X	X	X	X	X
Quercus hemisphaerica		X		X	X	X
Quercus incana	X	X	X	X		X
Quercus laevis		X				
Quercus marilandica					X	X
Quercus nigra	X					X
Quercus pumila	X		X	X	X	X
Quercus sp.			X			
Quercus stellata			X			
Quercus virginiana						X
Rhus copallinum	X		X	X	X	X
Rhynchosia sp.			X			
Rhynchosia reniformis		X	X	X	X	X
Rhynchosia tomentosa		X				
Rubus argutus	X					

Rubus cuneifolius		X	X	X	X	X
Rubus flagerllaris				X		
Rubus sp.	X					
Rudbeckia hirta		X	X	X		
Ruellia caroliniensis		X	X	X		X
Sassafras albidum			X			X
Schrankia microphylla	X	X	X	X		X
Schizachyrium scoparium	X	X	X	X		X
Scleria reticularis		X				
Smilax bona-nox	X				X	X
Smilax glauca	X					X
Smilax smallii			X			X
Solidago canadensis	X				X	X
Solanum carolinense						X
Solidago odora	X	X	X	X		X
Sonchus asper		X				
Stillingia sylvatica				X		
Stylosanthes biflora	X	X	X	X		X
Stylodon carneus			X	X		
Stylisma patens		X	X	X		
Tephrosia florida		X	X	X	X	
Tephrosia sp.					X	
Tephrosia virginiana	X					
Toxicodendron toxicarium		X		X	X	
Tragia urens		X	X	X	X	X
Tragia urticifolia				X		
Trichostema dichotomum					X	X
Trichostema setaceum	X					
UNK01803					X	
UNK03490				X		
UNK04400		X				
UNK04540				X		
UNK04560				X		
UNK04631		X				
UNK05201				X		
UNK05211				X		
UNK05861					X	
UNK05862					X	
UNK06290			X			
UNK06510			X			
UNK10080	X					X
UNK10130	X					
UNK10863	X					
UNK11040			X			
UNK11044			X			
UNK11052.6				X		
UNK11060					X	
UNK11080						

UNK11091						X
Vaccinium arboreum	X	X	X	X		
Vaccinium darrowii	X		X	X		X
Vaccinium elliotii					X	
Vaccinium myrsinites						X
Vaccinium stamineum	X		X	X		X
Vernonia angustifolia	X	X	X			X
Viburnum rufidulum						X
Viola sp						X
Viola septemloba	X		X	X		X
Vitis cinerea		X				
Vitis rotundifolia					X	X
Wahlenbergia marginata		X				X
Total Individual Sp. by Stand	58	70	82	74	53	93

Appendix IV. Presence of Vegetative Species Occurrence by Stand 2005.

Note: this species list is inclusive of all species found in 1000m<sup>2</sup> plots regardless if they met the measurement criteria of a given subplot.

Species Names	30001001	40000602	40001201	40001601	40002401	40004401
<i>Acer rubrum</i>		X		X		
<i>Andropogon</i> sp			X		X	
<i>Andropogon virginicus</i>	X	X	X	X	X	X
<i>Aristida stricta</i>	X	X	X	X		
<i>Asplenium platyneuron</i>		X				
<i>Aster adnatus</i>	X					
<i>Aster carolinianus</i>			X	X		
<i>Aster tortifolius</i>	X					
<i>Crataegus marshallii</i>						X
<i>Carex</i> sp		X				
<i>Chamaecrista fasciculata</i>			X			
<i>Cirsium</i> sp	X					
<i>Clitoria mariana</i>		X				
<i>Clitoria</i> sp				X		
<i>Cornus florida</i>	X					
<i>Crataegus</i> sp		X	X		X	
<i>Crotalaria lanceolata</i>			X			
<i>Dichanthelium</i> sp	X	X	X	X	X	X
<i>Dichondra carolinensis</i>					X	X
<i>Diospyros virginiana</i>			X	X	X	X
<i>Elaeagnus umbellata</i>						X
<i>Elephantopus tomentosus</i>		X	X	X		
<i>Eriogonum tomentosum</i>			X	X		
<i>Eupatirium capillifolium</i>					X	
<i>Eupatorium coelestinum</i>				X		
<i>Eupatorium</i> sp		X	X			X
<i>Galium hispidulum</i>				X		X
<i>Galium</i> sp	X					
<i>Galium tinctorium</i> var <i>floridanum</i>		X		X		
<i>Gaylussacia dumosa</i>			X	X		
<i>Gelsemium sempervirens</i>		X			X	X
<i>Glechoma hederacea</i>					X	
<i>Gnaphalium pensilvanicum</i>			X			
<i>Hedyotis procumbens</i>	X	X	X			
<i>Hieracium gronovii</i>		X				
<i>Hypericum</i> sp	X	X	X	X	X	X
<i>Hypericum tetrapetalum</i>	X					
<i>Ilex opaca</i>					X	
<i>Ilex vomitoria</i>					X	X
<i>Juniperus virginiana</i>					X	
<i>Lactuca floridana</i>				X		
<i>Lupinus</i> sp		X				

Lygodium japonicum		X				
Myrica cerifera		X			X	X
Oxalis sp					X	
Panicum sp	X	X	X	X	X	X
Passiflora sp						X
Phlox pilosa			X			
Pinus elliotii	X					
Pinus palustris	X					
Pinus taeda	X	X	X	X	X	X
Pinus virginiana	X					
Pityopsis graminifolia	X	X	X	X		
Prunella vulgaris		X				
Prunus serotina		X				X
Prunus sp			X			
Prunus umbellata						X
Petridium aquilinum	X	X	X	X		X
Quercus hemisphaerica				X	X	X
Quercus incana	X	X	X	X	X	X
Quercus marilandica	X	X	X	X	X	X
Quercus nigra	X	X	X	X	X	X
Quercus pumila	X			X		
Rhus copallinum	X	X	X		X	
Rhynchospora plumosa	X	X		X		
Rhynchosia reniformis			X	X		
Rubus cuneifolius	X	X	X	X	X	X
Rudbeckia hirta				X		
Saccharum alopecuroidum	X					
Sassafras albidum						X
Scutellaria sp	X				X	
Smilax bona-nox	X	X	X	X	X	X
Smilax sp						X
Solidago arguta			X	X	X	
Solidago odora	X		X	X	X	X
Solidago sp	X					
Stewartia malacodendron						X
Tephrosia florida	X					
Toxicodendron radicans		X		X	X	
Unknown #01 (Monocot)					X	
Unknown #03 (Monocot)					X	
Unknown #04 (Dicot)					X	
Unknown #06 (Dicot)					X	
Unknown #08 (Dicot)				X		X
Unknown #11 (Dicot)				X		
Unknown #14 (Leguminosae)				X		
Unknown #17 (Leguminosae)				X		
Unknown #19 (Dicot)				X		
Unknown #20 (Dicot)				X		
Unknown #21 (Dicot)						X

Unknown #25 (Monocot)						X
Unknown #26 (Compositae)			X			
Unknown #35 (Compositae)	X					
Unknown #39 (Dicot)	X					
Vaccinium arboreum	X	X	X	X	X	X
Vaccinium myrsinites		X	X	X	X	
Vaccinium stamineum	X	X	X	X	X	X
Viburnum rufidulum		X				X
Viburnum sp						X
Viola sp	X		X	X		
Vitis rotundifolia		X			X	X
Total Individual Sp. by Stand	36	37	36	42	36	36

Appendix V. List of Species and Quantity of Germinants from Seed Bank Study 2005.

Species	Quantity of Species Overall and Per Stand						
	Overall Qty.	30001001	40000602	40002401	40001201	40001601	40004401
<i>Acalypha gracilens</i>	32	2	3	8	4	2	13
<i>Andropogon virginicus</i>	4	2	2				
Asteraceae family	2		1	1			
<i>Baccharis hamillifolia</i>	3						3
<i>Bulbostylis ciliatifolia</i>	1				1		
<i>Carex atlantica</i> †	1					1	
<i>Cassia fasciculate</i>	1				1		
<i>Conyza canadensis</i>	4		1	1	2		
<i>Cyperus globulosus</i>	38	3		28	2		5
<i>Cyperus retrorsus</i>	1		1				
<i>Cyperus</i> sp. 1	1	1					
<i>Dichanthelium acuminatum</i>	110	9		99		2	
<i>Dichanthelium dichotomum</i>	28	25			2		1
<i>Dichanthelium ovale</i>	44			37	1	3	3
<i>Dichanthelium</i> sp. 1	3	1		2			
<i>Dichanthelium</i> sp. 2	1						1
<i>Dichanthelium spaerocarpon</i>	49	1	1	45			2
<i>Digitaria ciliaris</i>	6		5				1
<i>Digitaria filiformis</i>	10		3	7			
<i>Erechtites hieracifolia</i>	1						1
<i>Erugrostis hirsuta</i>	2						2
<i>Eupatorium capillifolium</i>	140	9	9	75	8	4	35
<i>Eupatorium compositifolium</i>	141	8	10	75	9	5	34
<i>Gnaphalium falcatum</i>	812	21	125	489	34	14	129
<i>Gnaphalium pensilvanicum</i>	649	7	122	383	8	7	122
<i>Gnaphalium purpureum</i>	132	6	12	82	23	3	6
<i>Gnaphalium spicatum</i>	11	3		7		1	
<i>Hedyotis boscii</i>	1				1		
<i>Hedyotis procumbens</i>	10	1	2	1	1	3	2
<i>Helianthus angustifolius</i>	1	1					
<i>Hypericum gentianoides</i>	48	1	1	39	6		1
<i>Hypericum hypericoides</i>	26			1			25
<i>Hypericum</i> sp.	5			4	1		
<i>Juncus dichotomus</i>	1			1			
<i>Lactuca floridana</i>	2			2			
<i>Liatis</i> sp.	33	5	2	10			16
<i>Linaria canadensis</i>	111	3	44	47	9	1	7
<i>Myrica cerifera</i>	1		1				
<i>Oxalis corniculata</i>	3	1		1			1
<i>Panicum capillare</i>	2	1					1

<i>Paspalum setaceum</i>	4			1	3		
<i>Phyllanthus urinaria</i>	2		2				
<i>Pinus</i> sp.	1		1				
<i>Polypremum procumbens</i>	34	6	2	6	3	1	16
<i>Rhus copallina</i>	2			2			
<i>Richardia scabra</i>	1			1			
<i>Rubus</i> sp.	87	1	1	57	7	1	20
<i>Scirpus cyperinus</i>	2		1		1		
<i>Scripus</i> sp.	1		1				
<i>Solanum nigrescens</i>	2						2
<i>Solidago</i> sp.	1		1				
<i>Trichostema dichotomum</i>	5			3			2
<i>Trichostema setaceum</i>	1	1					
<i>Triodanis perfoliata</i>	2		2				
<i>Typha angustifolia</i>	1			1			
<i>Veronica peregrina</i>	1						1
<i>Whalengergia marginata</i>	268		244	5	6		13
UNK D	24*	6	8	1		3	6
UNK M	1*		1				
Total Number of Germinates	2911	125	609	1522	133	51	471
Total Species	57**	24	27	32	22	14	28

† This species was not used in the analysis as it appeared in a control tray.

\* 24 dicots and 1 monocot died before any other distinctive characteristics developed.

\*\*Total number of species does not include germinants from \* and is quantitative based on species occurrence in all stands. However, this value does include the germinant found in a control tray.

Appendix VI.

**Summary table of 1995 cover and basal area measurements by plot per stand.**

Stand Number	Herbaceous Avg.% Cover 1m <sup>2</sup>	Understory Avg.% Cover 10m <sup>2</sup>	Midstory Avg. BA /100m <sup>2</sup>	Overstory Total BA/Ha
30001001	96.9	8.4	0.0038	3.4
40000602	29.9	10.6	0.0005	5.2
40001201	59.1	11.5	0.0098	0.0
40001601	50.9	22.1	0.0070	2.4
40002401	27.6	9.9	0.0087	0.1
40004401	40.5	28.8	0.0251	4.9

**Summary table of 2005 cover and basal area measurements by plot per stand.**

Stand Number	Herbaceous Avg.% Cover 1m <sup>2</sup>	Understory Avg.% Cover 10m <sup>2</sup>	Midstory Avg. BA /100m <sup>2</sup>	Overstory Total BA/Ha
30001001	19.8	5.8	0.0022	25.3
40000602	12.3	4.9	0.0071	33.9
40001201	5.4	4.8	0.0221	20.9
40001601	4.3	5.1	0.0012	29.5
40002401	3.5	5.1	0.0036	27.4
40004401	2.0	2.0	0.0014	28.8