Inferring NATL Site History

By
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The Natural Area Teaching Laboratory (NATL) is one of numerous "natural areas" on the campus of the University of Florida. The area itself comprises 24.3 ha and was purchased from C. C. Richbourg as a part of a larger, 192-acre parcel of land by the State of Florida in 1944 (http://natl.ifas.ufl.edu/). Currently, NATL is divided into tracts corresponding to different management goals: old-field succession plots, hammock forest, upland longleaf pine forest with prescribed fire, upland longleaf pine forest without fire.

Little is known about the site prior to its purchase by the state. This project sought to shed light on the site's history using a variety of methods. The first of these methods entailed recording basic forest inventory data from existing, permanent plots within NATL. The second thrust of this project involved obtaining tree cores from dominant, longleaf and loblolly pines within the area and analyzing the tree rings to observe historic growth patterns and obtain dates of establishment. The third and final portion of this project was a soil study that sought to determine whether or not the soils within NATL had been plowed in its recent (<100 years) history. All components of the project focused only on forested areas in NATL-west. No work was conducted in the old-field succession plots or in the recent addition to the natural area, NATL-east.

Methods

Permanent Plot Monitoring

There are six, 20 x 20 meter permanent plots located within NATL (http://natl.ifas.ufl.edu/BtyPlots.gif). These plots were established in 1997, and stand inventory data has been collected on 10 October 1997, 27 September 2001, 28 February of 2003, and for this study in late February and early March of 2005 (http://natl.ifas.ufl.edu/BtyPlots.xls). One of these plots is situated in an area that is being managed to restore upland longleaf pine stands; the remaining five plots are within hammock or longleaf pine forests not subjected to fire management. Tree species, diameter at breast height (dbh), tree health, and tree crown class were recorded for all individuals within the plot measuring 10 cm or greater in dbh.

Dendrochronology

The data presented here are from cores obtained from a total of 18 trees. These trees were selected to be cored, because they were the largest (by diameter and height) representatives of their species to be found within the study area. Other factors leading to selection included dominant stature in the canopy and, for longleaf pines, flattened and full crowns indicating maturity.

Nine cores were taken from *Pinus palustris* trees; nine were from *P. taeda* individuals. At least two cores were taken from each tree to increase the likelihood of capturing all tree rings and to minimize the affect of false rings. The first core for each tree was taken at 40 cm from the base of the tree unless butt swell of the tree necessitated obtaining cores from further up the tree. When swell was an issue, cores were taken as close to the 40 cm from the base of the tree as possible (core heights ranged between 50 cm and 130 cm). The second core for each tree was then taken approximately 10 cm higher than the first core and 90 degrees around the trunk from the first core.

All cores were dried, mounted and sanded to aid in ring measurement. Rings were then visually counted and widths were measured with a ruler to the nearest 0.25 mm. Where possible, i.e., when the core contained the center of the tree, the ages of trees were established directly. When direct age measurement was not possible, ages were estimated based upon the approximate radial distance not captured by the tree core (tree diameter/2-length of the core) and the comparable growth rates for individuals of the same species over the years that were not captured.

Table 1. Locations of cored pine trees.

Tree Code	**Species Code**	**Plot**	**Location within Plot**
PpC10	Pipa	C10	17 m 190^o SW of stake D10
PpE5	Pipa	E5	Lone tree 8 m north of Main Trail
PpE4a	Pipa	E4	8 m N of Gridline 5, 0.5 m W of path separating old field plots from longleaf pine plots
PpE4b	Pipa	E4	18.46 m, 140^o SE of stake E4
PpD4	Pipa	D4	20 m S, 13.84 m E of stake D4
PpD6	Pipa	D6	10 m N and 32.31 m E of stake D7
PpD7	Pipa	D7	7.69 m S and 27.69 m E of stake D7
PpC11	Pipa	C11	~25m S of stake D11, along E edge of permanent plot
PpD11	Pipa	D11	5.15 m SE (95 deg) of stake D11
PtH6a	Pita	H6	6m W (270 deg) of East Trail and 37.5m SW (195 deg) of Main Trail
PtH6b	Pita	H6	51.5m N of Division Trail and 1 m W of East Trail
PtG10	Pita	G10	31.5 m S and 36 m W of stake H10
PtH6c	Pita	H6	40 m S of Main Trail and 1.5 m W of East Trail
PtH6d	Pita	H6	36 m S of Main Trail and 26 m W of East Trail
PtG6	Pita	G6	27 m SW (190 deg) of tree PtH6d
PtG8	Pita	G8	On S edge of Division Trail and 38 m W of East Trail
PtE7	Pita	E7	23 m N and 42 m E of stake E8
PtE8	Pita	E8	12.3 m S of Division Trail and 7.69 m E of the trail connecting Gasline and Division Trails

For estimating the ages of *P. palustris* trees, an additional seven years was added to the number of annual rings observed on the cores. Upon germination, longleaf pines will persist in a grass stage, during which photosynthates will be allocated to below ground growth and only a tuft of needles will be visible at the surface. The grass stage persists for roughly 7 years and is an adaptation to the high fire return interval of longleaf pine systems.

A high number of loblolly cores were taken from quadrat H6 due to the unusually high density of *P. taeda* individuals in this area of NATL. The locations of all cored trees are presented in Table 1.

Soils

Six, 1.5 m-deep soil pits were dug and examined for the presence of a plow (Ap) layer. An Ap layer can be identified by its roughly homogenous texture and color, depth (Ap layers are approximately 15 cm deep, or the length of a plow blade) and the strikingly abrupt margin between it and the subsequent soil horizon. Information obtained from the field was complemented with data from a previous study conducted within NATL by Dr. Mary Collins in 1999.

Results

Permanent Plot Monitoring

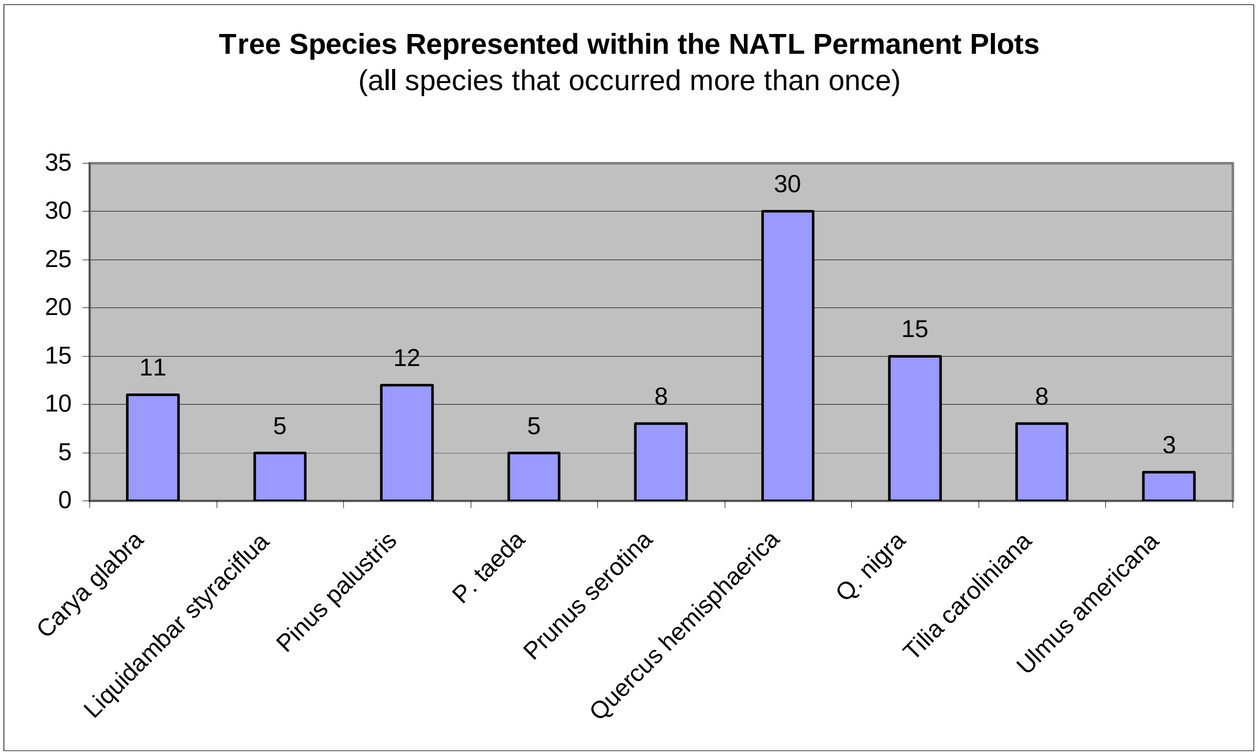
Figure 1 presents the number of trees with dbh greater than 10 cm inventoried within the six, 20 m x 20 m monitoring plots. Across all plots, *Q. hemisphaerica* is the most frequently occurring species with twice as many individuals as the next most abundant, *Q. nigra*. Regeneration across all plots is skewed toward these thinner-barked hammock species as well. There were only seven new recruits (i.e., were smaller than 10 cm dbh during previous inventories but were greater than 10 cm dbh during this study): three *Q. hemisphaerica*, three *Carya glabra*, and one *Q. nigra*. There were no new recruits in the longleaf restoration plot.

Growth rates of the trees are fairly consistent with what is known of their individual ecologies. Annual growth rates for each individual tree were calculated by the equation:

$$\frac{\text{(diameter Feb/Mar 2005 – diameter October 1997)}}{7.5}$$

Average annual growth rates by species were calculated by summing the individual annual growth rates for each species and then dividing that by the number of individuals of each species.

Figure 1.



The growth rate for *Q. hemisphaerica* is presented both for all individuals and separately for suppressed individuals and individuals of all other crown classes. Perhaps most surprising is the relatively high growth rate of *P. taeda* (only *Q. hemisphaerica* was faster) despite competition from hammock species (Table 2). These growth rates, however, should be observed with caution. Rates varied greatly as is depicted by their standard deviations. Site conditions and competitive pressures are strongly variable within the permanent plots.

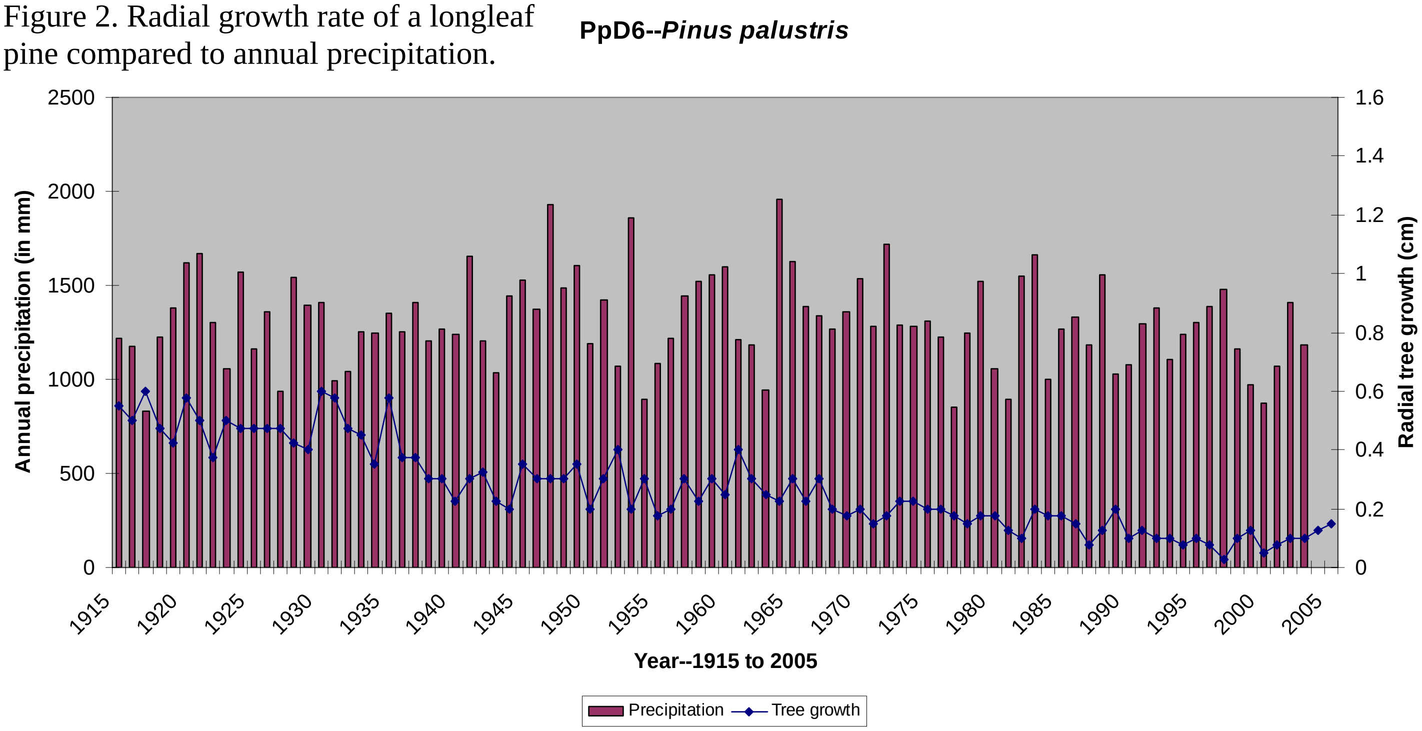
Table 2. Annual growth rates calculated from permanent plot data.

Species	Average annual growth	Standard deviation	New Recruits
Quercus hemisphaerica (all)	0.36	0.30	3
Quercus hemisphaerica (crown classes other than suppressed)	0.5	0.34	3
Q. hemisphaerica (crown class = suppressed)	0.17	0.28	0
Q. nigra	0.23	0.19	1
Pinus palustris	0.16	0.12	0
P. taeda	0.31	0.17	0
Carya glabra	0.22	0.15	3

Dendrochronology

The oldest longleaf pine that could be directly aged had 91 annual rings. Adding a seven year grass stage, this tree is estimated to be 98 years old (Figure 2; note that the tree code, PpD6 refers to the species and its quadrat location). There was a dip in its growth rate in 1937 that never fully returned to pre-1937 levels. The growth rate remained within the same range thereafter until around 1962, at which time it steadily declined until it reached its minimum in 1998.

Figure 2. Radial growth rate of a longleaf pine compared to annual precipitation.



Note: Precipitation data was not available for the years 2004 and 2005.

The range of ages, directly or indirectly determined, for all longleaf pine trees cored was from 57 to 98 years old (Table 3). All but one are at least 76 years of age. The growth rates of all of these trees have been steadily declining over their lives (Appendix I). The calculation of year of germination includes the seven year grass stage. Excluding PpC10, which is in hammock, none of the cored trees have germinated since 1922.

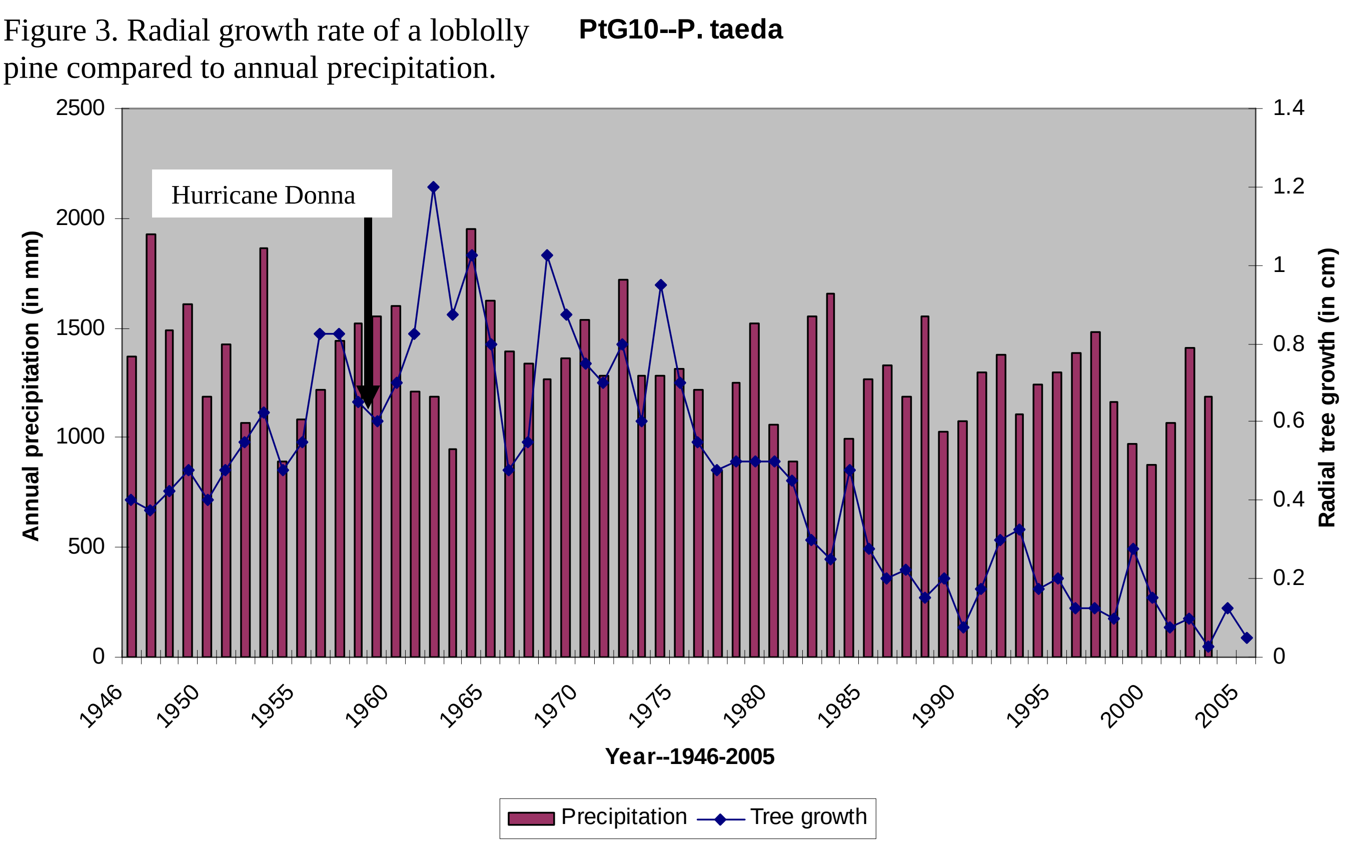
It is worth noting that with exception of trees PpC10, PpE4b, and PpD11, all of which are outside of the longleaf pine restoration area, all longleaf pines have experience relative increases in their annual growth rates within the last several years (Appendix I). These trees appear to be responding to fire management. Also, while not uniform among all trees, some individuals appear to have responded to hurricane disturbances with sharp increases in growth the two or three years after the disturbance (Appendix I).

Table 3. **Determined ages of *Pinus palustris* trees**

Tree	*Dbh (cm)*	*Age Direct*	*Age Indirect (# rings counted)*	*Year of Germination*
PpC10	44.6	57	---	1941
PpE5	67	---	93 (64)	1905
PpE4a	51.5	---	84 (74)	1914
PpE4b	46.1	84	---	1914
PpD4	64.4	---	98 (82)	1900
PpD6	52.2	91	---	1907
PpD7	55.2	77	---	1921
PpC11	61.1	76	---	1922
PpD11	49.7	84	---	1914

The oldest loblolly pine aged by ring count was 52 years old. Figure 4 depicts the annual growth rate of PtH10 in relation to annual precipitation. Of interest is the decrease in growth for two years after 1958 and then a spike in growth for the next three years beginning in 1961 (Figure 3). The core taken from this tree had a scar in its eleventh year (1958) growth ring, indicating that it had been damaged. This would account for the slight dip in growth during 1959 and 1960. The growth spike of 1961-1963 is possibly due to Hurricane Donna in 1960. While local records do not indicate that Hurricane Donna, whose eye passed well east of Gainesville, resulted in significant storm damage

Figure 3. Radial growth rate of a loblolly pine compared to annual precipitation.



Precipitation data from http://www.coaps.fsu.edu/climate_center/prcpdat/gainsv.html; data for 2004 and 2005 was not available.

(i.e., fallen trees), it is possible that the increase in precipitation relative to the preceding few years associated with the storm resulted in the observed accelerated growth. Several of the other loblollies show similar growth increases around this time (Appendix II).

The ages of cored loblollies ranged from 42 years to 112 years. This 112 year-old tree is by far the largest of the loblollies and suffers from heart rot. It is located just south of Division Trail in quadrat G8 and evinces characteristics of a wolf tree, a tree that grew in a wide clearing with no other nearby trees to induce self-pruning.

Table 4.	**Determined ages of *Pinus taeda* trees.**			
Tree	*Dbh (cm)*	*Age Direct*	*Age indirect (# rings counted)*	*Year of Germination*
PtH6a	49.1	49	---	1957
PtH6b	49.5	42	---	1964
PtG10	79.4	---	78 (60)	1928
PtH6c	43.2	47	---	1959
PtH6d	50.8	52	---	1954
PtG6	66.2	---	60 (52)	1946
PtG8	85.2	---	112 (62)	1894
PtE7	59.1	---	46 (42)	1960
PtE8	51.8	44	---	1962

Looking at the remaining loblollies, the majority fall within the range of 42 to 60 years old and are situated in roughly the same area between Gasline and Main Trails. The 78-year old loblolly is further from this central group and grows closer to the southeastern corner of NATL, an area characterized by sinkholes and moister soils (Collins 1999).

Soils

Ap horizons were found in two of the six soil pits (Appendix III). Charcoal was also present in the soil profile of soil pit 5 in quadrat D6. This evidence of past fire is undoubtedly reflective of fire management efforts begun in 1996. The remaining four pits evinced no definite Ap layer.

Of the soils mapped by Dr. Collins, only one type found earns a "prime farmland" rating by the Soil Survey of Alachua County (USDA 1985). This is the Micanopy formation (MI in Appendix IV) found in three small pockets. This soil type, however, is prime farmland only if drained. For vegetables and small fruit, Millhopper (M) is also well suited. Both Sparr (S) and Millhopper are well suited to some pasture grasses (USDA 1985).

Discussion

Dr. Collins found NATL to house a "complexity of…landscapes and associated soils" (Collins 2000, p. 22). I find this to be true of the site history of the area as well. Data indicate that sections within the current extent of NATL have been cleared on at least two separate occasions within the last century and one half.

One clearing event would have occurred at the end of the 1800s. Evidence supporting the likelihood of this scenario is the presence of at least three wolf trees within NATL. These trees; the 112 year old loblolly pine, a 77.3 cm dbh pignut hickory in quadrat H10, and a 73.0 cm dbh longleaf pine in A8; are all located south of Division Trail. The extent of the clearing is, therefore, unclear with the exception that it included the area between Division and Gasline Trails. Interestingly, the two Ap layers I found were also in this area. The evidence supports the notion that this land was cultivated after it was cleared at the end of the 19th century. It is also likely that this was the last time NATL-west was cultivated for crop production.

Both the ages of cored loblollies and aerial photos indicate that a second, independent clearing event occurred sometime between 1937 and 1949. Aerial photographs suggest that the more recent clearing event extended from the area north of Division Trail to the southwestern corner of what now defines the NATL boundary. Vegetation is clearly present in the southeastern section in both the 1937 (Appendix V) and 1949 (Appendix VI) photographs. Given the karstic topography of that section, it is likely that this area has always supported hammock species and has not been cleared for any agricultural purposes.

The fact that no Ap layers were found north of Division Trail does not necessarily exclude the possibility of farming after the mid-20th century clearing (Collins, pers. comm.). Ap layers do deteriorate with time, and heterogeneous soil types would lead to differential rates of soil mixing and development. I believe it is more likely, however, that some other soil-disturbing land use followed the circa 1940 clearing. For instance, soil disturbance associated with a timber harvest and/or grazing could render Ap layers less visible.

Data support the hypothesis that the part of the area that appears from the aerial photos to have been cleared was deforested for its timber. The average time it would have taken for the six longleaf pine trees whose ages could be directly determined (n=6) to reach merchantable size (dbh = 30cm) was 31 years. The average year of germination for the nine, cored longleaf pines was 1915. On average, then, the *P. palustris* trees present within NATL today would have been below merchantable size in 1945 and thus would have been left to grow to their current sizes. The selective removal of larger longleaf pine trees around 1940 would explain the sizes and ages of longleaf pines presently within NATL and the persistence of longleaf pines due to a perpetual seed source.

Soil disturbance associated with such a small harvest is likely to have been minimal. Because Ap layers are not visible north of Division Trail, it may be that some other land use subsequent to the timber harvest further disturbed the soil thus rendering Ap layers that would have been present from cultivation at the turn of the century less visible. Using the area as pasture would be just such a land use. It would also help to explain why area beyond the extent of longleaf pine habitat would have been cleared around 1940.

Thus I believe the immediate site history for NATL-west prior to its purchase by UF to be as follows:

1. Larger-scale clearing for crop production around 1900; the area cleared would have included most of what is now NATL-west with the exception of the karstic, southeastern corner.
2. Smaller-scale clearing (extent as indicated by aerial photographs in Appendices V and VI) for longleaf pine timber sale (western portion of cleared area) and pasture around 1940;
3. 1944: UF purchases the property.

Since their establishment, both the longleaf and loblolly pines have experienced disturbances. Hurricanes in 1928, 1935 and 1960 all appear to have promoted relative accelerated growth during the years immediately following the storms. This could be due to decreased competition because of hurricane-induced mortality among competing trees or higher than average precipitation. Given that there are a number of trees with records of these events in their growth patterns, none of these events were catastrophic (i.e., cleared virtually the entire landscape) in intensity.

The damage scar found in tree PtH10 is indicative of yet another disturbance event. Since similar scars were not observed in other cores, it is likely that this was a small-scale event, possibly an individual lightning strike that did not become a fire. Another possibility is that a small fire did burn in 1958 because of activities associated with the construction of the adjacent Surge Area, which would have been taking place in the late 1950s.

It is clear from the permanent plot data and experience that in the absence of management, hammock species will encroach into the longleaf pine areas and eventually displace the *P. palustris*. *Q. hemisphaerica* is particularly effective in its regeneration, whether it is under hammock or longleaf pine canopies. This is a fast growing species and accounts for the majority of new recruits in the permanent plots. Evidence of its rapid growth was also captured by one core taken from a 48.8 cm-dbh individual within quadrat C10 of NATL; this tree was only thirty-two years old.

Limitations of this Study and Suggestions for Future Work

One clear limitation of the study presented here is that the sample sizes of cored trees are quite small. Also, the trees cored were neither systematically nor randomly selected. Thus, one suggestion for future research is to expand the current study. The first step would be to do a thorough cruise of NATL-west and identify all of the longleaf and loblolly pines within the property boundaries. Ideally, their locations could be recorded via a global positioning system. Then, cores could be taken in a more comprehensive and systematic way. For instance, one tree from each grouping of trees of the same species could be cored, if trees were found in a clumped distribution, as appears to be the case with the loblolly pines. The “representative” tree from each group could be selected randomly, or researchers could choose to core the tree they deem to be the most dominant.

NATL is a small enough area that permanent monitoring plots could be set up in all of the forested grid quadrats. I suggest that an ecosystem or forestry measurements class be designed and offered every other year or so that could establish and continually collect data from the plots. Students would learn basic forest inventorying skills, plant identification and ecosystem management. They could learn about basal area, species stocking curves, species area curves, forest regeneration and light regimes, and much more related to forest ecology.

The exact content of the course could vary each time it was offered. For example, one spring the class could be offered such that it coincided with prescribed burns within NATL. The class could learn fire ecology and set up monitoring plots in which fuels could be quantified and post-fire effects could be measured. These would be compared with control plots. Other studies could measure forest floor insolation related to species composition, nutrient cycling, decomposition rates, etc. These would be semester-long projects devised for small groups of students formed from the class. The forests of NATL, like its soils, are heterogeneous. A course created around measuring and monitoring that heterogeneity would benefit not only the students but could greatly add to the knowledge of the site.

Should another hurricane occur, or should management dictate the removal of trees within NATL, a project seeking to establish allometric equations relating tree diameter to canopy and/or tree biomass would be interesting. The creation of allometric equations, however, is a destructive process that would remove nutrients in the form of tree biomass from the sites. Such a project should thus coincide with natural events and/or management goals.

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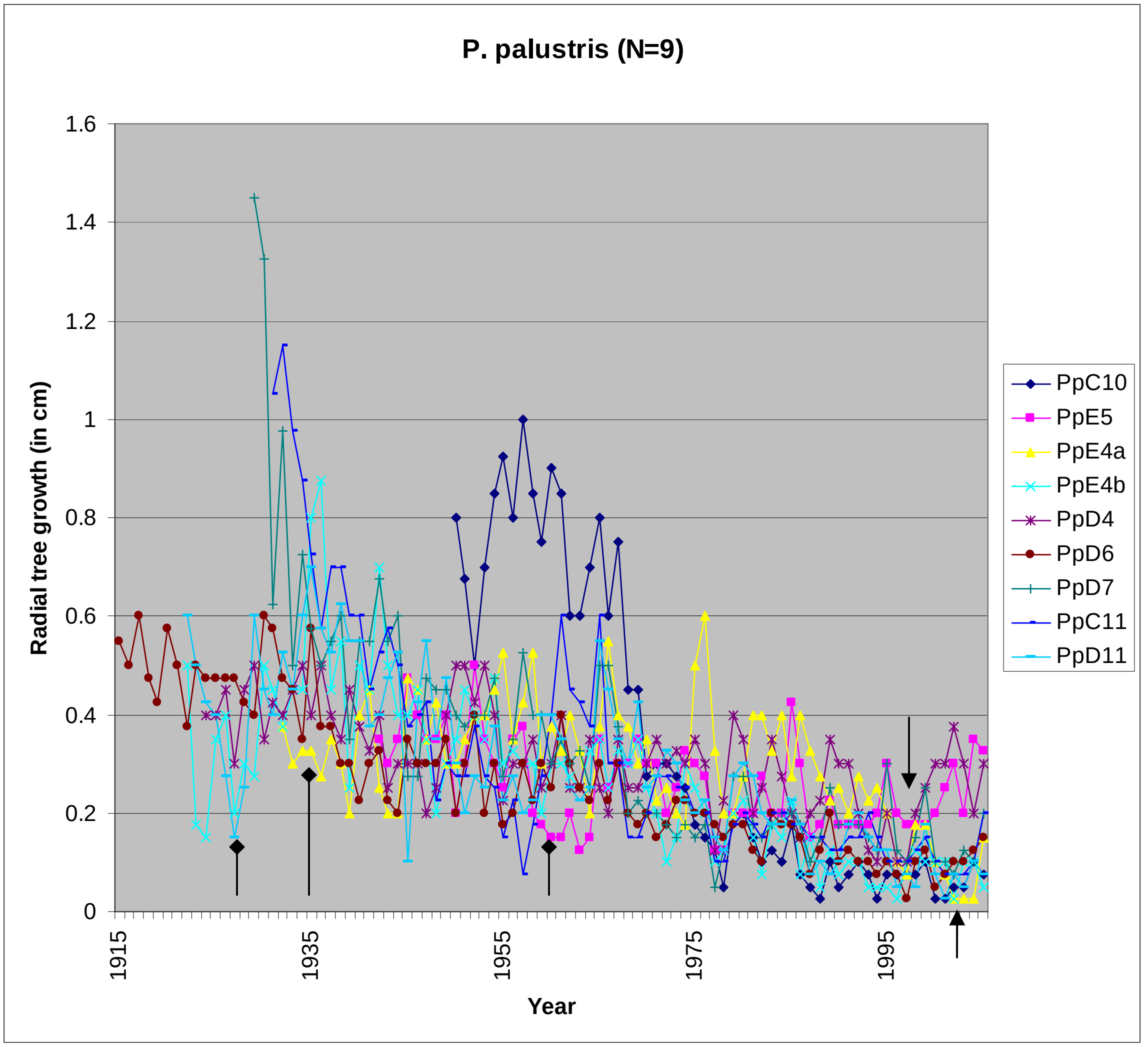
References

Collins, M.E. 2000. Detailed Inventory of Soil Resources: Natural Area Teaching Laboratory. Preliminary Report. http://natl.ifas.ufl.edu/PSoilRpt.htm.

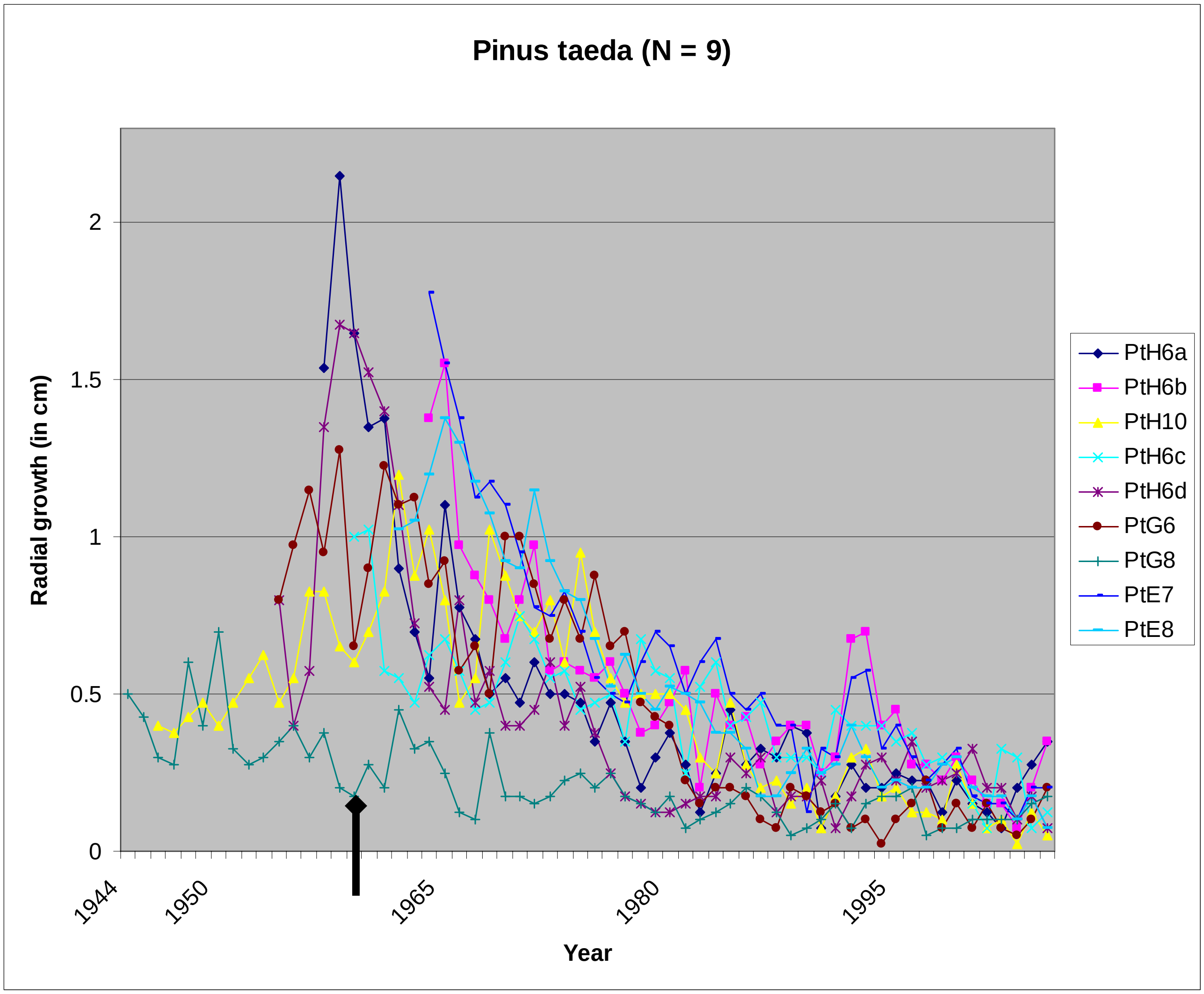
USDA (United States Department of Agriculture) Soil Conservation Service. 1985. Soil Survey of Alachua County Florida.

Appendix I
Annual Growth Rates of All Longleaf Pines Cored



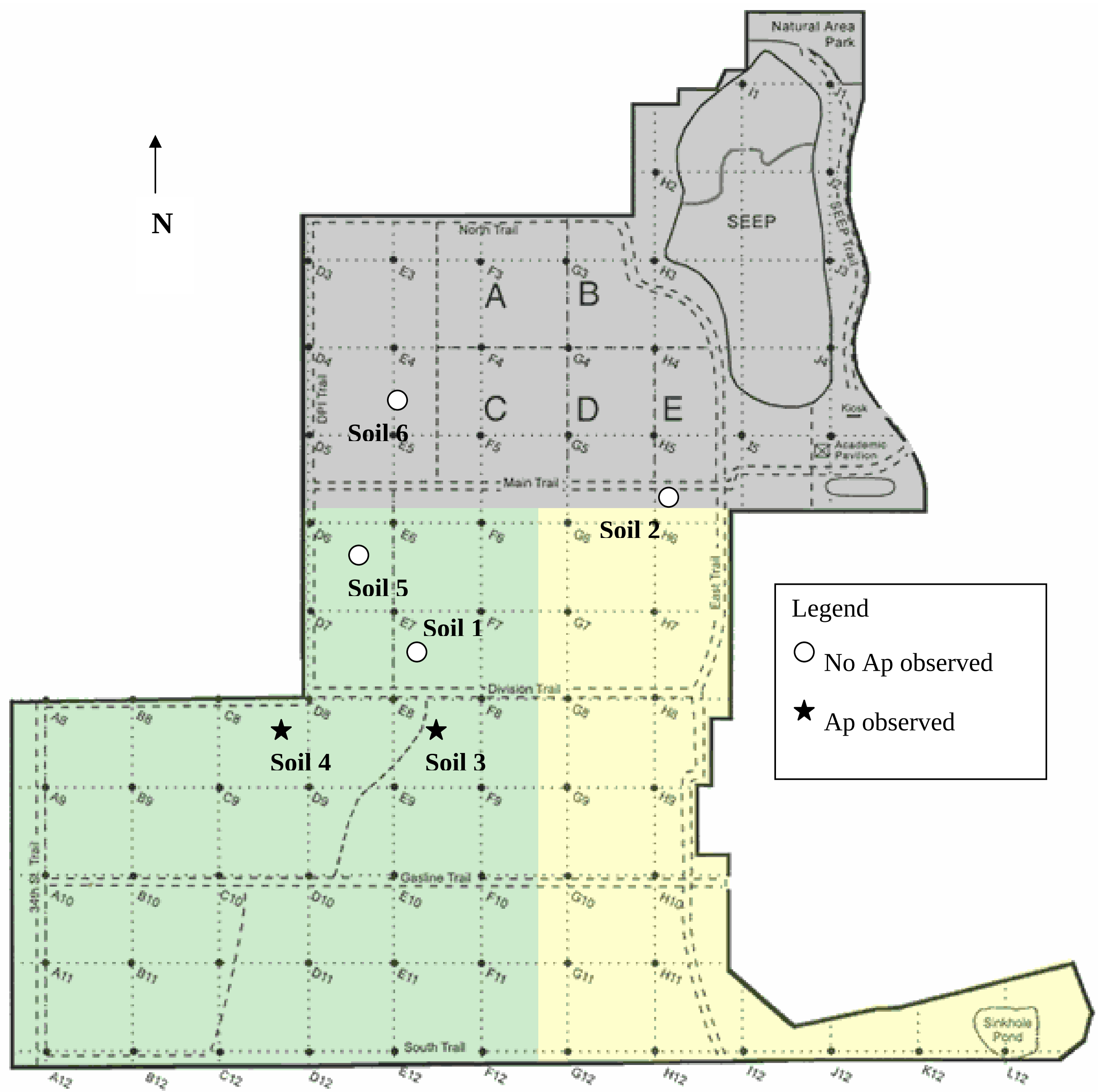
Note the relative increase in annual growth rates of longleaf pines as indicated by the arrows. Diamond tipped arrows indicate the 1928 Okeechobee Hurricane, 1935 Florida Keys Labor Day Hurricane and 1960 Hurricane Donna. Hurricane data from http://www.southcom.mil/usag-miami/sites/hurricane/hurricane_history.asp.

Appendix II
Annual Growth Rates of All Loblolly Pines Cored

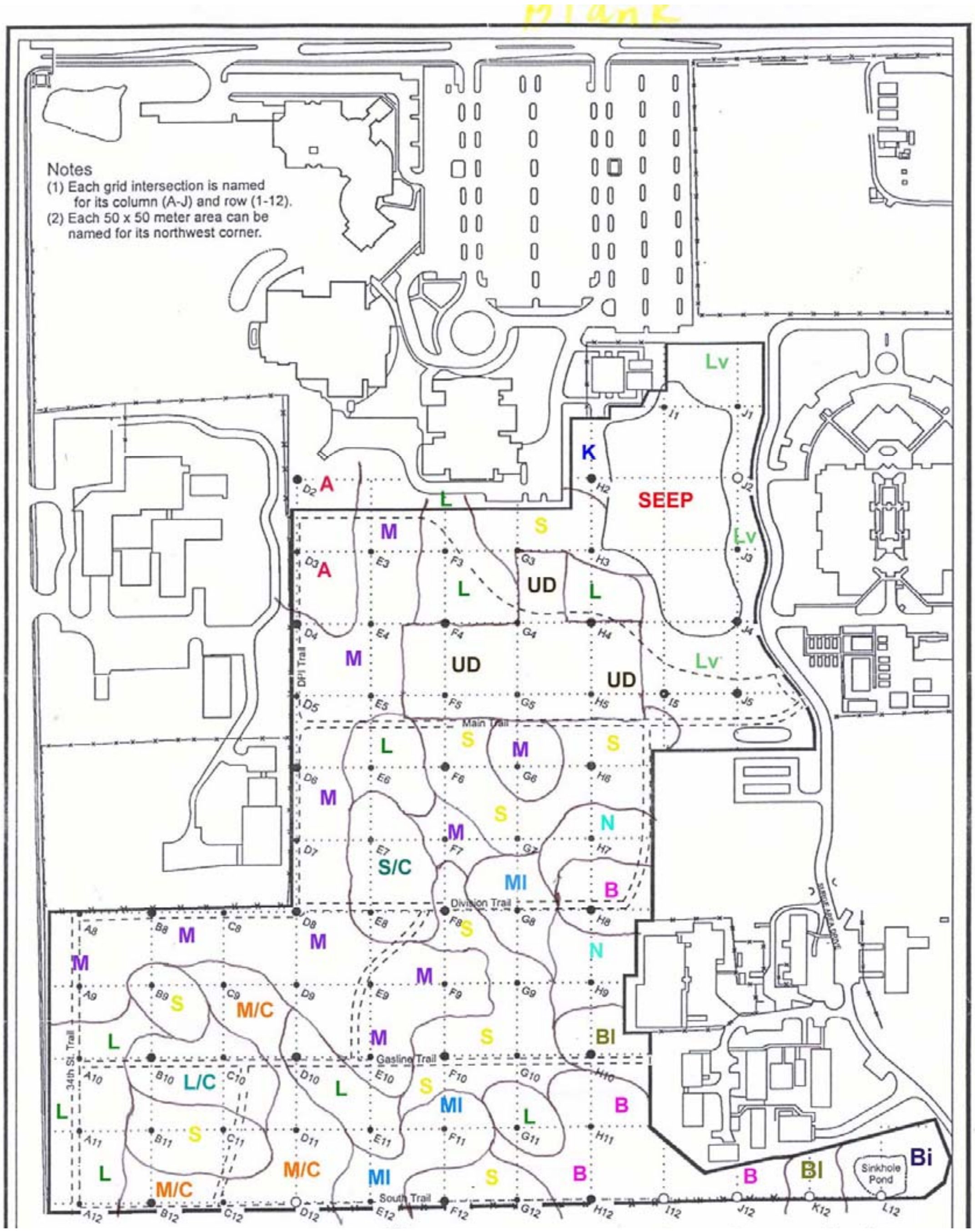


Note the growth spike shown by most individuals after Hurricane Donna, indicated by the diamond tipped arrow.

Appendix III
Map of Soil Pits



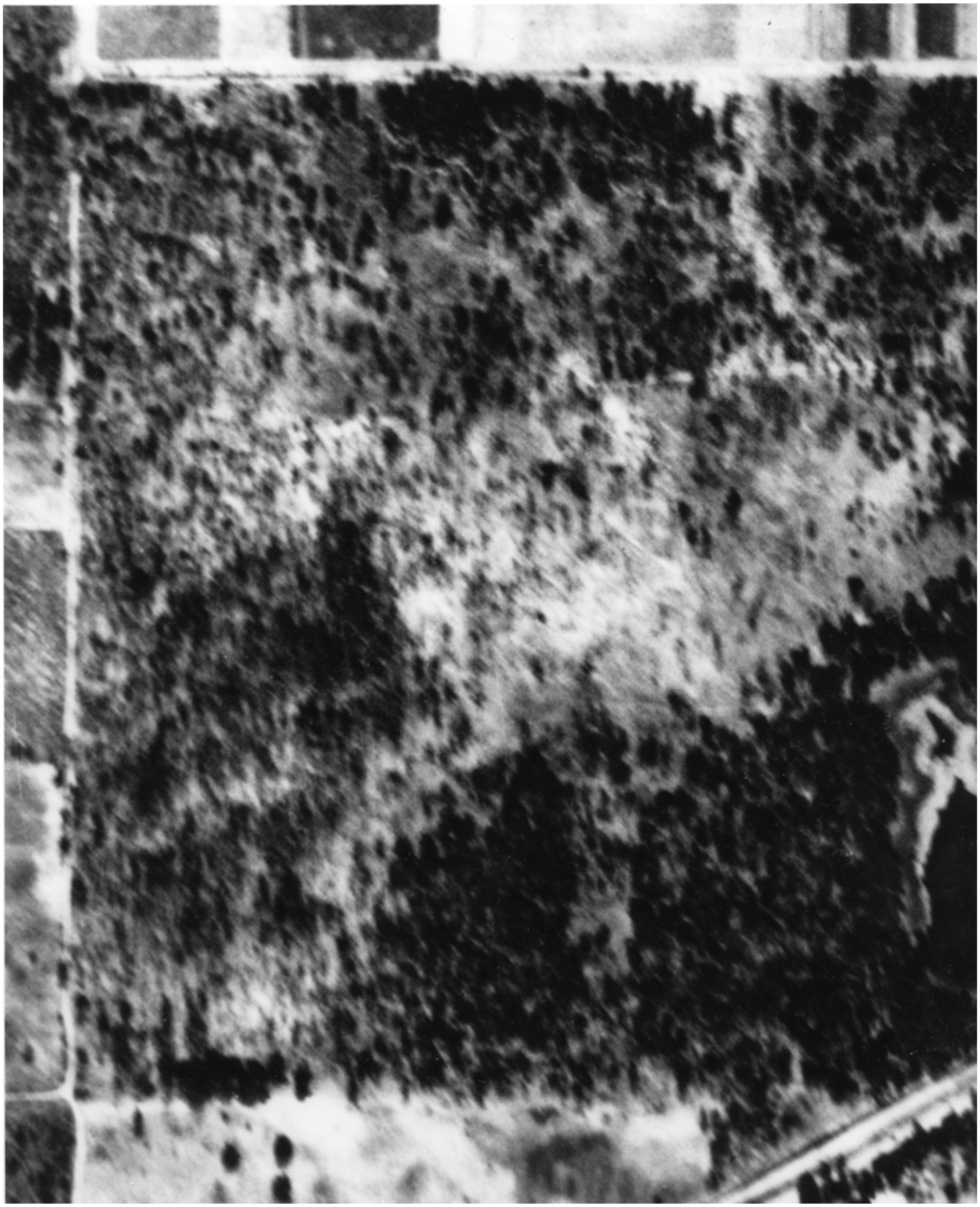
Appendix IV
Soil Map of NATL (from Collins 2000)



Legend

A = Arrendondo
B = Bibb
Bi = Bivans
Bl = Blichton
K = Kanapaha
L = Lochloosa
L/C = Lochloosa, clayey subsoil phase
Lv = Lochloosa, thin surface variant
M = Millhopper
M/C = Millhopper, clayey susoil phase
MI = Micanopy
N = Nobleton
S = Sparr
S/C = Sparr, clayey subsoil phase
Ud = Udorthents

Appendix V
1937 Aerial Photograph



Appendix VI
1949 Aerial Photograph

Note the scarce vegetation in the southwest corner as compared to the 1939 aerial photograph.