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PREFACE

IMPAC is an acronym for Intensive Management Practices Assessment Center, a cooperative venture between the University of Florida, the U.S. Forest Service, and forest industry. The Center is evaluating the effects of intensive forest management practices (such as clear cut harvesting, site preparation, and planting) on an array of forest resources (including water, understory vegetation, soil, and wildlife) for the major site types of the slash pine ecosystem. Our objective is to provide information that aids land managers in perpetually improving the forest resource, and assists regulatory agencies in preventing environmental degradation.

Because of the preeminent importance within the ecosystem of the flatwoods site type, our own initial experimental installations are within flatwoods forests belonging to Container Corporation of America and the University of Florida. In response to the Federal mandate to protect water from nonpoint sources of pollution, water quality considerations are given high priority, and one experimental approach involves paired watersheds subjected to pretreatment calibration.

IMPAC REPORTS are issued periodically, and voluntary contributions are encouraged. Submitted manuscripts should be relevant to management of the slash pine ecosystem. Succinct and readily comprehensible papers concerned with the ecological and environmental effects of intensive management are especially welcomed. Submitted manuscripts are reviewed by members of an Editorial Board selected by the Editors. Accepted Reports are ordinarily published within 30 to 75 days. Recommendations on preparation of manuscripts appear inside the back cover of this Report.

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Influence of Pine Forest Removal on Flatwood Soil Temperature and Moisture Conditions[1/]

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ABSTRACT

Soil temperatures and moisture regimes were investigated in a mixed slash (Pinus elliottii Engelm, Var. elliottii)--long leaf (Pinus palustris Mill.) pine flatwood forest in north Florida at 0, 5, 10, 20 and 50 cm depths. Measurements were taken in three site conditions: undisturbed; harvested and burned; and harvested, sheared, chopped and bedded sites on the two dominant soil series in the area--Electra and Wauchula. Maximum site preparation area had the highest soil temperature followed by the minimum site preparation and then the undisturbed control areas. Mean minimum temperatures were higher in the control followed by maximum and minimum preparations. Regarding depth, high maximum temperatures occurred at surface followed by 10, 20 and 50 cm. The opposite occurred in relation to mean minimum temperature.

1/Research conducted at a site initially established by CRIFF (Cooperative Research in Forest Fertilization) and currently jointly supported by IMPAC.
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Soil moisture regimes were also characterized on the two soil series with three site conditions at four soil depths. There were significant differences in soil moisture regime between the two soils, with soil moisture higher in the Wauchula than the Electra soil. The maximum site preparation area possessed higher moisture contents followed by minimum site preparation and the control. The soil at 50 cm depths possessed significantly higher soil moisture, followed by soil at 5, 10 and 20 cm depths.

METHODS AND MATERIALS

Study Area

The study area was established about 16 km northeast of Gainesville, Florida, near Waldo Road (State Highway 24) in the Austin Cary Forest, a property of the University of Florida. The study area was a typical northeast Florida mixed longleaf-slash pine flatwoods. The soils have been described as imperfectly drained sands of the lower coastal plain flatwoods, and Electra and Wauchula (See Appendix) are the two dominant soil series in the area. The climate is characterized by an average rainfall of about 1229 cm and the range over the period 1962-1972 was 814 mm to 1956 mm. Average maximum temperature for January was 20.5 C and the minimum 7 C. For July, the average maximum was 32.7 C and the average minimum 21.6 C. Frost in December through February was not unusual, but there were only about 150 hours per year where the temperature was below 0 C (Kaufman, Pritchett and Choate, 1977).

Study Area Treatment

The study area was split across the two Spodosol soil series (See Appendix for descriptions)Electra and Wauchula, and included three site conditions; control area (undisturbed forest), maximum preparation area and minimum preparation area. The treatment of the maximum preparation was by use of K-G blade (bulldozer blade set at an angle) shearing stems and stumps at the groundline after clearcut forest harvesting, chopping with drum cutters, and bedding. The minimum preparation site was treated by burning the debris remaining after clearcut harvesting.

METHODOLOGY

Temperature

Two stations were established on Electra soil, one in the control area and the other in the clearcut area. The station in the clearcut area was between the maximum and minimum preparations areas so that sensors could be extended into each preparation area. The station in the control area, was equipped with three mechanical soil thermographs and the station in clearcut areas was equipped with a YSI 11-point thermistor temperature recording system.

Mechanical thermographs consisted of a 30 m steel flexible capillary with a rigid cylindrical bulb, 20 cm in length, 2.54 cm in diameter, containing the temperature sensitive mercury element at the end of the capillary. The range of sensitivity was between -17 to 43 C. Response time was 5 minutes. The instruments were temperature calibrated throughout the experimental period.

Instruments were placed in wood shelters painted white with natural ventilation. The instruments were calibrated before being put in the field and the calibration was based on a set of specified values assigned by international agreement. The temperature ranges were between 0 and 50 C. and was checked weekly with a secondary standard thermometer in the field.

Soil temperatures were taken at the surface, 10, 20 and 50 cm depths. Surface temperatures were measured by putting the mechanical soil thermograph probe in the horizontal position covered with about 1 cm of forest floor (litter) material. Soil temperatures at 10, 20 and 50 cm were measured by burying soil thermograph probes at these depths in the mineral soil.

Average soil temperature values at the different depths were computed from soil thermograph charts that were changed weekly.

A YSI 11-point telethermometer manufactured by Yellow Spring Instruments, model 46A was connected to a YSI-80 series automatic recorder, which recorded in succession temperatures of all thermistors probes. A period of 60 minutes, five minutes between successive points,was required for the instrument to print a complete cycle of temperatures. Four thermistor probes at surface, 10, 20 and 50 cm were used to measure soil temperatures in each site preparation (maximum and minimum) areas.

The thermistor probes used were the following: surface temperature stainless steel probes adjusted to 100 C and with a time constant of 1.7 sec; general purpose temperature probes with vinyl material and with a time constant of 7 sec (these probes were used at 10 and 20 cm soil depths); tubular pointed metal stainless steel probes adjusted to 150 C with a time constant of 3.7 sec (used at 50 cm soil depth). All probes were checked with a second standard thermometer before connecting to the telethermometer.

Soil temperature values from different depths were computed from telethermometer charts that were changed every 15 days. Soil temperature data in the clearcut areas were interrupted when there were equipment failures in the course of the experiment. Because of practical limitations, no replications in space were made for temperature data in each site.

Soil temperature data for the experimental analysis were based on values of maximum and minimum, for each depth and each site, where observations were made.

Data reported here were obtained to determine the effect of site preparation on soil temperature regime. Input data came from control, maximum and minimum preparation sites at 0, 10, 20 and 50 cm in the

Electra soil, during the period from September to October 1977. The instruments used to measure soil temperature have differences in accuracy and response time (YSI is more accurate and faster in response time) but these were assumed to be of little significance. A factorial 3 x 4 design was employed to analyze the effects of three site preparations and four soil depths in the Electra soil.

A second objective was to determine the effect of soil series on soil temperature. Input data came from control areas at surface (0) and 20 cm in Electra and Wauchula soils during November and December 1977. A factorial 2 x 2 design was used to analyze the data.

Moisture data

Measurements of soil water content were made at 5, 10, 20 and 50 cm soil depths, during the period from July to December 1977. Surface moisture was not measured because the soils near the surface dry quickly regardless of the treatment.

Soil water content was determined by the gravimetric method and expressed on oven dry (105 C) basis. The soil samples for this determination were from the two soil series, Electra and Wauchula, on the control, maximum and minimum preparation sites. An aluminum soil tube was used to take samples at different depths. Care was taken to avoid loss of water by evaporation during the sampling process by placing the soil in aluminum cans and sealing immediately. This prevented loss of water while samples were transported to the laboratory. Numbers were recorded on the cans corresponding to locations and respective depths to provide accurate identification. The vapor that condensed on the inside of the can was weighed and included in the water determination. The samples were weighed after each drying to constant weight in an oven at 105 C. The samples taken at depth of 0-5 cm were considered to be representative of 5 cm layer. The samples from 5-15 cm were taken at corresponding to the 10 cm, and samples from 15-25 cm and from 45-55 cm were taken as corresponding to the 20 and 50 cm layers, respectively.

Moisture content comparisons were made to determine the effect of soil, site preparation and soil depth on soil moisture. Input data came from control, maximum and minimum preparation sites at 5, 10, 20 and 50 cm in Electra and Wauchula soils during July to December, 1977. A factorial 2 x 3 x 4 design was used to analyze the effect of soil series, site preparation and soil depth on soil moisture.

RESULTS AND DISCUSSION

Effect of Site Preparations and Soil Depth on Soil Temperature Regime

Soil temperatures were significantly different among the site preparations (Table 1). The maximum preparation area had higher mean maximum temperature (28.7 C) followed by minimum preparation (27.7 C) or the control (27.4 C). The latter two means for temperature were not significantly different. Mean minimum temperatures were higher in the control area (24.2 C) as compared to the temperature on the maximum (21.3 C) or the minimum site (21.2 C) preparations. This resulted because more radiation reached the soil surface in the clearcut areas, while in the undisturbed area the vegetation was more effective in decreasing the influx of heat during the day and preventing radiation losses at night. The maximum prepared area possessed less vegetation and was exposed to more radiation; thus this condition had higher maximum temperatures.

Similar effects of site treatment on minimum soil temperature were also observed by Shultz (1976) on a flatwoods site in north Florida. He found at 2.5 cm below the soil surface, the maximum temperature increased with site preparation intensity -- control < burn < disc < bed treatments.

In relation to depths the highest mean maximum temperature (33.5 C) occurred at the surface followed by that at 10, 20 and 50 cm depths. The opposite occurred for the mean minimum temperatures as the highest temperatures (23.5 C) were at 50 cm. (Table 2)

Table 1. Mean temperatures of forest soil in three site conditions. (September - October, 1977)

Variable	Undisturbed Control	Site Preparations Minimum	Maximum
	Temperature(C)		
Mean Maximum	27.4 (B)	27.7 (B)	28.7 (A)
Mean Minimum	24.2 (A)	21.2 (B)	21.3 (B)

Means followed by the same letters are not significantly different ($\alpha = .05$).

Table 2. Temperatures at four depths in forest soil. (September - October, 1977)

Variable	Depth (cm) 0	10	20	50
	Temperature (C)			
Mean Maximum	33.4 (A)	27.7 (B)	25.5 (C)	25.1 (C)
Mean Minimum	20.1 (C)	22.2 (B)	23.1 (A)	23.5 (A)

Means followed by the same letters are not significantly different ($\alpha = .05$).

This shows that the temperature variation is considerable in the upper soil layers and that practically no temperature variation occurs at 50 cm depth. The temperature variation is of course greatest during the summer long days when more direct radiation causes incoming radiation to be greater in the daytime.

Analyses of variance for minimum temperatures showed significant interactions between site preparations and soil depths (Table 3). Mean minimum temperature at all depths were higher in the control (undisturbed forest) than in the clearcut prepared sites, especially at the surface and 10 cm. The mean minimum temperatures within each site averaged about 2 C cooler at the surface than at 10 cm in all areas.

At the surface, mean maximum temperature was higher (34.8 C) under maximum site preparation followed by the control or the minimum site preparation treatment. Rapid invasion by the groundcover vegetation and the shading by this vegetation and residual debris in the minimum preparation site probably accounts for the minimum soil temperatures in this site being similar to that of the control.

Maximum temperatures at 10, 20 and 50 cm were in the order: control < minimum preparation < maximum preparation. The differences in maximum temperature observed below the surface, however, failed significance tests. Only the higher maximum temperature at the surface of the maximum prepared site was significantly different. Intensive preparation left the surface exposed to more incident radiation.

Table 3. Temperatures at four depths in forest soil in three site conditions. (September - October, 1977)

	Undisturbed Control		Site Preparation			
			Max. Preparation		Min. Preparation	
Depth(cm)	Max.(C)	Min.(C)	Max.(C)	Min.(C)	Max.(C)	Min. (C)
0	32.9	23.5	34.8	18.2	32.7	18.6
10	26.9	25.2	28.6	20.9	27.4	20.5
20	24.9	24.0	26.1	22.6	25.4	22.4
50	24.8	24.0	25.3	23.1	25.2	23.1

Effect of Soil, Site Preparation and Soil Depth on Soil Moisture Regime

Soil moisture regimes for the two soil series (Electra and Wauchula), in three site conditions (control, minimum site preparation and maximum site preparation) and at four soil depths (5, 10, 20 and 50 cm), were determined during July to December, 1977. The analysis of variance showed there were significant differences in moisture regime between soils and site preparation but not for soil depths (Table 4). The interaction between soil moisture and site preparation was significant. However, interactions between soils and depth; and site preparations and depths were not significant. Also, the three-way interaction was not significant. Average soil water content was higher (14.1 vs 11.8%) in Wauchula than Electra. The maximum site preparation area possessed higher moisture content (15.9%) than the minimum site preparation (13.2%) and the control (9.8%). The presence of vegetation probably caused moisture reductions in the minimum prepared and control sites.

In general, there were relatively small differences in soil moisture contents between the 10 and 20 cm depths (Table 5). In the control area on Electra soil, moisture content at 50 cm depths differed little from the 10 and 20 cm depths. In the Wauchula soil, the control area had higher soil moisture at the 5 cm and at 50 cm. This pattern was typical of that for both soils when site prepared. At 50 cm soil depths, the moisture content was considerably greater in Wauchula than in the Electra soil except in maximum preparation plots. Maximum site preparation on the Electra soil was associated with higher soil moisture contents at all depths. This pattern was not apparent on the Wauchula soil.

Table 4. Mean soil moisture (%) under forest soils at three site conditions. (July - December, 1977)

Soil	Moisture (%)	Site Preparation	Moisture (%)	Depth (cm)	Moisture (%)
Wauchula	14.1 (A)	Maximum	15.9 (A)	50	15.5 (A)
Electra	11.8 (B)	Minimum	13.2 (B)	5	14.6 (A)
		Undisturbed Control	9.8 (C)	10	11.7 (B)
				20	10.0 (C)

Means followed by the same letters are not significantly different (α= .05).

Table 5. Mean soil moisture content (%) for four depths, site preparations, under two forest soils. (July - December, 1977

Depth (cm)	Undisturbed Control	Site Preparation Minimum	Maximum
		Electra	
5	12.9	10.6	14.4
10	9.2	9.3	15.4
20	6.1	8.0	12.7
50	8.6	14.5	20.4
		Wauchula	
5	11.8	20.6	17.5
10	8.5	13.4	14.7
20	7.1	12.1	13.9
50	14.0	17.3	17.9

Under minimum site preparation on the Wauchula soil, the moisture content for all soil depths were considerably greater than at corresponding depths on the Electra soil especially at 5 cm. The moisture content in Wauchula followed the order 5 >50 >10 >20 cm while in Electra the order was 50 >5 >10 >20 cm. Soil moisture on the control sites at 5 cm depths, in comparison with other areas at the same depths, always had the lowest soil moisture contents while the maximum site preparation area always had the highest soil moisture contents.

Possible explanations for the soil moisture differences found among the soils and treatments are:

1. Transpirational losses in the control area which supported an undisturbed forest stand contributed to the drier conditions occurring on those sites. Clearcutting the forest removed most vegetative cover thus lessening soil moisture losses by transpiration. Apparently the maximum site preparation was more effective in reducing moisture loss in this way on the drier Electra soil.

2. Water tables provide a source of free water. Proximity to the water table probably accounts for the generally higher moisture content at 50 cm than at other sub-surface depths. The fine-textured B-horizon which restricts downward water flow was nearer the soil surface in the Wauchula soil causing the soil to remain wetter longer.

3. Organic matter at the 5 cm depth was more abundant than at deeper depths. Since organic matter has a high affinity for water, this is the probable cause of the higher water content at this depth. Although soil organic matter contents were not determined, forest cutting and site preparation apparently increased the organic matter content and soil moisture retention -- perhaps by incorporation of harvesting debris.

SUMMARY AND CONCLUSIONS

Site disturbance effects on soil temperature and moisture regimes were studied in slash-longleaf pine flatwoods using un undisturbed stand and two clearcut harvested and site prepared areas. Two intensities of preparations were used on each of two soils -- Electra and Wauchula. Effects of site preparation on soil temperature at various soil depths were determined from measurements using mechanical soil thermographs and a YSI 11-point thermistor temperature recording system during the period September through October, 1977.

The undisturbed control area, minimum site preparation and maximum site preparation areas were monitored at the soil surface and at 10, 20 and 50 cm depths. This investigation showed the maximum site preparation area to have the highest soil temperatures followed by the minimum site preparation and then the undisturbed control areas. Mean minimum temperatures were higher in the control followed by maximum and minimum preparations. Regrading depth, high maximum temperatures occurred at the soil surface,decreasing with depth. The opposite occurred in relation to mean minimum temperature. These results show that canopy removal by clearcut forest harvesting followed by intensive site preparation results in significant alteration of the soil micro-climate.

Effects of soil type and associated site preparation on soil moisture for various soil depths were evaluated. Soil moisture was analyzed by gravimetric procedures during the period from July to December, 1977. Results showed a significant difference in moisture regimes between soils and between site preparations. Soil water content was higher in the Wauchula than in the Electra soil. The area treated with maximum site preparation had higher soil moisture which was followed by the minimum prepared undisturbed areas. For depths, the 50 and 5 cm soil samples had higher(but nonsignificant)soil moisture contents than those from 10 and 20 cm depths. Higher contents at these levels were probably associated with organic matter in the surface and the water table near 50 cm. Factors that may account for differences among various treatments were; 1) plant transpiration probably caused the low moisture contents in the undisturbed control area, 2) water table proximity probably accounted for the higher moisture contents of the Wauchula soil, and 3) organic matter content at shallow depths was higher than at 10 and 20 cm.

The conclusion that can be drawn from this study is that canopy removal by clearcut harvesting followed by intensive site preparation results in increases in soil temperature, especially on the maximum prepared site, and soil moisture content especially on the drier Electra soil. This micro-climatic alteration should have effects on plant growth, organic matter decomposition, nutrient release, metabolic activity and composition of the microbiotic populations because soil temperature and moisture content are the primary environmental variables influencing soil processes.

APPENDIX

Description of Wauchula and Electra Soils

Soil Profile Description

Electra Series

The Electra series consists of somewhat poorly drained, slowly or very slowly permeable soils formed in sandy and loamy marine sediments on slight ridges in flatwoods areas in the Coastal Plain. The subsoil and the lower part of the subsurface is saturated in summer and early in the fall. Water runs off the surface slowly. Slope ranges from 0 to 5 percent.

Taxonomic Class: Sandy, siliceous, hyperthermic Arenic Ultic Haplohumods.

Typical Pedon: Electra fine sand--forested.
(Colors are for moist soil unless otherwise stated.)

A1--0 to 7 inches; gray (10YR 5/1) fine sand; weak medium granular structure; very friable; many fine and medium roots; few coarse roots; extremely acid; clear smooth boundary. (2 to 8 inches thick)

A21--7 to 47 inches; white (10YR 8/1) fine sand; few fine distinct grayish brown (10YR 5/2) streaks along root channels; single grained; loose; common fine and medium roots and few coarse roots decreasing to common medium roots below about 24 inches; sand grains are uncoated; strongly acid; abrupt wavy boundary. (28 to 46 inches thick)

B2h--47 to 60 inches; dark reddish brown (5YR 3/2) find sand; few coarse distinct dark brown (10YR 4/3) mottles near base of horizon; massive; friable; few fine roots; sand grains well coated with colloidal organic matter; very strongly acid; clear wavy boundary. (7 to 18 inches thick)

B2tg--60 to 80 inches; light brownish gray (2.5Y 6/2) fine sandy loam; many course distinct dark grayish brown (10YR 4/2) streaks; weak medium subangular blocky structure; friable; common medium dead and few fine live roots; sand grains bridged and coated with clay; very strongly acid.

Type Location: St. Lucie County, Florida; about 8.5 miles south of Fort Pierce; 0.1 mile west of U. S. Highway 1; 0.15 mile south of Banyan Road; and 400 feet east of cable line trail; NE1/4NE1/4 sec. 27, T. 36 S., R. 40 E.

Range in Characteristics: Solum thickness is 60 or more inches. It ranges from extremely acid to strongly acid in all horizons.

The A1 or Ap horizon has hue of 10YR or N, value 4 to 6, chroma 1 or less. The A2 horizon has hue of 10YR, value 5 to 8, chroma 1 or 2. The A horizon is sand or find sand. Total thickness of the A horizon ranges from 30 to 50 inches.

The Bh horizon has hue of 5YR, value 2 or 3, chroma 1 or 2; hue of 10YR, value 2, chroma 1 or 2; hue of N, value 2, chroma 0; or hue of 7.5YR, value 3, chroma 2. It is sand or fine sand.

Some pedons have a thin, soft transitional horizon between the A2 horizon and Bh horizon that has hue of 10YR, value 3 or 4, chroma 1, or value 5, chroma 2. It is sand or find sand with many clean grains. Some pedons also have a B3 horizon that has hue of 10YR, value 4, chroma 2 to 4. It is sand or fine sand and 0 to 5 inches thick.

Some pedons have an A'2 horizon in hue of 10YR, value 5 to 7, chroma 1 to 3. It is sand or fine sand.

The Btg or B'tg horizon has hue of 10YR, value 5 to 7, chroma 1 or 2, or value 4, chroma 3 or 4; or hue of 2.5Y, value 6 or 7, chroma 2 to 4 with mottles in shades of gray, yellow, red, or brown. It is fine sandy loam, sandy loam, sandy clay loam, or light sandy clay.

Some pedons have a B'3 horizon that has hue of 10YR or N, value 5 or 6, chroma 1 or less with mottles of higher chroma. It is sandy clay.

Competing Series: There are no competing series in the same family. Other closely related competing series are the Cassia, Immokalee, Oldsmar, Pomello, Pomona, and Wauchula series. Cassia, Immoklee, and Pomello soils do not have argillic horizons beneath the spodic horizon. In addition, Cassia soils have a spodic horizon at depths of less than 30 inches. Immokalee, Oldsmar, Pomona, and Wauchula soils are poorly drained. Oldsmar soils have an argillic horizon with base saturation of more than 35 percent. Pomona and Wauchula soils have spodic horizons within depths of 30 inches.

Geographic Setting: Electra soils are on slight ridges in central and southern Florida. Slopes are dominantly 0 to 2 percent but range to 5 percent. Near the type location mean annual precipitation is about 55 inches and is heaviest in the summer. Mean annual temperature near the type location is about 74^{o}F.

Geographically Associated Soils: These are the closely related Cassia and Pomello series and the Adamsville Candler, Myakka, Pompano, and Tavares series. Adamsville, Candler, and Tavares soils are on higher ridges and lack spodic and argillic horizons. Myakka soils are poorly drained, lack argillic horizons, and the spodic horizon is within depths of 30 inches. Pompano soils are on lower elevations, and lack a spodic horizon.

Drainage and Permeability: Somewhat poorly drained; slow runoff. Permeability is rapid in the A horizons and moderate in the Bh horizon and slow to very slow in the Bt horizon. The water table is at depths of 25 to 40 inches for cumulative periods of 4 months during most years and recedes to depths of more than 40 inches during drier periods.

Use and Vegetation: These soils are not used for cultivated crops. A few small areas are cleared and used for improved pasture. Most areas remain in native vegetation consisting of dwarf live oak, a few longleaf and sand pine, runner oak, sawpalmetto, and blueberry. Creeping bluestem, chalky bluestem, lopsided indiangrass, low panicums, pineland threeawn, paspalums, and numerous forbs dominate the understory.

Distribution and Extent: Peninsular Florida. The series is moderately extensive.

Series Established: Marion County, Florida; 1974.

Remarks: These soils were formerly classified in the Ground-Water Podzolic great soil group. Formerly, they were included with the Pomello series. This definition restricts the Electra series to those soils without weakly to strongly cemented spodic horizons that meet the requirements of ortstein but have slowly to very slowly permeable argillic horizons.

National Cooperative Soil Survey

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Soil Profile Description

Wauchula Series

The Wauchula series is a member of the sandy, siliceous, hyperthermic family of Ultic Haplaquods. These soils have a sandy dark colored A1 horizon and a sandy light colored A2 horizon that total less than 30 inches thick over a Bh horizon and an underlying Bt horizon with low base saturation.

Typifying Pedon: Wauchula fine sand--forested.

(Colors are for moist soil unless otherwise stated.)

A11--0 to 3 inches; black (10YR 2/1 crushed) fine sand; weak fine crumb structure; friable; many fine medium and coarse roots; strongly acid; clear wavy boundary. (2 to 5 inches thick)

A12--3 to 7 inches; very dark gray (10YR 3/1 crushed) fine sand; single grained; loose; many fine medium and coarse roots; strongly acid; clear wavy boundary. (2 to 4 inches thick)

A21-7 to 12 inches; gray (10YR 5/1) fine sand; single grained; loose; common medium roots; medium vertical streaks of dark and very dark gray along root channels; very strongly acid; clear smooth boundary. (3 to 6 inches thick)

A22--12 to 21 inches; light gray (10YR 7/1) fine sand; single grained; loose; medium vertical dark gray and very dark gray streaks in the matrix and along root channels; few to common fine and medium roots; very strongly acid; 1/2- to 2-inch transition layer of dark grayish brown; clear wavy boundary. (6 to 17 inches thick)

B21h--21 to 25 inches; balck (5YR 2/1) fine sand; weak fine subangular blocky structure parting to moderate fine crumb structure; firm, weakly cemented; many sand grains are coated with organic matter; few sand grains are clean; many fine and medium roots; very strongly acid; gradual wavy boundary. (3 to 6 inches thick)

B22h--25 to 28 inches; dark reddish brown (5YR 2/2) fine sand; weak fine crumb structure; firm weakly cemented; few fine and medium roots; many sand grains coated with organic matter; very strongly acid; clear wavy boundary. (3 to 6 inches thick)

B3--28 to 31 inches; brown (10YR 4/3) fine sand; few medium faint very dark brown streaks and mottles; single grained; loose; many sand grains are thinly coated with organic matter; very strongly acid; gradual wavy boundary. (0 to 4 inches thick)

A'2--31 to 37 inches; pale brown (10YR 6/3) fine sand; few fine faint streaks of very dark grayish brown; single grained; loose; very strongly acid; gradual wavy boundary. (0 to 6 inches thick)

B'1t--37 to 46 inches; grayish brown (10YR 5/2) fine sandy loam; few medium prominent red (2.5Y 4/8) and distinct brownish yellow (10YR 6/8) mottles; weak fine granualr structure; friable; sand grains are bridged and coated with clay; few fine light gray (10YR 7/1) sand lenses; very strongly acid; gradual wavy boundary. (2 to 12 inches thick)

B'2t--46 to 65 inches; gray (N 6/) sandy clay loam; few coarse distinct reddish yellow (7.5YR 6/6); strong brown (7.5YR 5/8) and dark brown (7.5YR 4/4) mottles; weak fine subangular blocky structure; friable; slightly sticky; sand grains are distinctly coated and bridged with clay; few thin patchy clay films on ped faces and in root channels; very strongly acid; gradual wavy boundary. (10 to 38 inches thick)

B'3--65 to 80 inches; gray (N 6/) fine sandy loam; few fine distinct brownish yellow and strong brown mottles; massive; friables slightly sticky; sand grains are coated and weakly bridged with clay; few lenses of fine sand; very strongly acid.

Type Location: Hardee County, Florida; about 1,500 feet west of Peace River and 1,700 feet north of State Road 64 in NW1/4NE1/4, sec. 3, R. 25 E., T. 34 S.

Range in Characteristics: Soil reaction is very strongly or strongly acid throughout.

The Al or Ap horizon is black (10YR 2/1), very dark gray (10YR 3/1), dark gray (10YR 4/1), or dark grayish brown (10YR 4/2) sand or find sand. This horizon is a mixture of organic matter and clean sand grains. The A2 horizon is gray (10YR 5/1, 6/1; N 5/ , N 6/), grayish brown (10YR 5/2), light brownish gray (10YR 6/2), light gray (10YR 7/1, 7/2; N 7/), or white (10YR 8/1, 8/2, N 8/) sand or fine sand. Some pedons have yellow, brown, or red mottles.

The Bh horizon is black (10YR 2/1; 5YR 2/0, very dark gray (10YR 3/1), very dark brown (10YR 2/2), dark brown (10YR 3/3; 7.5YR 3/2), or dark reddish brown (5YR 2/2, 3/2, 3/3, 3/4) snad or fine sand. Sand grains in this horizon have thin or thick coats of organic matter; consistence ranges from soft to firm and weakly cemented.

The B3 horizon is brown (10YR 4/3, 5/3; 7.5YR 4/2, 4/4), pale brown (10YR 6/3), or dark yellowish brown (10YR 3/4, 4/4). In many pedons few to common, fine to coarse weakly cemented Bh bodies are in this horizon. In some pedons the B3 horizon is absent and the Bh horizon rests directly on the B't horizon.

Where present, the A'2 horizon is very pale brown (10YR 7/3, 7/4), pale brown (10YR 6/3), light brownish gray (10YR 6/2), gray (10YR 5/1, 6/1), or light gray (10YR 7/1, 7/2) sand or fine sand.

The B't horizon is gray (10YR 5/1, 6/1, N 5/ , N 6/), light brownish gray (10YR 6/2), grayish brown (10YR 5/2; 2.5Y 5/2), dark gray (10YR 4/1), dark grayish brown (10YR 4/2; 2.5Y 4/2), light olive gray (5Y 6/2). Texture ranges from sandy loam to sandy clay loam. Mottles of brown, yellow, gray, or red mottles are in this horizon. In some pedons, lenses of sandy material are in this horizon. This horizon ranges from about 15 to 35 percent clay. The Bt horizon has base saturation of less than 35 percent at depth of 21 to 40 inches.

Competing Series and their Differentiae: These are the Cassia, EauGallie, Immokalee, Leon, Lynn Haven, Mascotte, Myakka, Ona, Oldsmar, Pomello, Pomona, and Wabasso soils lack a B't horizon beneath the Bh horizon. In addition, Cassia and Pomello soils are not as wet. Pomello soils have a Bh horizon below 30 inches. EauGallie, Pomona, and Oldsmar soils have a B't horizon at depths below 40 inches. Leon, Lynn Haven, Mascotte, and Ridgeland soils have mean annual soil temperatures of 59^{o} to 72^{o} F, at depths of 20 inches below the surface. Ona and St. Johns soils have an umbric epipedon; Ona soils lack an A2 horizon. The B't horizon of the Wabasso soils has a base saturation of 35 percent or more.

Setting: Wauchula soils are dominantly on nearly level areas of the lower Coastal Plain. They are in depressions and on slopes ranging to 5 percent in some places. They have formed in sandy over moderately fine-textured marine deposits. At the type location average annual precipitation is about 55 to 60 inches and mean annual temperature is about 74^{o} F.

Principal Associated Soils: These are the competing EauGallie, Immokalee, Myakka, Oldsmar, Ona, Pomello, St. Johns, and Wabasso series and the Basinger, Charlotte, Placid, and Pompano series. None of the latter soils have a spodic horizon.

Drainage and Permeability: Poorly drained; slow runoff; moderately rapid or moderate permeability. Water table is at depths of less than 10 inches for 1 to 4 months during most years. It is at depths of about 10 to 40 inches for periods as long as about 6 months, but during the driest season it receded to depths of more than 40 inches. Depressions are covered with standing water for periods of 6 to 9 months or more in most years.

Use and Vegetation: Large areas of this soil are used for improved pasture and range. Water control here is adequate; some areas of this soil are used for citrus and vegetable crops. Natural vegetation is longleaf and slash pines, sawpalmetto, and an understory of inkberry, fetter, southern bayberry, and pineland threeawn.

Distribution and Extent: Peninsular Florida. The series is of moderate extent.

Series Established: Lake County, Florida; 1970.

Remarks: These soils were formerly included in the Leon series and classified in the Ground-Water Podzol great soil group.

National Cooperative Soil Survey

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