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Characterization of newly accreted soils on reconstructed (LILA) tree islands in the Everglades

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BACKGROUND INFORMATION

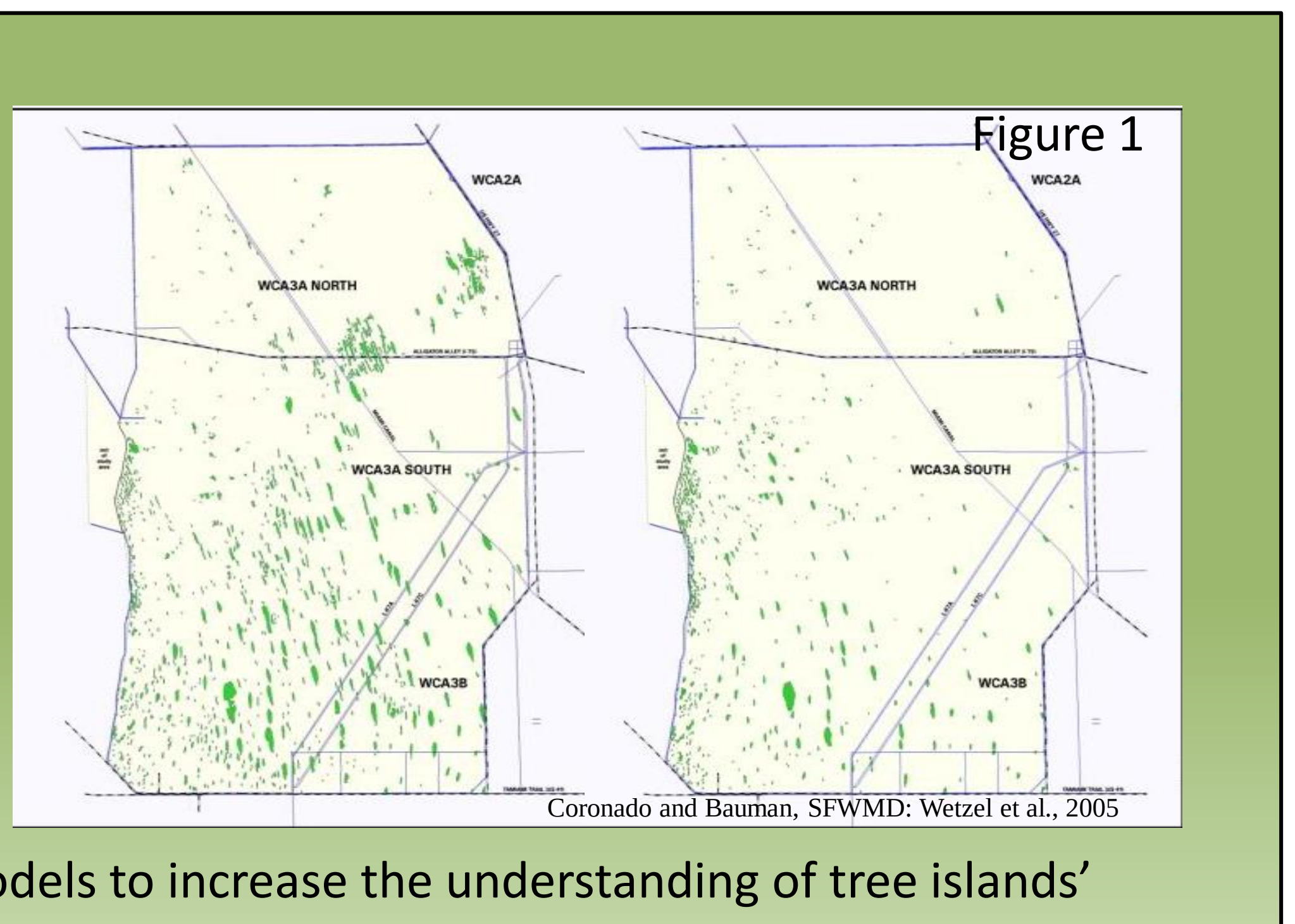
Figure 1

Coronado and Bauman, SFWMD: Wetzel et al., 2005

Tree islands comprise a small area of the Everglades, but they are a vital element of the landscape. Hydrological modifications have affected tree islands, leading to a decrease in numbers, and extent. Small tree islands (< 3.2 ha) have decreased by 98% in Water Conservation Area 2A (WCA-2A) (Wetzel et al., 2005) (Fig. 1). Soils in tree islands are often higher in nutrient content, and rate of nutrient cycling compared to the marsh (Wetzel et al., 2005; Ross et al., 2006).

Reconstructed tree islands have been used as physical models to increase the understanding of tree islands' dynamics, and establish parameters that could be applied by managers in restoration projects in the Everglades, improving the condition of tree islands, and reducing their decline in numbers. The objective of this research was to determine the physicochemical characteristics of newly accreted soils in reconstructed tree islands.

STUDY AREA

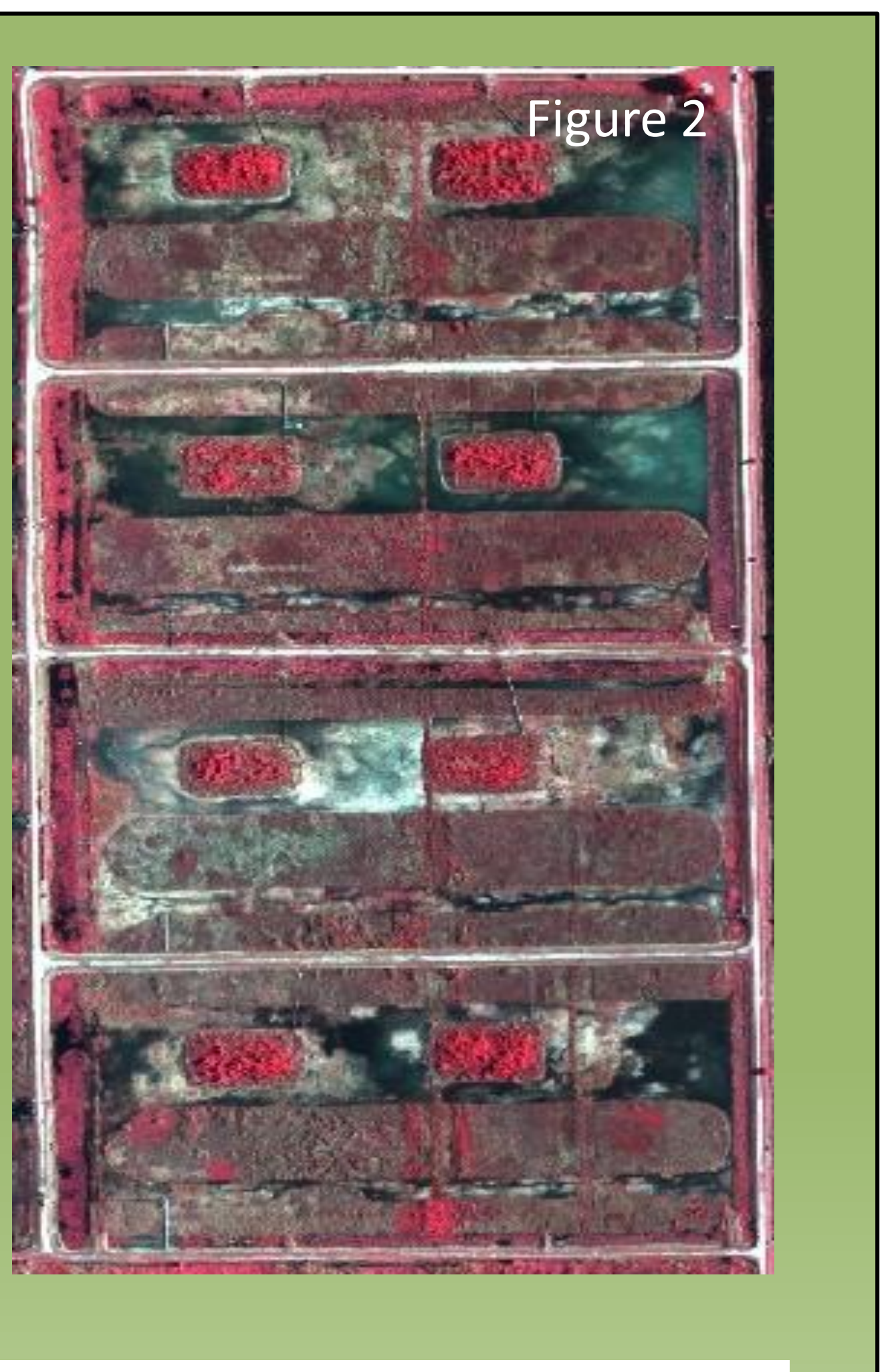
Figure 2

The Loxahatchee Impoundment Landscape Assessment (LILA) is located in the Arthur R. Marshall Loxahatchee National Wildlife Refuge in Boynton Beach, FL. LILA recreates the main landscape features of the Everglades (tree islands, ridges, and sloughs) under semi-controlled hydrologic conditions. LILA consists of four eight-hectare macrocosms, each composed of two tree islands, a ridge and a slough (Fig. 2)

The highest part of the tree islands, head high (HH), is located at the center, soils are never flooded at HH. The head low elevation (HL) is located down slope of the head of the tree islands, and was flooded for approximately 140 days y^{-1} (Fig. 3). Four planting densities were implemented in each tree island at spacing of 1.00, 1.66, 2.33, and 3.00 m (Stofella et al., 2010) (Fig. 4).

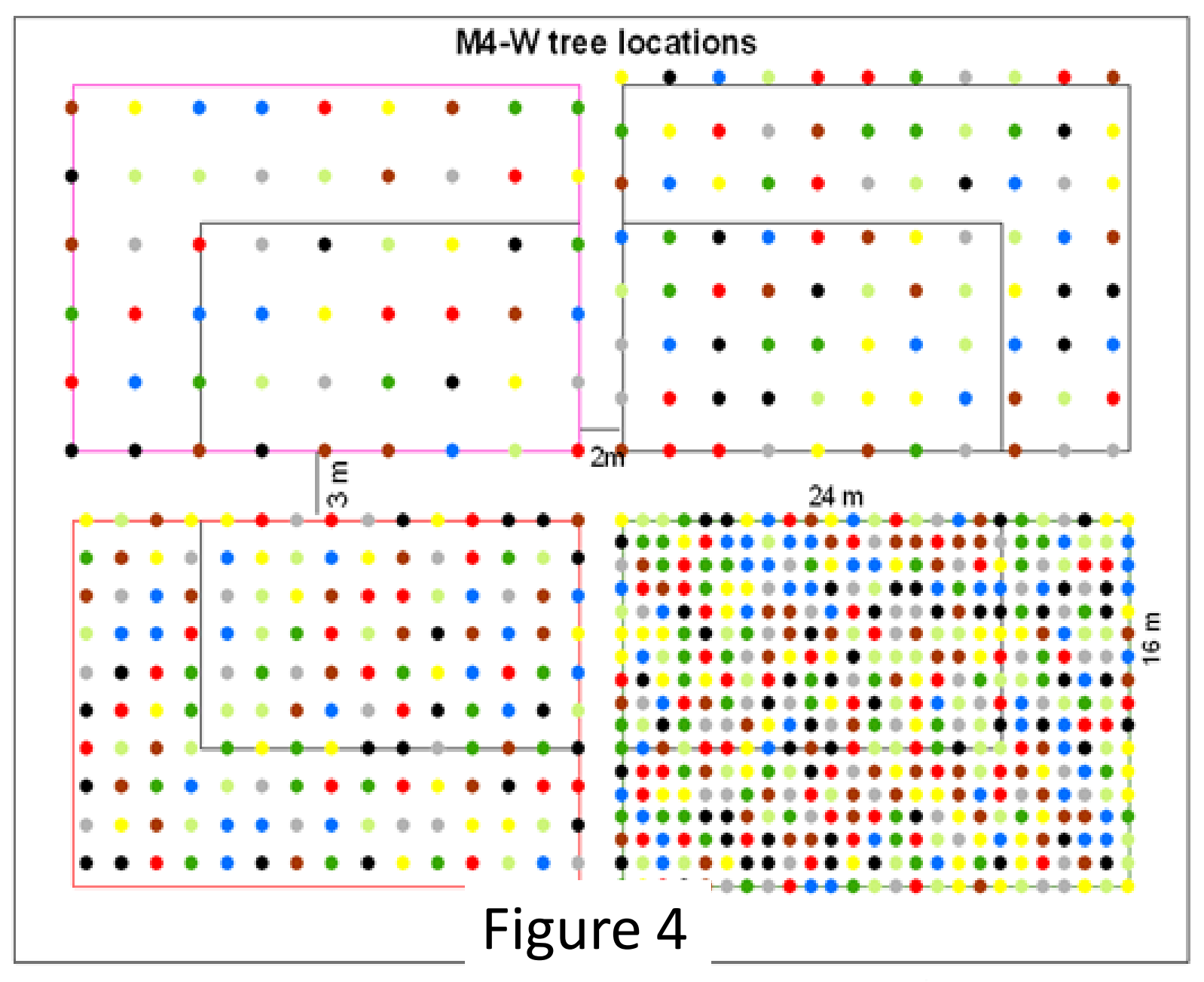

Figure 4

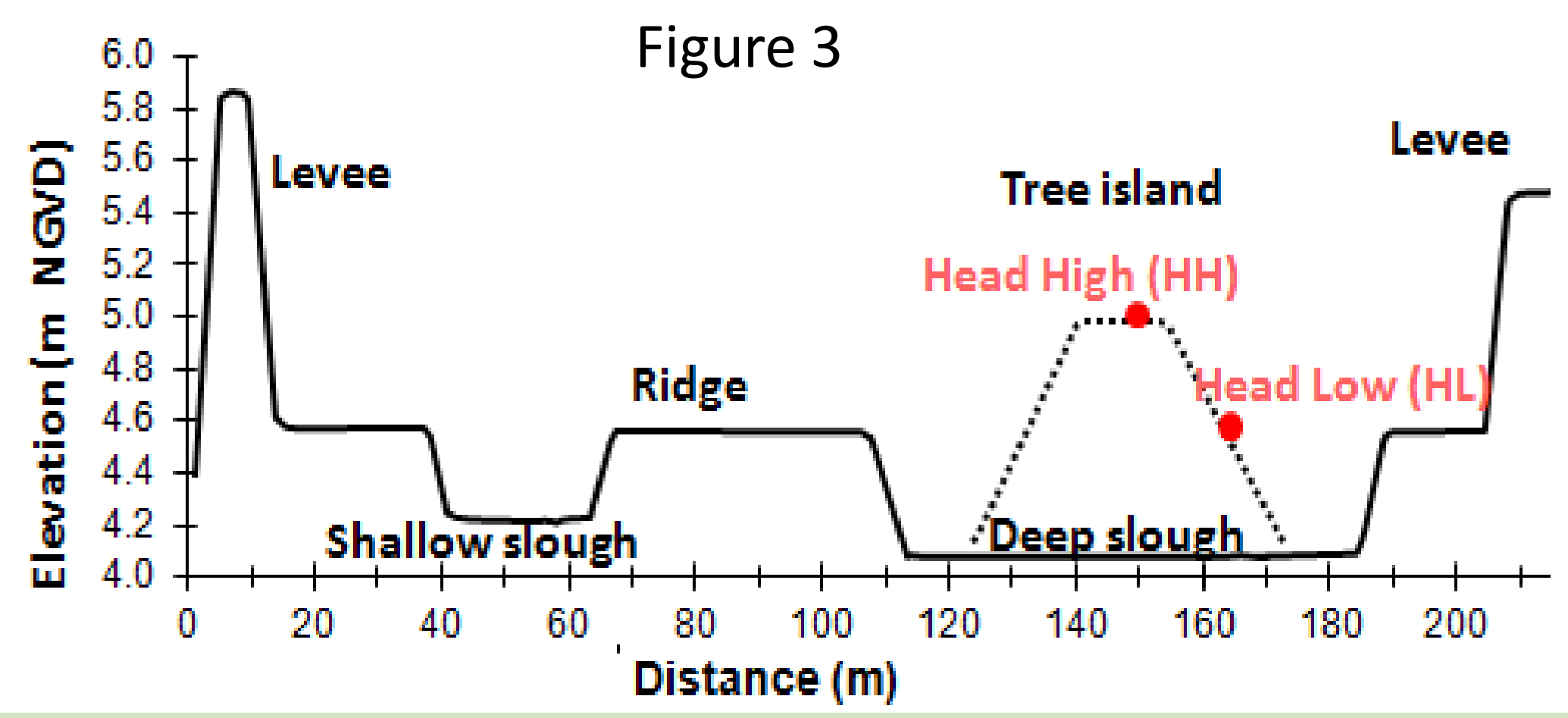
Figure 3

METHODS

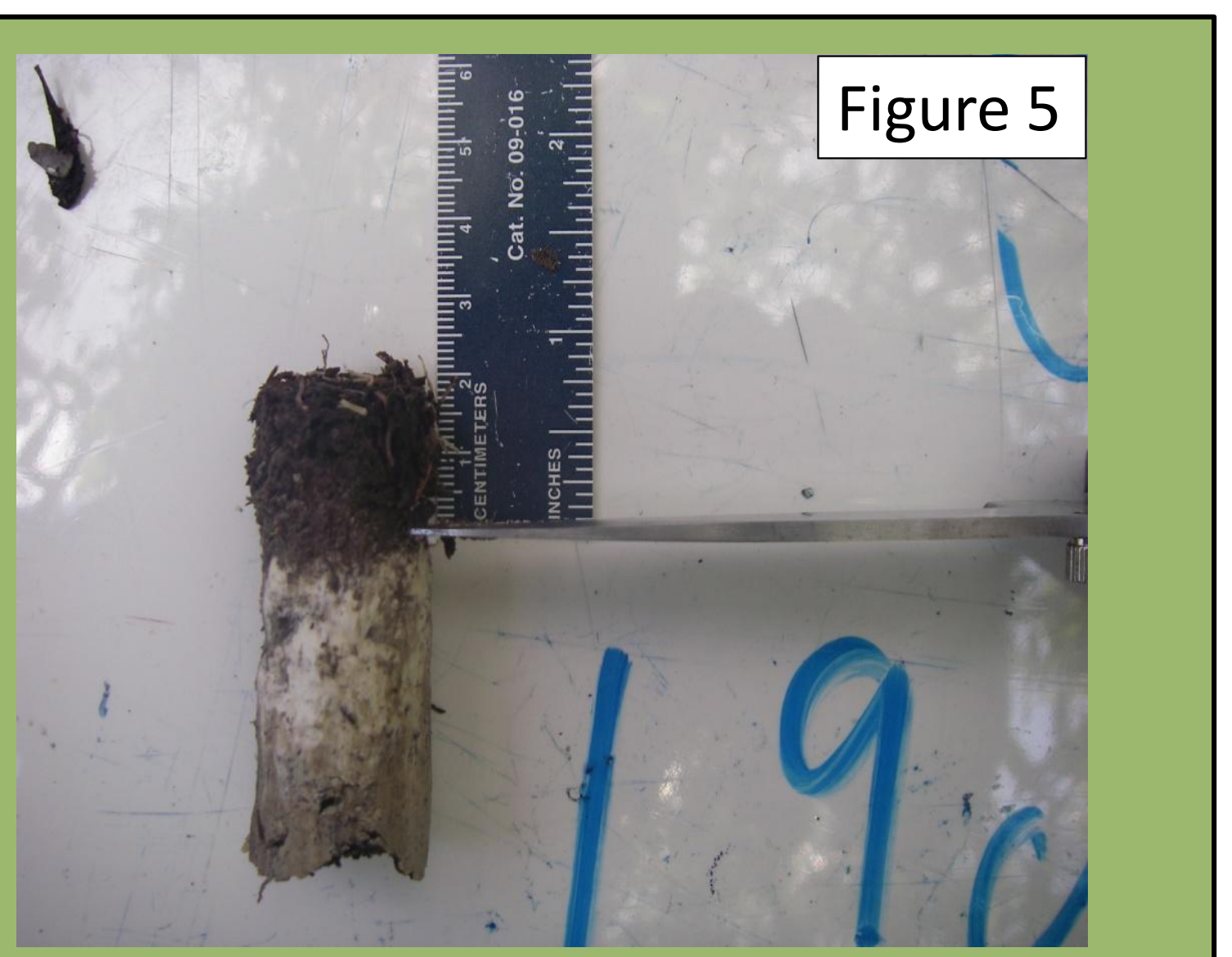
Figure 5

Feldspar markers horizons were placed in triplicates at the HH, and HL elevations in the high density planting of the eight tree islands. Accretion measurements were taken by extracting a core at the feldspar locations and measuring the amount of soil that had accreted above the bright white feldspar layer (Fig. 5). Annual measurements were made in 2010, 2011, and 2012 between April and June.

Soil physicochemical characteristics were analyzed by taking 10 cm soil cores from the four western islands at the HH and HL elevations in the highest (1 m) and lowest (3 m spacing) density plantings, 12 cores per island, 48 cores total. Cores were separated in two increments based on previous feldspar markers estimations: top (0-3 cm), which represents the newly accreted soil and bottom (3-10 cm) that represents older soil.

Soils were analyzed for field bulk density (FBD), pH, organic matter (OM), total carbon (TC), total nitrogen (TN), and total phosphorus (TP). Fractions of available P (water soluble P + NaCl extracted P), Ca-Mg bound P, and residual P were determined using three extracting solutions: DDI H_2O, 0.5M NaCl, and 0.5M HCl with a sample to solution ratio of 1:50, following a sequential fractionation procedure modified from Reddy et al. (1998).

RESULTS AND DISCUSSION

Soil accreted on tree islands at an average rate of 0.7 cm y^{-1}. The head of the tree islands showed significantly greater soil accretion at high (2.5 ± 1.1 cm) than at low elevations (1.8 ± 0.8 cm) for the period from 2009 to 2012 (Fig. 6).

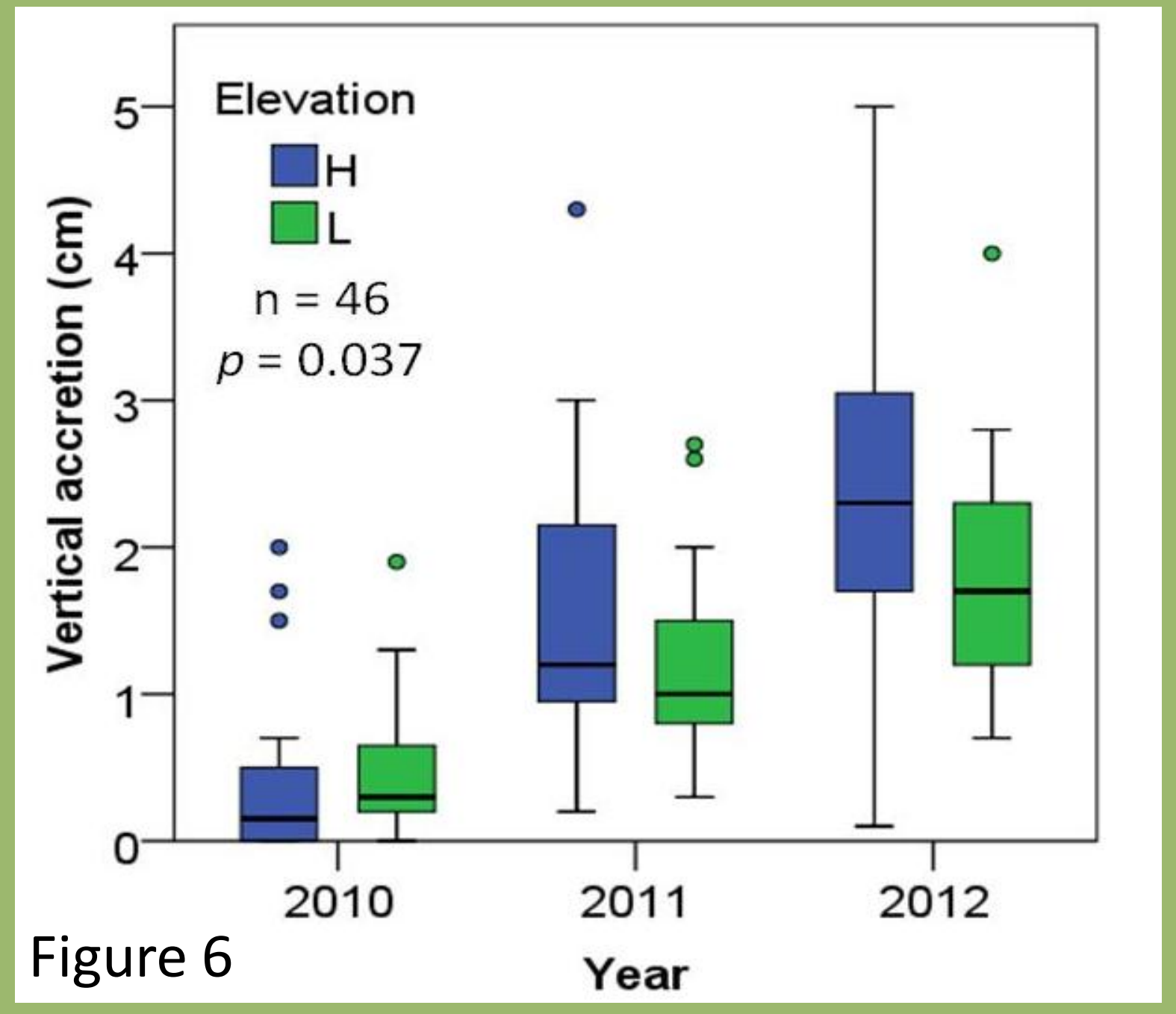
Figure 6

New soils had significantly higher nutrient concentrations, higher OM, and lower FBD. The C:P and N:P molar ratios were significantly lower in new soils indicating that P is less limiting in the newly accreted soils (Table 1).

Table 1

Parameter (Unit)	Soil depth		p value
	0-3 cm	3-10 cm	
pH	7.28 ± 0.42	7.28 ± 0.39	0.998
FBD (gdw cm^{-3})	0.45 ± 0.22	0.73 ± 0.33	<0.001
TP (µg g^{-1} dw)	374 ± 202	216 ± 134	<0.001
TP (µg cm^{-3})	135 ± 56	122 ± 38	0.362
TN (mg g^{-1} dw)	14.4 ± 6.8	10.2 ± 5.7	0.002
TC (mg g^{-1} dw)	190 ± 90	132 ± 75	0.002
C:N	15.3 ± 1.1	15.2 ± 1.1	0.487
C:P	1401 ± 327	1710 ± 653	0.007
N:P	91 ± 21	113 ± 40	0.001
OM (g g^{-1} dw)	0.36 ± 0.19	0.25 ± 0.18	0.007

New soils had significantly higher concentrations of all P fractions compared to older soils (Fig. 7)
Available P, as percentage of TP, was significantly higher at the new soil compared to the older soil ($p < 0.001$).

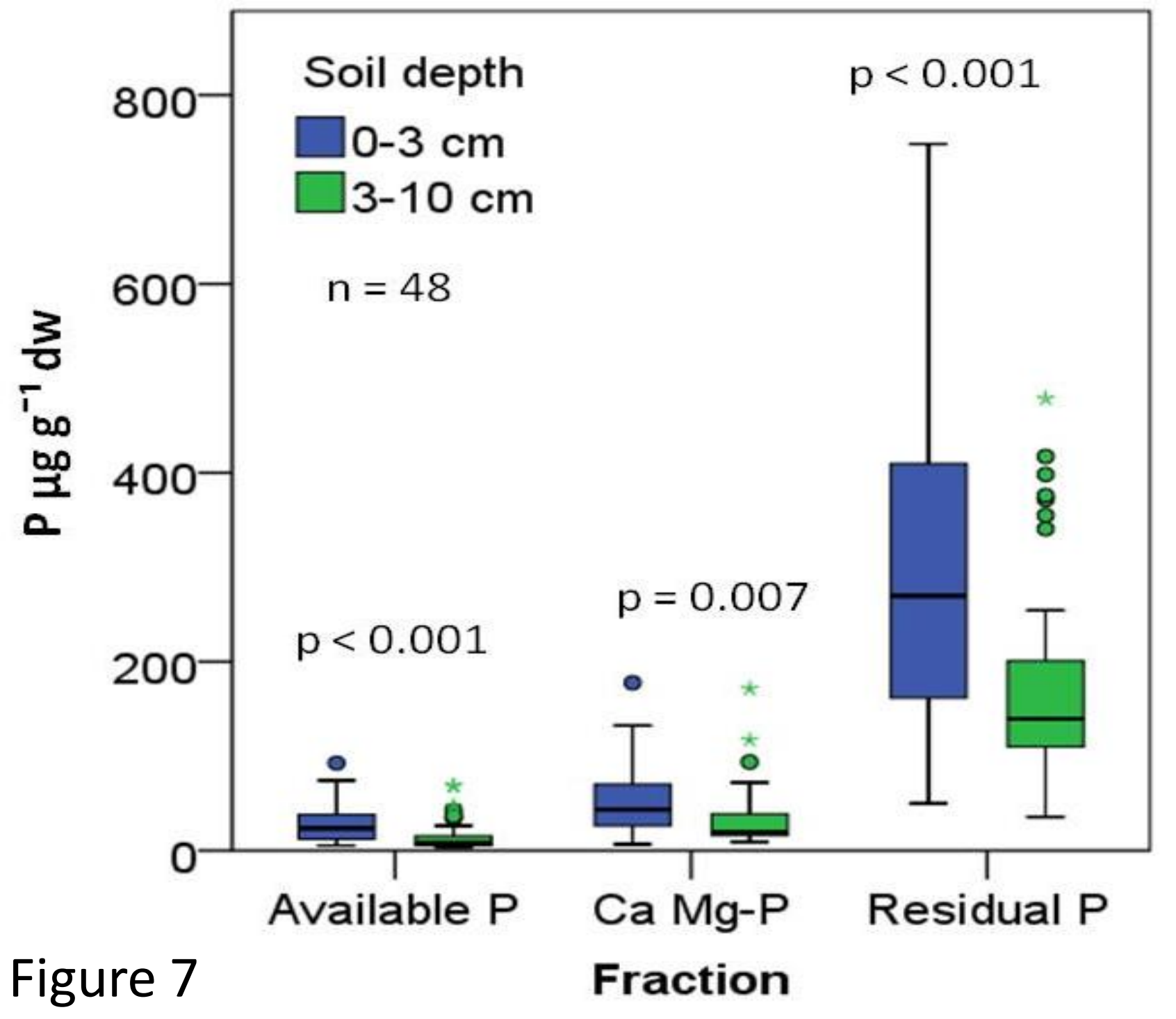
Figure 7

There were significant differences in TP between new and old soil that were more pronounced in the high planting density. Newly accreted soils at the high planting density had the highest TP concentrations (Fig. 8).

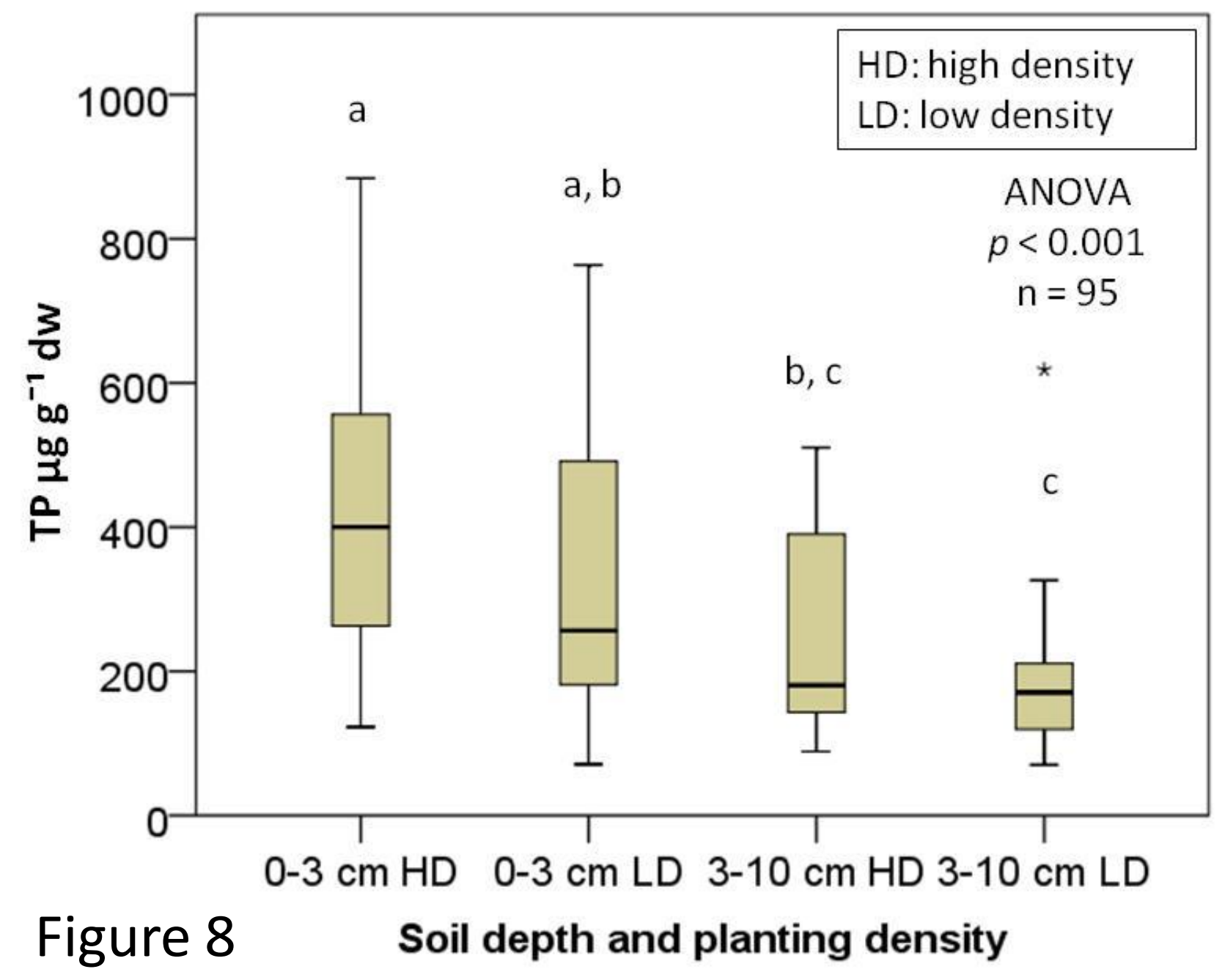
Figure 8

RESULTS AND DISCUSSION (CONT.)

There were significant differences in available P between new and old soils that were more pronounced at the high planting density. New soils in the high planting density had the highest available P concentrations (Fig. 9).

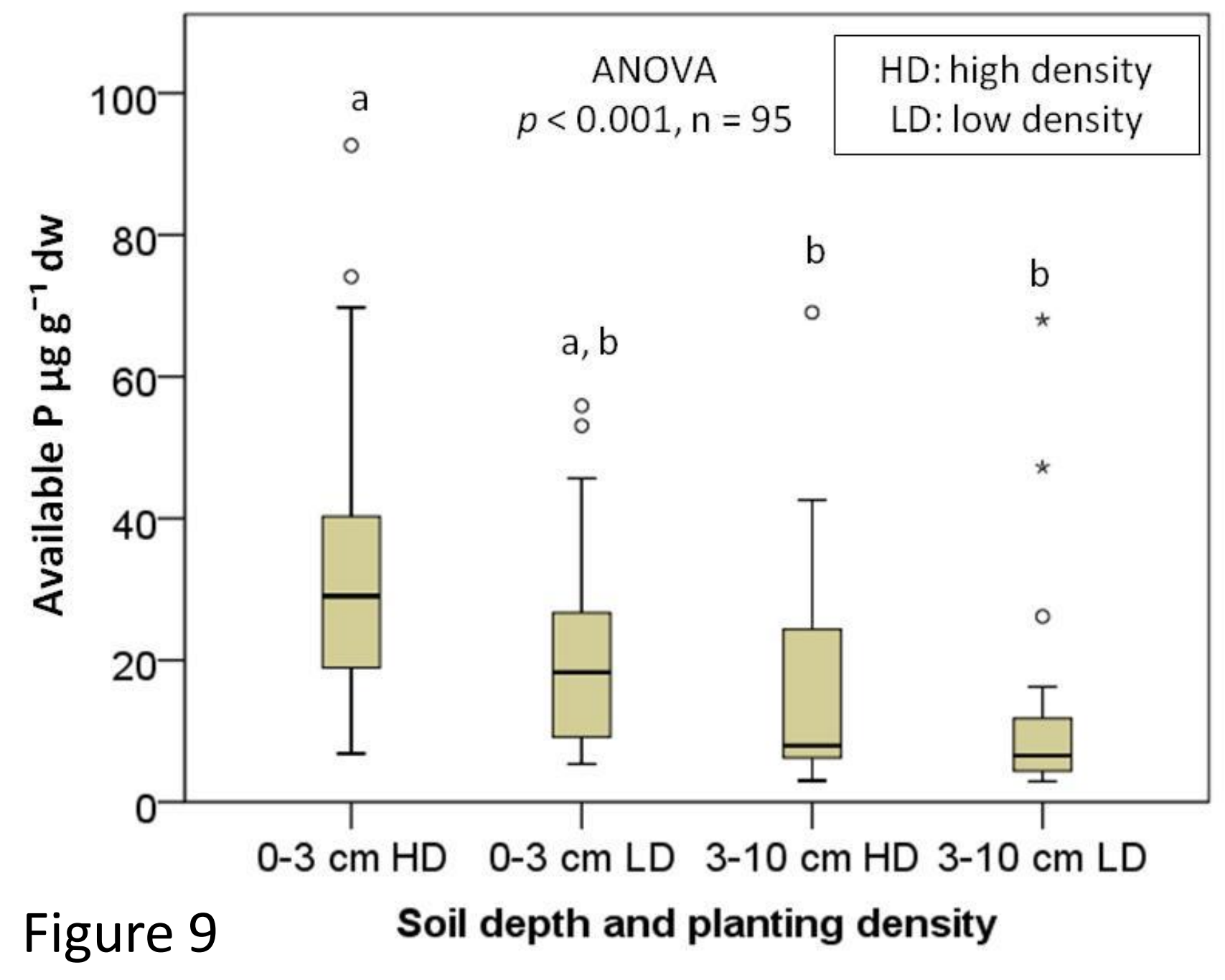
Figure 9

Soils exhibited a significant positive correlation between OM and concentration of TP, TN, and TC (Table 2).

Parameter (units)	pH	FBD (gdw cm^{-3})	TP (µg g^{-1} dw)	OM (g g^{-1} dw)	TN (mg g^{-1} dw)	TC (mg g^{-1} dw)
FBD (gdw cm^{-3})	.498**					
TP (µg g^{-1} dw)	-.370**	-.791**				
OM (g g^{-1} dw)	-.501**	-.824**	.905**			
TN (mg g^{-1} dw)	-.343**	-.773**	.888**	.904**		
TC (mg g^{-1} dw)	-.353**	-.768**	.875**	.899**	.991**	
TP (µg cm^{-3})	.063	-.007	.358**	.125	.167	.181

** Significant at 0.01 level, * significant at 0.05 level.

Table 2

Places within tree islands where trees are more productive, such as the high density planting, produce new soil with higher OM content. Organic matter carried nutrients (P, N, and C) that were incorporated into the soil, therefore areas with high OM input had higher nutrient concentrations. Available P is higher in new soils and where trees are more productive, suggesting that tree productivity induces a positive feedback by which trees return OM to the soil increasing nutrient availability, which could be used for plant growth. Phosphorus is stored predominantly in the residual pool in LILA tree islands. The residual pool includes organic P suggesting that reconstructed tree islands store P in the organic pool, and P concentrations in these tree islands are related to OM production.

CONCLUSIONS

Soil nutrients in LILA tree islands differ from natural tree islands of the Everglades, particularly in TP concentrations, which have not reached yet the very high concentrations exhibited by tree islands. Though biogeochemical characteristics of natural tree islands are not present yet in these young tree islands, presumably because time has not been enough to establish the mechanisms that allow such conditions, soil nutrients are increasing because of the addition of OM to the soil. Recreating tree islands provides a means of establishing plant communities, but long-term survival of these forests depends on continued soil development. In order to evaluate their long term viability, further research and monitoring is required to determine the trend these young tree islands will follow.

ACKNOWLEDGEMENTS

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