INTER-ROTATIONAL EFFECTS OF FERTILIZATION AND WEED CONTROL ON GROWTH AND SOIL NUTRIENT AVAILABILITY IN A 2-YEAR-OLD LOBLOLLY PINE PLANTATION IN NORTH FLORIDA

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INTRODUCTION

- Fertilization and understory competition control are common silvicultural practices used in loblolly pine (*Pinus taeda*) stands in the southern United States, improving yields up to two- to four-fold.
- These silvicultural practices have either increased or decreased soil C pools when used in intensively managed pine ecosystems (Shan et al. 2001; Vogel et al. 2011). Silvicultural treatments that reduce soil organic matter (e.g., herbicide applications) could potentially influence long-term site nutrient supply.
- Most studies documenting improvement in pine yields due to fertilization and weed control treatments do not extend over multiple rotations. Therefore, the long term effects of these practices on sustainable, inter-rotational site productivity are not clearly understood.
- The objective of this study was to:
  - investigate variation in total aboveground biomass, nutrient content and soil nutrient supply rates in 2-year-old loblolly pine stands as affected by historical management treatments like fertilization and weed control (IMPAC experiment – Intensively Managed Practices Assessment Center; Swindel et al. 1988).

METHODS

Study site:

- Gainesville, FL ; Mean elevation: 45 m ; Mean annual temperature: 27° C; Annual rainfall : 1229 mm (*NOAA 2008*)
- Climate: Warm and humid
- Soil: Poorly drained Pomona fine sands (*sandy, siliceous, hyperthermic, Ultic Alaquods*)

First rotation treatments:

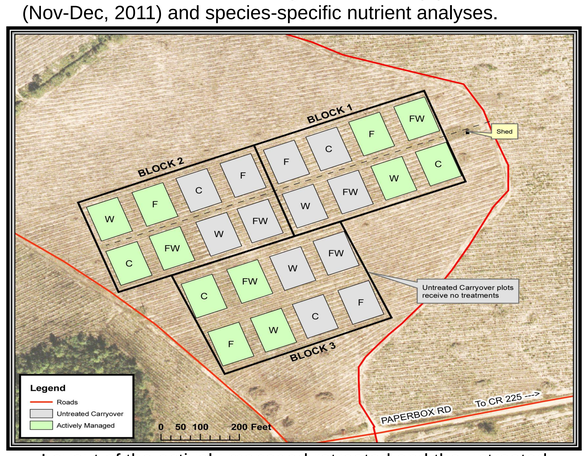
- Established in 1983 and harvested in 2009.
- 2x2x2 factorial experiment consisting of species (loblolly and slash pine), sustained weed control, and annual fertilization arranged in a randomized split-plot (species as whole plots) design resulting in four treatments for both species; Control (C), Fertilizer only (F), Fertilizer and weed control (FW), and Weed control only (W).
- Total nutrient additions over the life of the original study (first rotation) for the F and FW treatments for both species were (kg/ha): 1088 N, 230 P, 430 K, 108 Ca, 72 Mg, 72 S, 4.1 Mn, 5.4 Fe, 0.9 Cu, 4 Zn, and 0.9 B.
- The understory vegetation was mulched in the C and F only treatment plots prior to harvest at age 25.
- Growth dynamics for the first rotation were recently summarized over the 25-year study period by Jokela et al. (2010).

Second rotation treatments:

- Single full-sib loblolly pine family planted in Dec 2009. All plots were treated to control *Panicum* spp. and tip moth (*Rhyacionia frustrana)* at time of planting.
- Established on sites that received the same treatments in the previous rotation: Control (C), Fertilizer only (F), Weed control only (W), and Fertilizer and Weed control (FW) resulting in two **randomized complete block design experiments.**
- **Actively managed retreated experiment:** Received the same silvicultural treatments in both rotations (established on the previous loblolly pine plots). Fertilizer additions through age 2 yrs included 672 kg/ha of 10-10-10 + micronutrients.
- **Untreated carryover experiment:** Did not receive treatments in this rotation, but received silvicultural treatments in the previous rotation (established on the previous slash pine plots).

Data collection and analyses:

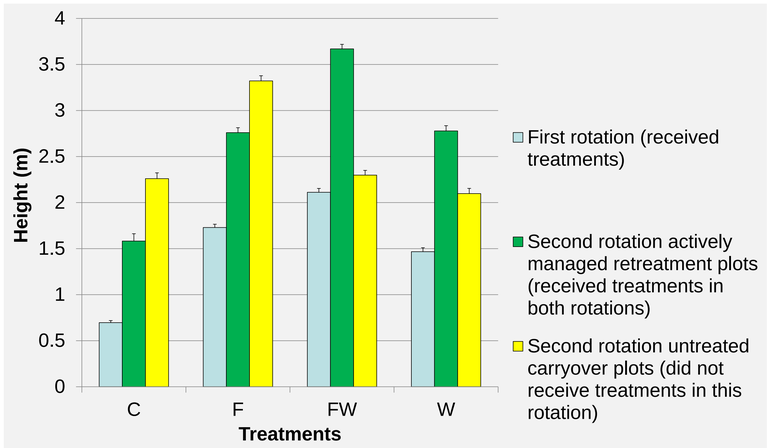
- Estimates of aboveground pine biomass for loblolly pine were based on established allometric functions developed from the same genetic source, age, and soils (Adegbidi et al. 2002).
- Estimates of soil nutrient supply rates for eight weeks were based on ion-exchange membranes (PRS™; Western Ag Innovations Inc.) buried in August 2011.
- Estimates of understory aboveground biomass and nutrient accumulations were made using destructive clip plot harvests (Nov-Dec, 2011) and species-specific nutrient analyses.



Layout of the actively managed retreated and the untreated carryover plots at the IMPAC Experimental Study, Gainesville, FL.

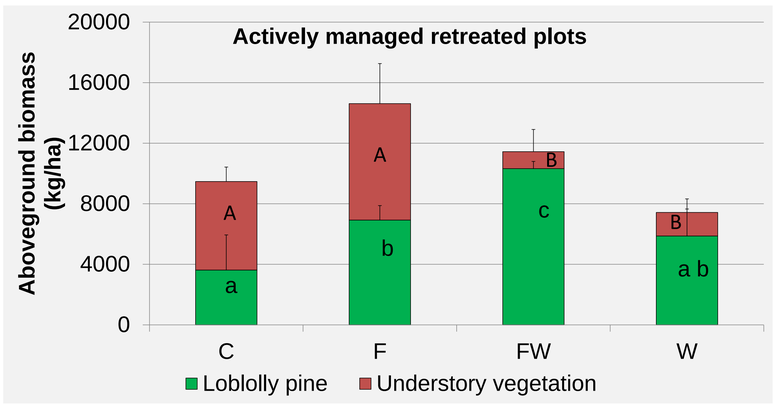
RESULTS

Fig. 1. Inter-rotational comparison among treatments in total height of 2-year old loblolly pine growing at the IMPAC study.



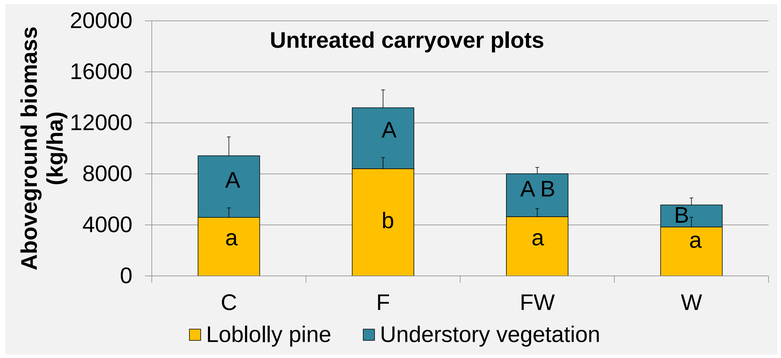
- Second rotation heights of both the actively managed and untreated carryover plots were greater than the first rotation at age 2 yrs.

Fig. 2. Accumulation of aboveground biomass (pine and understory vegetation) in a second rotation, 2-year-old loblolly pine plantation as affected by fertilizer and weed control treatments in the actively managed retreated plots.



- The FW treatment significantly increased loblolly pine aboveground biomass accumulation relative to all other treatments.

Fig. 3. Accumulation of aboveground biomass (pine and understory vegetation) in a second rotation, 2-year-old loblolly pine plantation as affected by the historical application of fertilizer and weed control treatments in the untreated carryover plots.



- Significant gains in loblolly pine aboveground biomass were observed in the F only treatment. The FW treatment, which received the same historical nutrient additions, was not significantly different than the C or W treatments. These results suggest that the understory vegetation and the forest floor in the F treatment was likely an important nutrient source, via mineralization, in the second rotation (Vogel et al. 2011).

ACKNOWLEDGEMENTS

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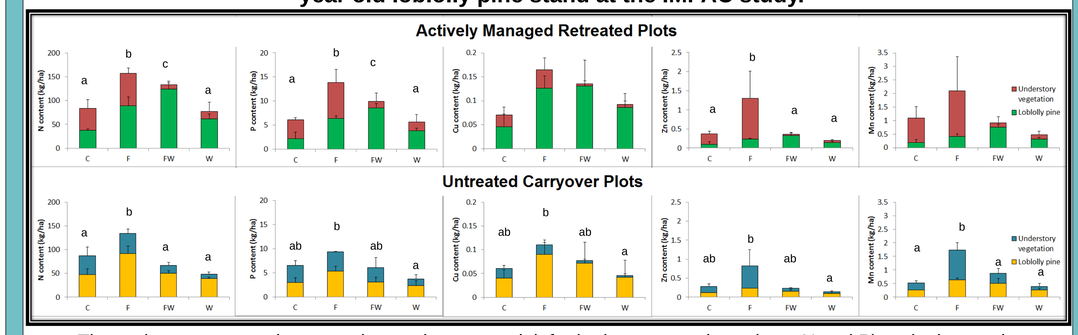
Fig. 4. Total nutrient accumulation in the aboveground biomass (pine and understory) of a 2-year old loblolly pine stand at the IMPAC study.



- The understory vegetation served as an important sink for both macronutrients (e.g., N and P) and micronutrients (e.g., Mn, Zn, and Cu) in the C and F treatments.

Table 1. Soil nutrient supply rates (Micrograms/10 cm²/ 8 weeks; PRS™ Western Ag Innovations Inc.) at 15 cm in the actively managed retreated plots (Tukey's HSD at alpha = 0.1).

Treatments	N	K	P	Mn	Cu	Zn	B
C	8	65	10	3.1	0.1	1.0	0.2
	b	a	ab	b	b	b	a
F	62	104	36	9.1	0.9	4.4	0.2
	ab	a	a	ab	a	a	a
FW	222	78	29	9.4	0.7	5.4	0.2
	a	a	a	a	a	a	a
W	10	74	4	3.2	0.1	1.1	0.1
	b	a	b	b	b	b	a

- As expected, additions of fertilizer significantly increased soil nutrient supply rates of N, P, Mn, Cu, and Zn in the F only and FW treatments of the actively managed retreated plots.

Table 2. Soil nutrient supply rates (Micrograms/10 cm²/ 8 weeks; PRS™ Western Ag Innovations Inc.) at 15 cm for the untreated carryover plots (Tukey's HSD at alpha =0.1).

Treatments	N	K	P	Mn	Cu	Zn	B
C	6	68	9	3.1	0.1	0.9	0.2
	a	a	a	a	a	a	a
F	3	75	21	11.3	0.4	3.8	0.2
	a	a	b	b	a	b	a
FW	5	58	8	4.3	0.2	3.7	0.2
	a	a	a	a	a	b	a
W	5	47	4	2.4	0.1	1.4	0.2
	a	a	a	a	a	a	a

- Soil nutrient supply rates for P and Mn were significantly higher for the F only treatment in the untreated carryover plots. Lower exchangeable P and Mn in the FW treatment, which historically did not include understory vegetation, suggests lower availability, and possible leaching losses from the E to the Bhs horizon.
- Aboveground pine biomass and soil nutrient supply rates were highly correlated for P (Corr. Coeff. = 0.83, p-Value <0.001), Mn (Corr. Coeff. = 0.79, p-Value <0.01), and Cu (Corr. Coeff. = 0.73, p-Value <0.01).
- Zn supply rates were significantly higher in the F only and FW treatments compared to W and C treatments.

CONCLUSIONS

- Significantly higher growth response in the F only treatment of the untreated carryover plots suggest that the understory vegetation from the previous rotation served as an important nutrient sink, especially for P, which then subsequently became a nutrient source (through mineralization) in the second rotation.
- The FW treatment in the untreated carryover plots, which historically received the same level of nutrient additions as the F only treatment, was not as productive, and did not differ from the W or C treatments. Lower exchangeable P and Mn in the FW treatment, which historically did not include understory vegetation, suggests possible leaching losses from the E to the Bhs and Bt horizons. Continued monitoring of growth and foliar nutrient levels will be used to determine root access to soil nutrients in these lower horizons.
- Early results suggest that loblolly pine is growing better in the second rotation than the first rotation. A suite of improved cultural practices (e.g., advanced genetics, seedling stock, site preparation) and environmental factors (e.g., elevated atmospheric CO_2, climatic variability) may be responsible.

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