



# Comparing the carbon allocation patterns of different genotypes of loblolly pine (*Pinus taeda* L.) under intensive silvicultural practices



FOREST PRODUCTIVITY COOPERATIVE  
North Carolina State University - Virginia Polytechnic Institute and State University - Universidad de Concepción

Yuan Fang<sup>a</sup>, Jose Stape<sup>a</sup>, Barry Goldfarb<sup>a</sup>, Tom Fox<sup>b</sup>, Tim Albaugh<sup>b</sup>

<sup>a</sup>Department of Forestry and Environmental Resources, North Carolina State University, Raleigh, NC, USA

<sup>b</sup>Department of Forestry, Virginia Polytechnic Institute and State University, Blacksburg, VA, USA



## 1. INTRODUCTION & OBJECTIVES

### ❖ Genetic improvement increases productivity

Productivity of southern pine plantations has increased substantially due to improved silvicultural practices, such as genetic improvement (Figure 1).

### ❖ Carbon allocation patterns vary widely among different genetics

Genetic improvement increases aboveground carbon (C) sequestration, but effects on belowground C are poorly understood. How sensitive belowground C is to differences in genetics are unclear.

### ❖ Soil carbon dioxide (CO<sub>2</sub>) flux is a major component of terrestrial C cycles

Understanding the plant mediation of these fluxes has global relevance for the C cycle. For example, a 10% change in global terrestrial soil CO<sub>2</sub> flux could double or completely ameliorate anthropogenic CO<sub>2</sub> emissions.

### ❖ Important to understand the genetic effects on carbon allocation patterns

To address these issues, our objective is to quantify total belowground C allocation (TBCA) of four loblolly pine genotypes (three clones and one open pollinated) during a one year observation period by observing the soil CO<sub>2</sub> flux and litterfall each month.

### Objectives

- 1) Compare the growth response, soil CO<sub>2</sub> flux, and carbon allocation patterns, at stand level, of loblolly pine clones under intensive silvicultural management.
- 2) Explore the difference of soil CO<sub>2</sub> flux between within-row and inter-row.
- 3) Understand the effects of genetic improvement (moderate crown vs. broad crown; clones vs. open pollinated) on below ground carbon allocation.

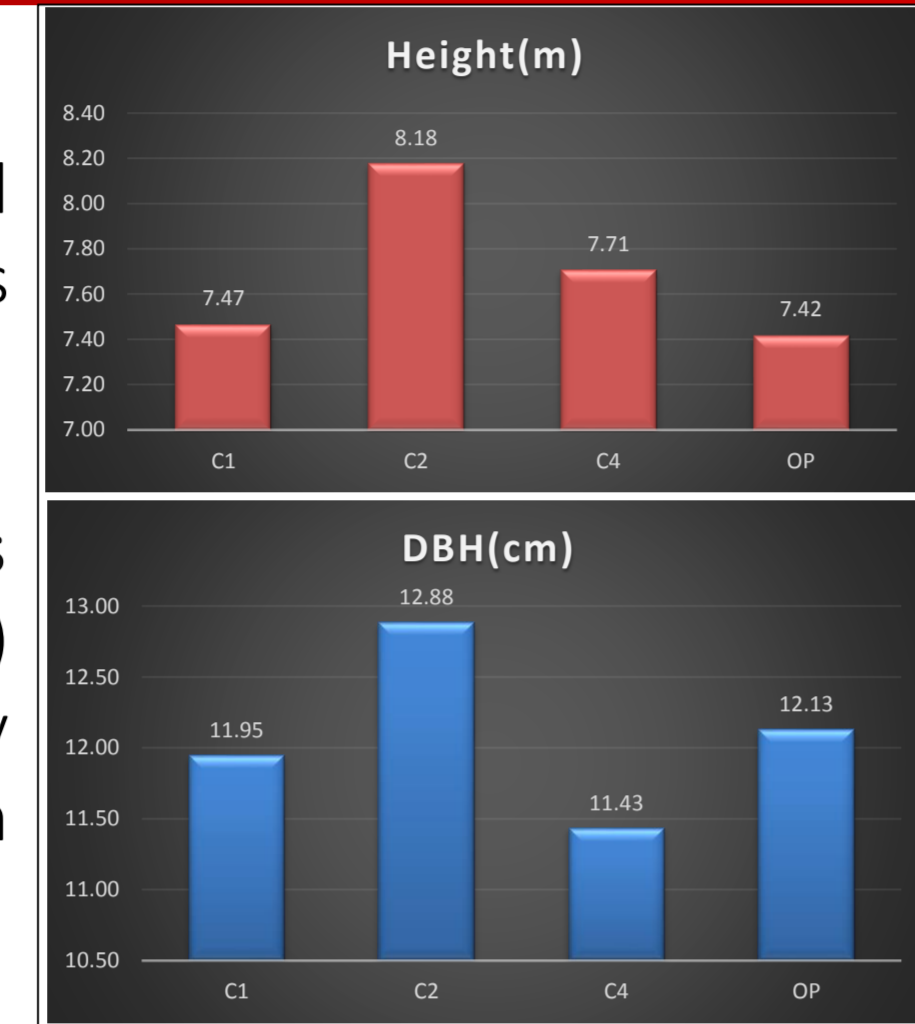


Figure 1. Genetic effects on tree height and DBH. Measured at 5 years old. (Tim Albaugh)

## 2. METHODS

The total belowground carbon allocation (TBCA) will be studied at Bladen Lakes, NC (FPC-RW 20). The measurements will only be carried out inside 5 x 5 rows (the plot is 9 x 9 rows).

1. *Soil CO<sub>2</sub> flux*. Sampling at 2 positions (within-row and inter-row) with 4 replications per plot; measured with LI-8100 Automated Soil Gas Flux System, with a 20 cm diameter chamber (Figure 2). The measurements will be conducted once a month for one year.

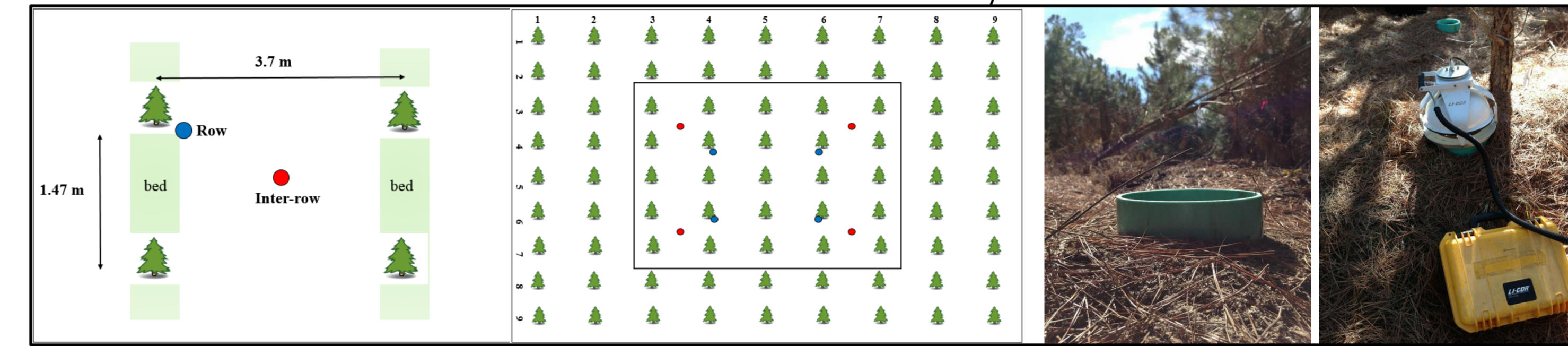


Figure 2. Locations of soil C flux sampling in the layout of individual 9 tree x 9 tree plots for one genotype at 750 trees/acre planting; the collar and Licor-8100 are used in this study.

2. *Soil C*. Sampling in 2 positions (within-row and inter-row) with 2 replications (Figure 3), at depth 0-15 cm, 15-30 cm, 35-45 cm, and at the beginning and end of the study.

3. *Soil density*. Sampling at each depth: 0-15 cm, 15-30 cm, 30-45 cm.

4. *Litter fall*. Collecting once a month by a 0.16 m<sup>2</sup> litter fall trap at 3 random positions per plot.

5. *Forest floor*. Sampling once per year at 1 location with 2 replications.



Figure 3. Locations of soil C sampling; auger used for sampling, litter fall collector in plot; analysis of the ash content in a muffle to evaluate the amount of mineral soil present in the samples, after being sieved.

## 3. EXPERIMENTAL SITE

The carbon allocation patterns will be studied at the FPC Region Wide 20 sites. The project sites are installed at 3 locations; Bladen Lakes, NC, Reynolds, VA in 2009, and Santa Catarina, Brazil in 2010. This study will be established at Bladen Lakes, NC (Figure 4), located in the coastal plain (coordinates: 34.8273, -78.6076). The soils are poorly drained Ultisols mapped at the Rains series (fine-loamy, siliceous, semiactive, thermic Typic Paleaquults).



Figure 4. RW20 Bladen Lakes is located southeast of Fayetteville, NC.

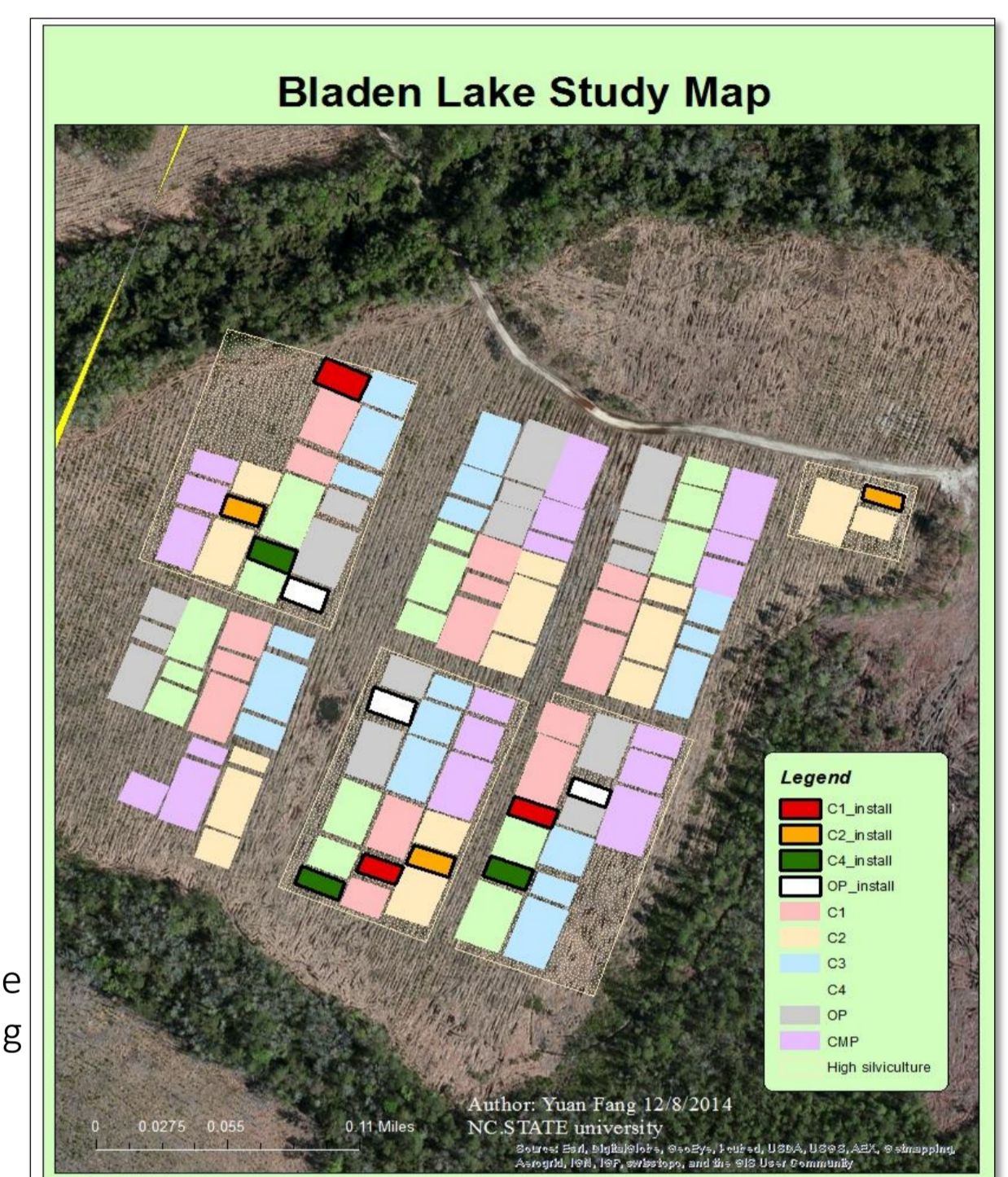


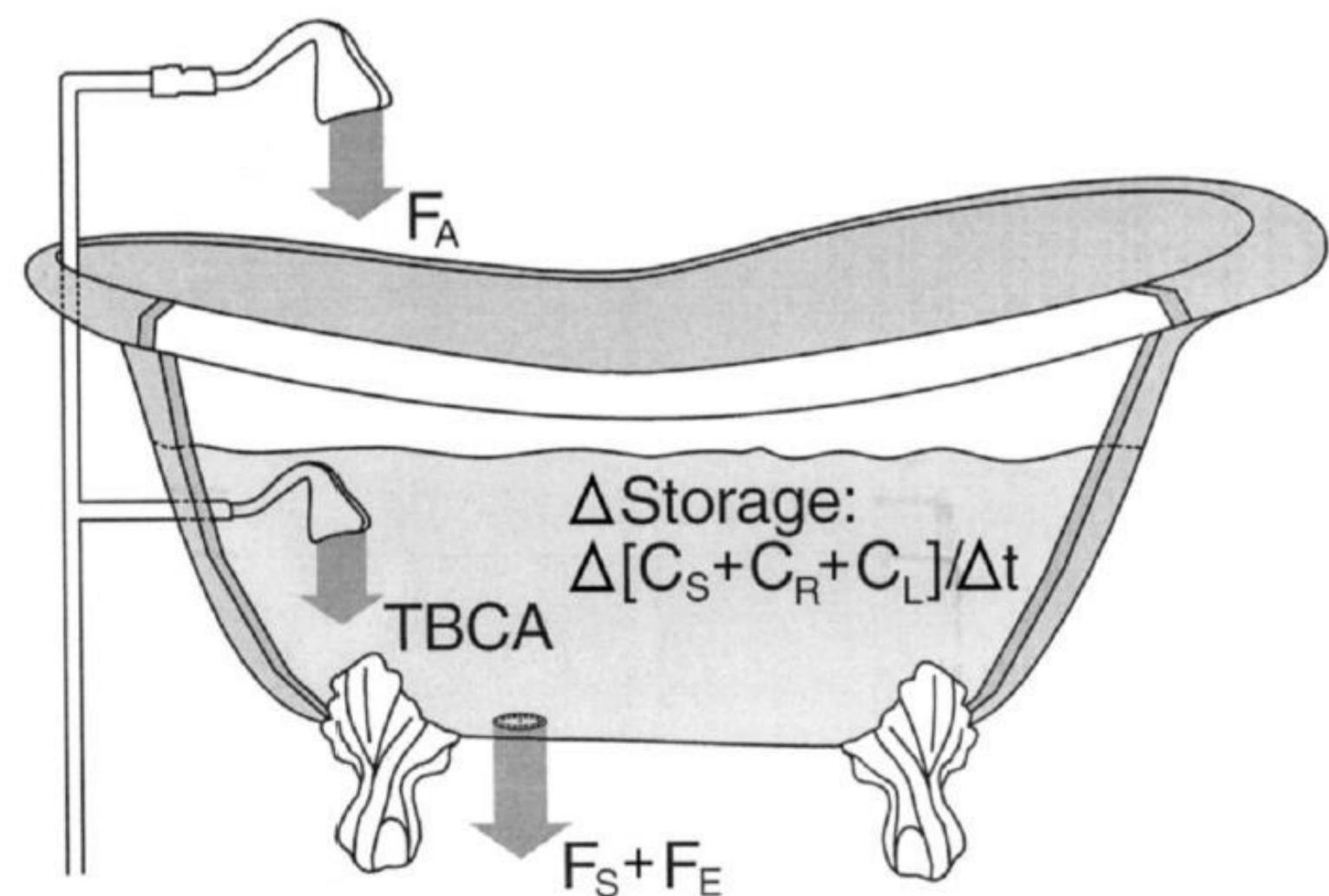
Figure 5. Layout of RW20 at Bladen Lakes, NC. The site map indicates the locations of 4 genotypes with 3 replications, at 750 trees/acre planting spacing and high silviculture treatments.

### Block Plot Study Design and Treatment:

The same block plot design and treatment is at each RW20 location. The study was installed as a split-split plot design with 3 replications. The treatments includes 2 levels of silviculture (low, high) X 6 different genotypes (1 Open Pollinated (OP), 1 Mass control pollinated (MCP), 4 clones) X 3 initial planting spacings (250, 500, 750 trees/acre). The treatments to study are 4 genetics which are OP, C1 (Moderate + crown ideotype clone), C2 (Moderate - crown ideotype clone), C4 (Broad crown ideotype clone) at high silvicultural treatments and low planting spaces (750 trees/acre)(Figure 6).

## 4. Total Belowground Carbon Allocation (TBCA)

We measure TBCA as surface carbon dioxide efflux minus C inputs from above ground litter, plus the change in C stored in roots, litter, and soil. We evaluate this C balance approach by examining the sensitivity of our TBCA measurements to differences in genetics.



Analogy for mass balance approach to estimate TBCA. The flux of water into the tub from the underwater faucet (TBCA) can be calculated for any period of time by measuring the flux of water out of the tub ( $F_S + F_E$ ), the flux into the tub from the faucet above water ( $F_A$ ), and any change in water stored in the tub over the period ( $\Delta[C_S + C_R + C_L]/\Delta t$ ).

$$TBCA = F_S + F_E - F_A + \Delta[C_S + C_R + C_L]/\Delta t$$

Where TBCA- the total of root respiration, carbohydrates used for mycorrhizae or exudates, and production of fine roots,  $C_S$ -carbon content of mineral soil,  $C_R$ -carbon content of root (coarse fine) biomass,  $C_L$ -carbon content of the litter layer. surface carbon dioxide,  $F_S$ -[CO<sub>2</sub>] efflux or "soil" respiration,  $F_E$ -export (erosion, leaching, or CH<sub>4</sub> efflux),  $F_A$ -aboveground litterfall. (Giardina CP et al., 2002)

## 5. RESULTS

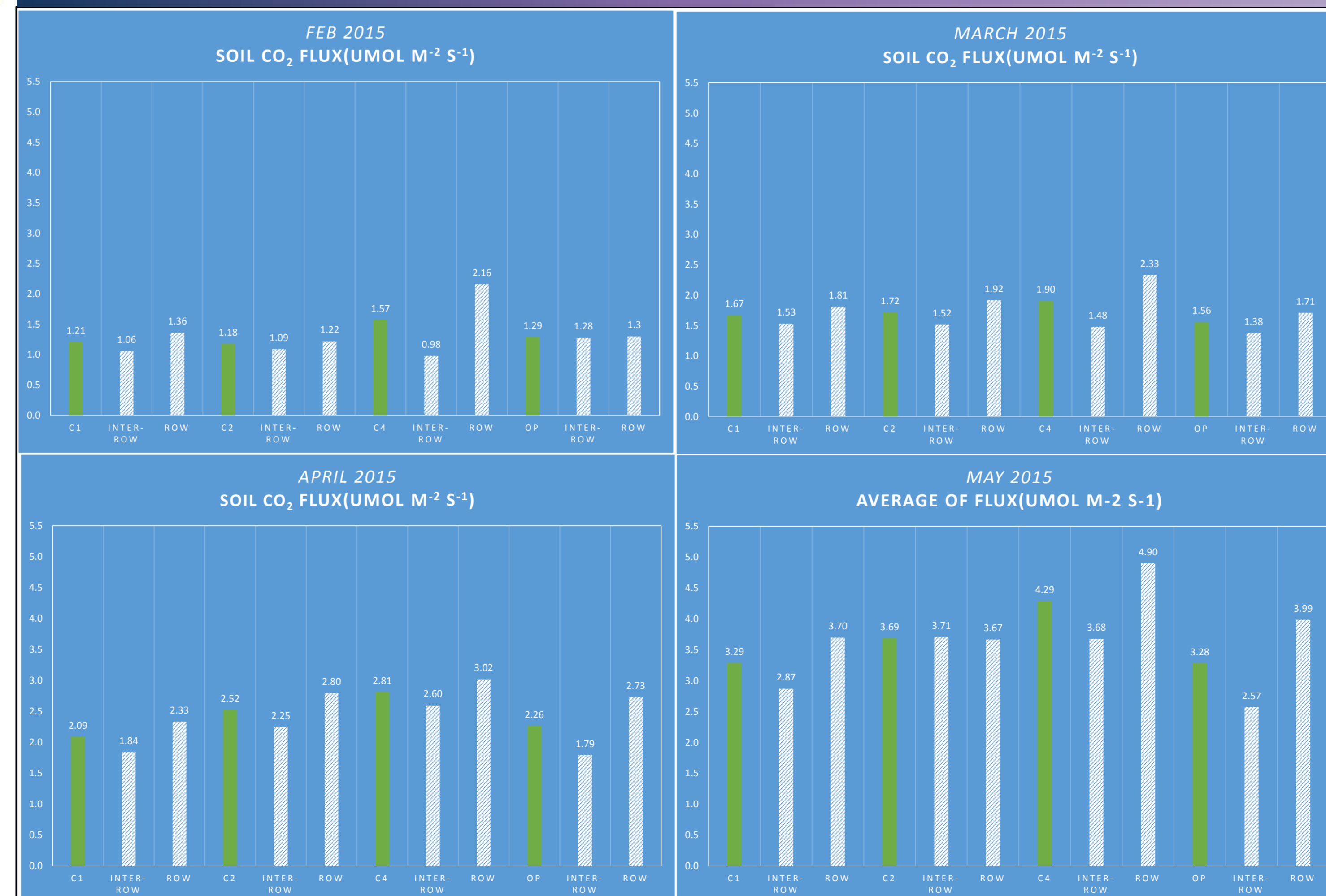


Figure 6. The Soil CO<sub>2</sub> Flux observations for four months, the average soil temperature at 10 cm was 5.5 °C in February, 10.38 °C in March, 14.84 °C in April, and 18.93 °C in May. OP (open pollinated) genetic plots have a high mortality. C4 (broad crown) has a relatively high soil CO<sub>2</sub> flux than C1 (moderate + crown) and C2(moderate crown).

### ACKNOWLEDGEMENTS

This research is supported by the project of Pine Integrated Network: Education, Mitigation, and Adaptation project (PINEMAP), USDA National Institute of Food and Agriculture (NIFA) and Forest Productivity Cooperative (FPC).

## 6. EXPECTED RESULTS

### Expected results

Soil carbon allocation patterns vary with genotypes. Soil C flux of broad crown ideotype may be higher than others due to the positive correlation between root areas and projected canopy area. The moderate+ crown (Clone 1) may be the most productive genotype, because of less canopy competition and less root respiration relative to the broad crown genotype. The soil C flux rate are relatively higher within row than inter-row due to intensive root respiration.

### Study Progression

- 1) 10/23-25/2014 Vegetation control for high silviculture plots.
- 2) 11/2014 Prepared materials (e.g. made collars from PVC pipe) for study.
- 3) 2/7-8/2015 Installed collars and litter fall collector on site, soil C, forest floor sampling.
- 4) 2/14/2015 The first soil CO<sub>2</sub> flux measurements.
- 5) 3/27, 4/26, 5/25 2015 Soil CO<sub>2</sub> flux measurements and litter fall collection.

