The effects of rainfall reduction and nutrient availability on net ecosystem productivity (NEP), Tier_3

Bracho, Noormets, Gonzalez, Martin, Vogel, Markewitz,
Sailer, Strahm, Samuelson, Will, Wilson
et al…….

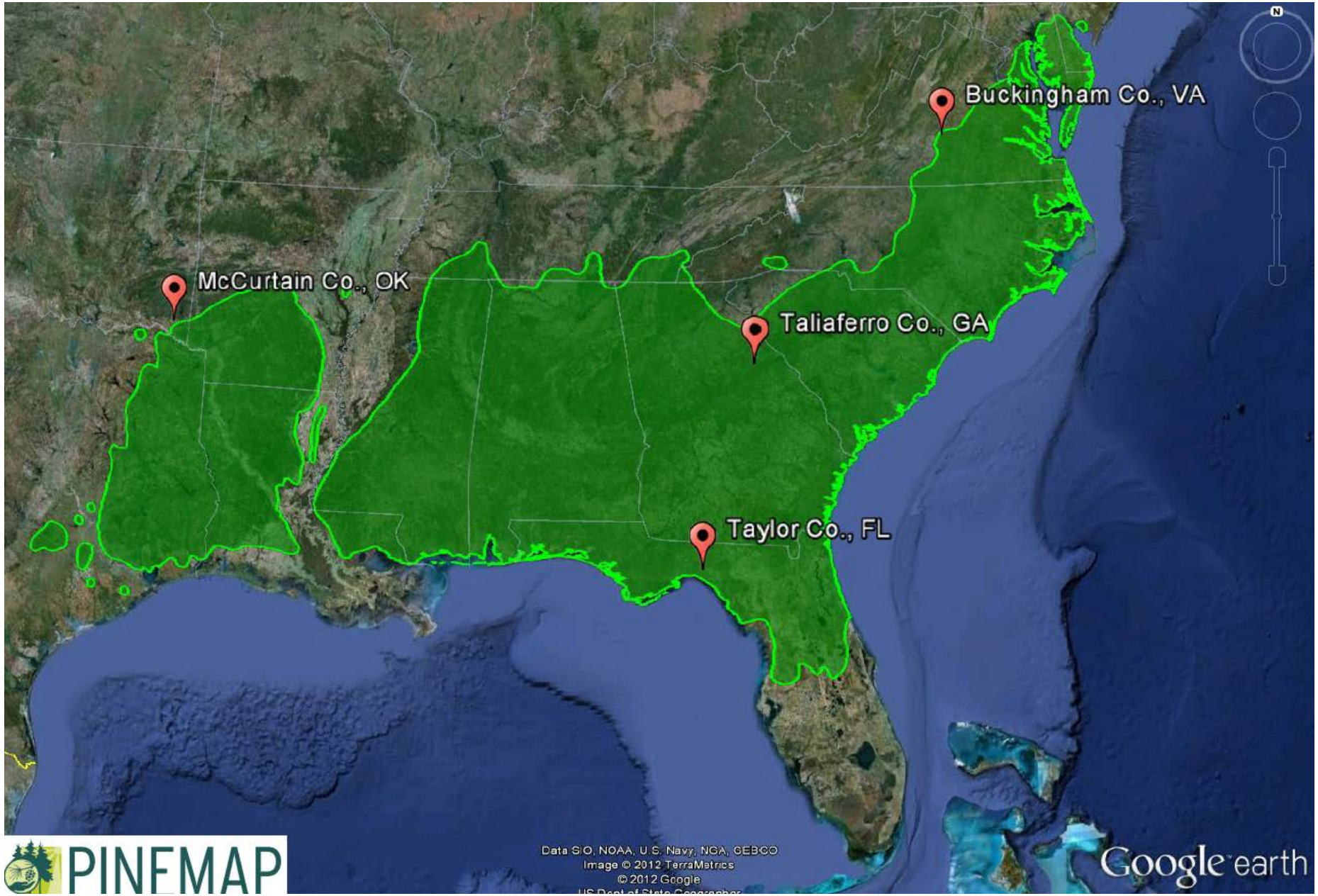
NEP: net gain or loss of carbon by an ecosystem in a time interval

$$NEP = NPP - R_H$$

NPP= Net primary productivity
biomass inventories.

R_H= Heterotrophic respiration
Root severing collars

Tier III "Throughfall Exclusion x Fertilization" network



Site	Latitude	Longitude	Annual precip (mm)	Annual Temp (°C)	Planting date
Florida	30°12’22”N	83°52’12”W	1450	19.4	12/1/2003
Georgia	33°37’35”N	82°47’54”W	1220	16.1	2/1/2006
Oklahoma	34°01’47”N	94°49’23”W	1300	16.6	1/1/2008
Virginia	37°27’37”N	78°39’50”W	1120	13.6	3/1/2003

Will et al 2015

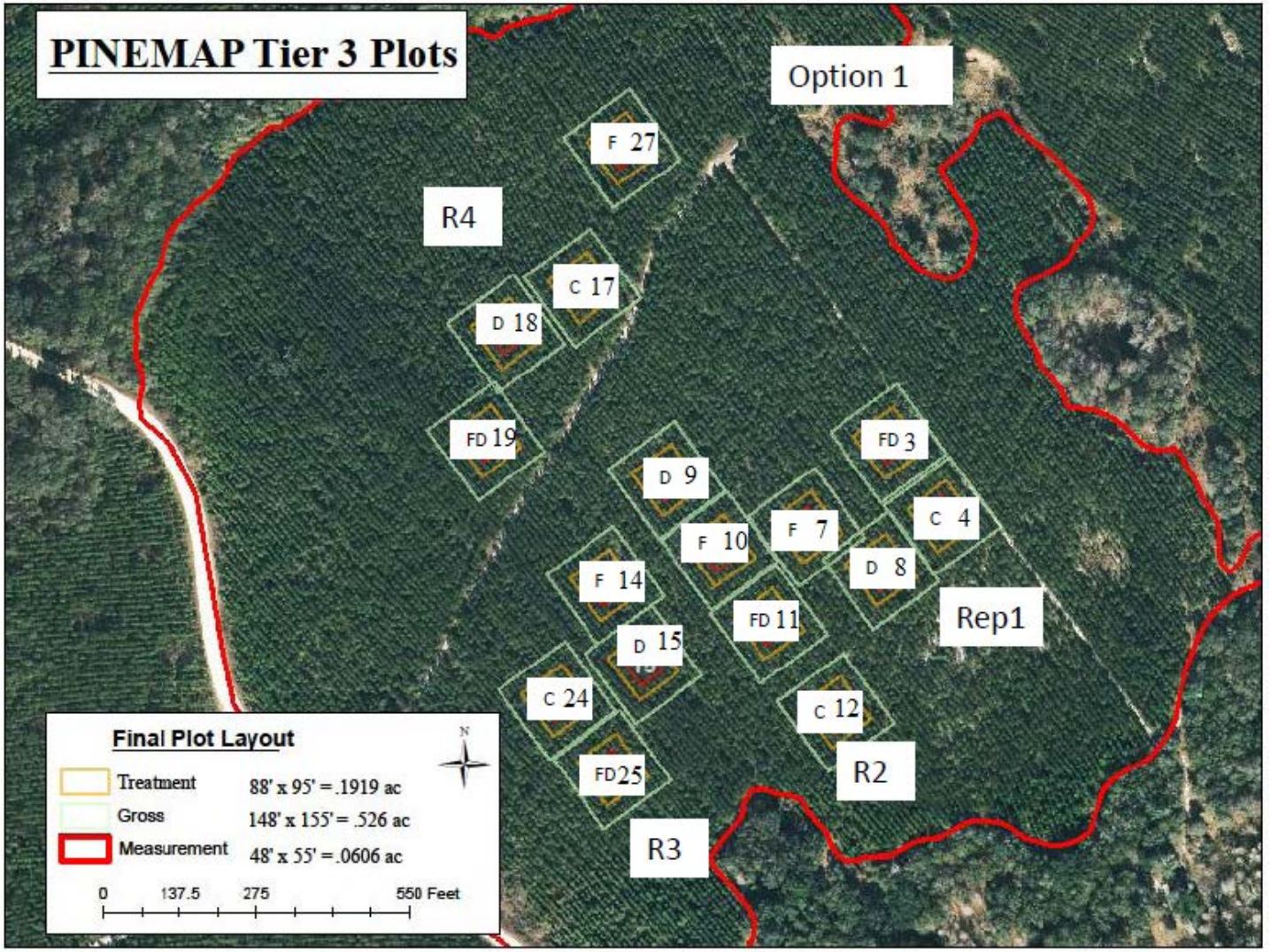
More information on sites set up see Will et al 2015

At each site:

4 Replications 2 X 2

Control (C), rain exclusion (D),

Fertilizer (F), Fertilizer + rain reduction (F*D)



Rain reduction

Plot-level Biomass and **NPP** Estimations

TIER 3 Dataset

Carlos A. Gonzalez

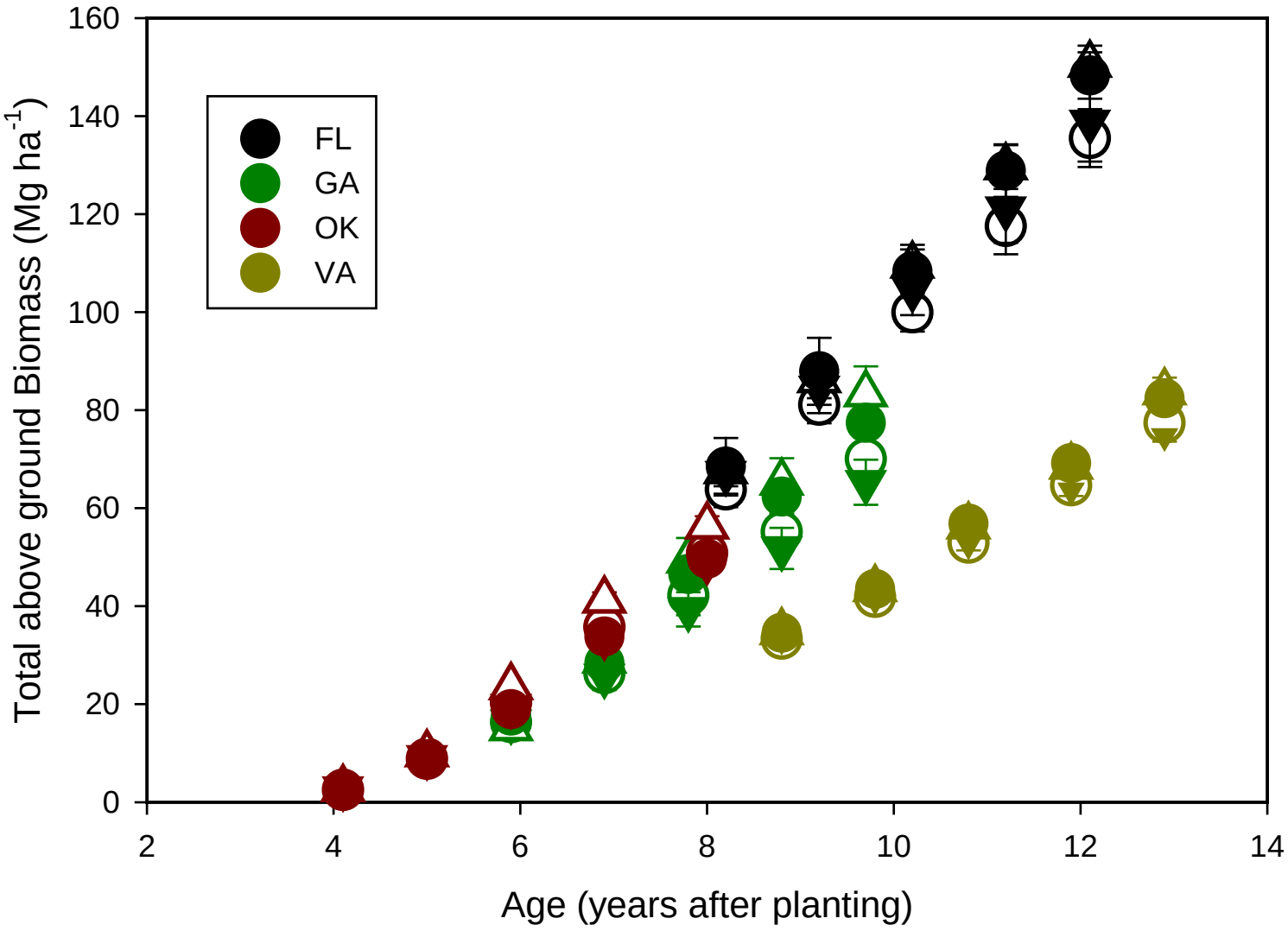
Inventories (dbh & height) dormant seasons 2011-2015

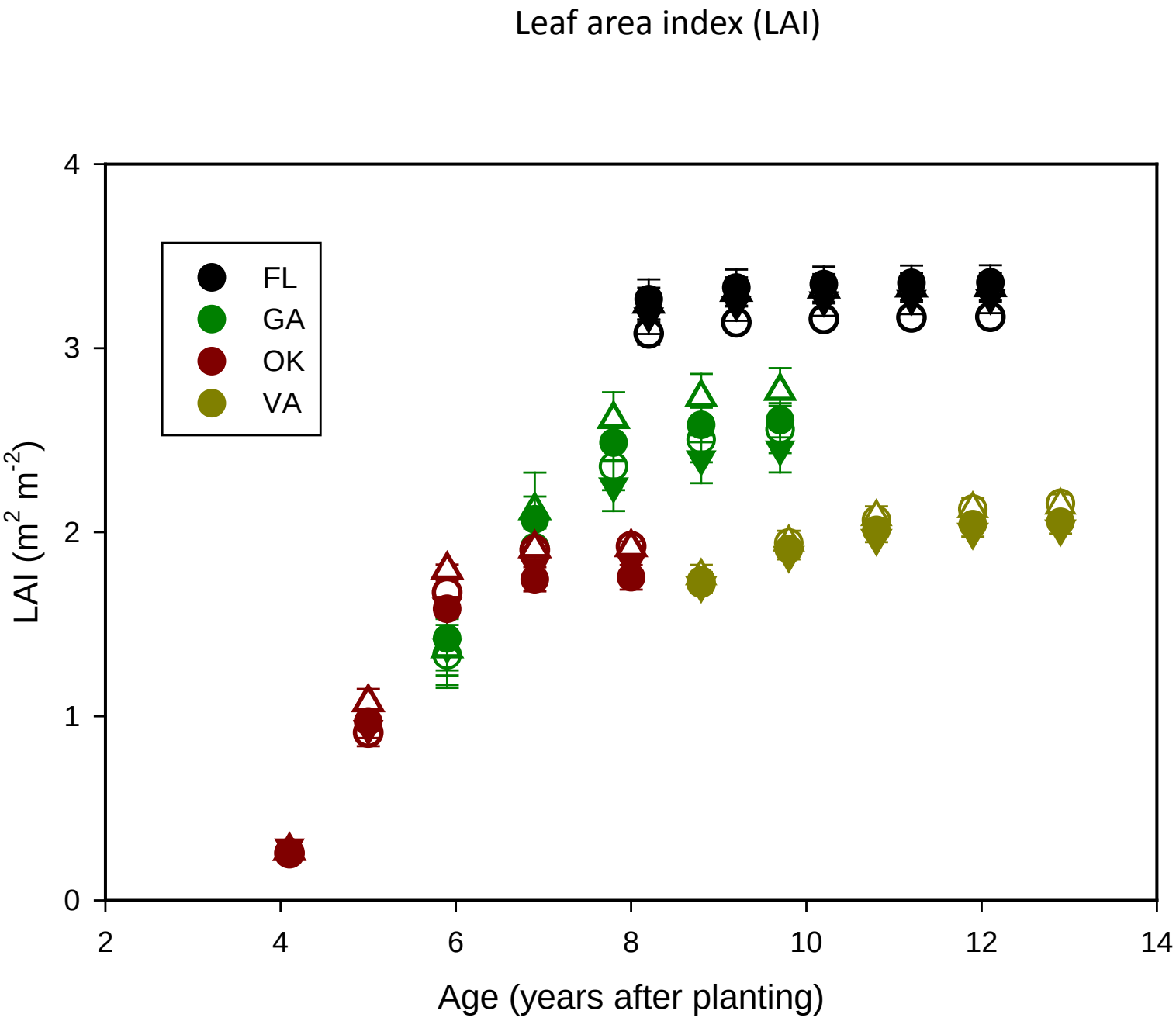
Above-ground biomass → Gonzalez-Benecke et al 2014

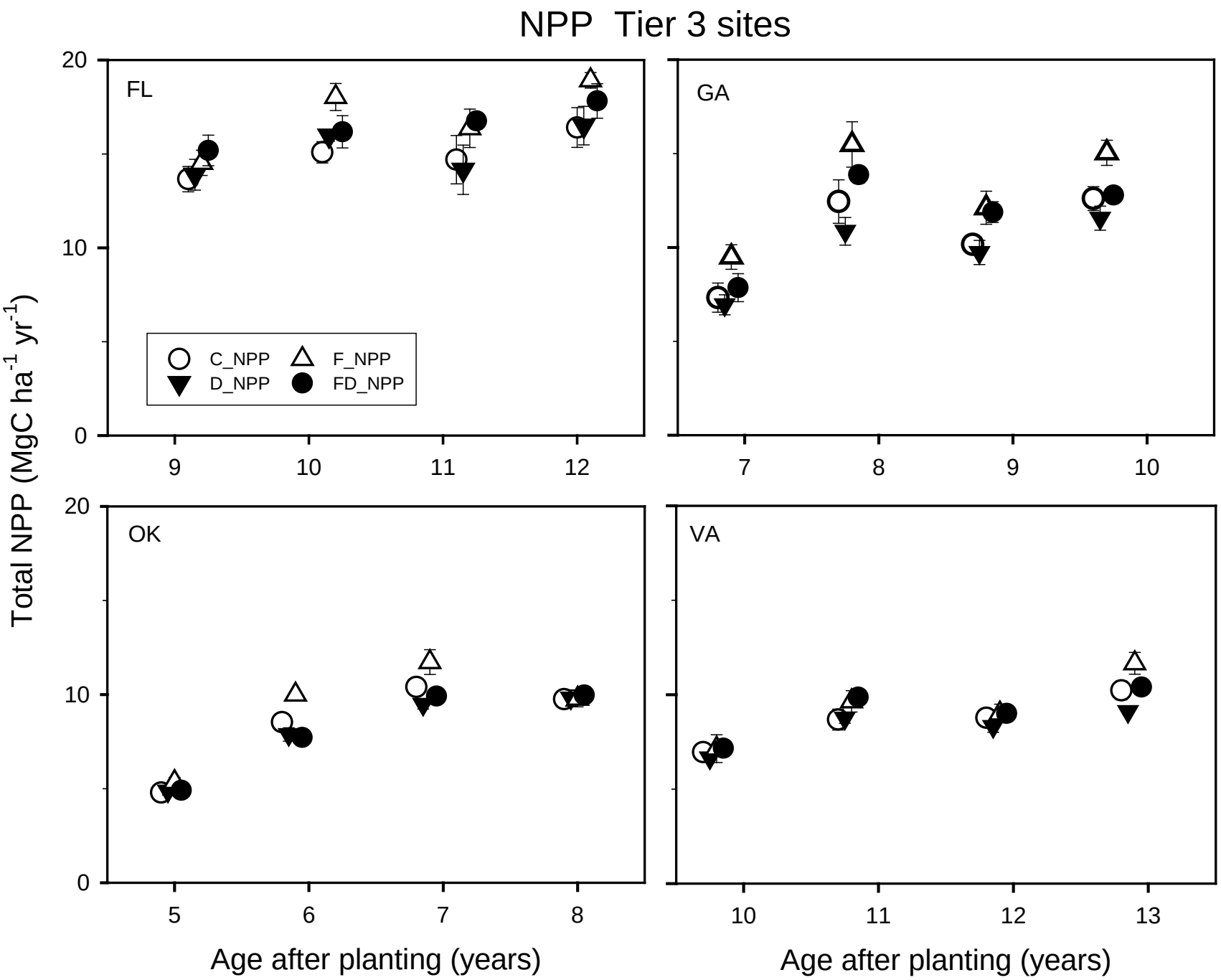
Above ground NPP (Mg ha^{-1} yr^{-1}) for each measurement interval estimated as the increment in Woody biomass + foliage production

For more information see Gonzalez-Benecke et al 2014

Above Ground Biomass




Leaf area index (LAI)
FL
GA
OK
VA
LAI (m2 m-2)
0
1
2
3
4
2
4
6
8
10
12
14
Age (years after planting)


NPP Tier 3 sites
FL
GA
OK
VA
C_NPP
F_NPP
D_NPP
FD_NPP
Total NPP (MgC ha-1 yr-1)
Age after planting (years)
Age after planting (years)
0
10
20
9
10
11
12
7
8
9
10
5
6
7
8
10
11
12
13

Main effects: Site, Fertilization(F), rain reduction(D) were tested on NPP using mixed models (proc mixed, SAS 9.4), block as a random variable.

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
SITE	3	246	168.84	<.0001
F	1	246	23.14	<.0001
D	1	246	5.05	0.0255
F*D	1	246	0.69	0.4062

Per site

Type 3 Tests of Fixed Effects Pr > F				
	FL	GA	OK	VA
F	0.0008	<.0001	0.6222	0.0147
D	0.7037	0.0105	0.5208	0.3003
F*D	0.4364	0.5860	0.7208	0.7258

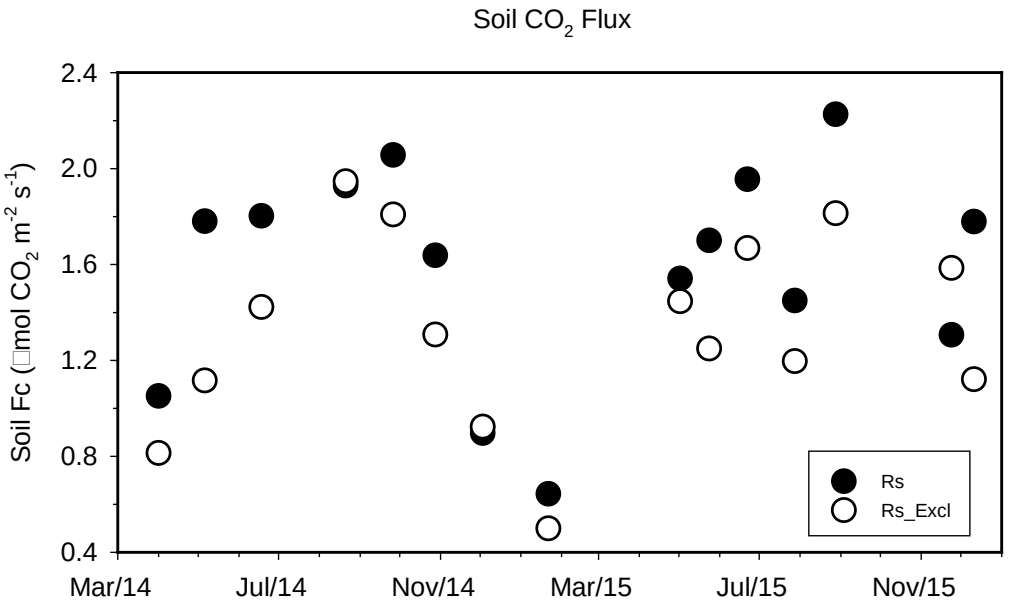
$$NEP = NPP - R_H$$

NPP= Net primary productivity
biomass inventories.

R_H= Heterotrophic respiration
Root severing collars

Soil respiration measurements (R_S & R_H):

All Tier3 sites with at least one year of paired R_S & R_H.
Soil temperature (Ts) & soil moisture (VWC)



Soil Respiration (R_S)
Model Soil respiration by treatment R_S=f(Ts,AGB)

Parameter	Control	Drought	Fertilized	D*F
Intercept	-0.5864	-0.7319	-0.7512	-0.9005
Tsoil	0.0753	0.0727	0.0703	0.0723
AGB	0.0034	0.0045	0.0053	0.0061
r^2	0.578	0.558	0.552	0.583

Tsoil = Soil temperature

AGB = Above ground biomass

SOIL TEMPERATURE

$$Ts_{daily} = f(Tair_{daily})$$

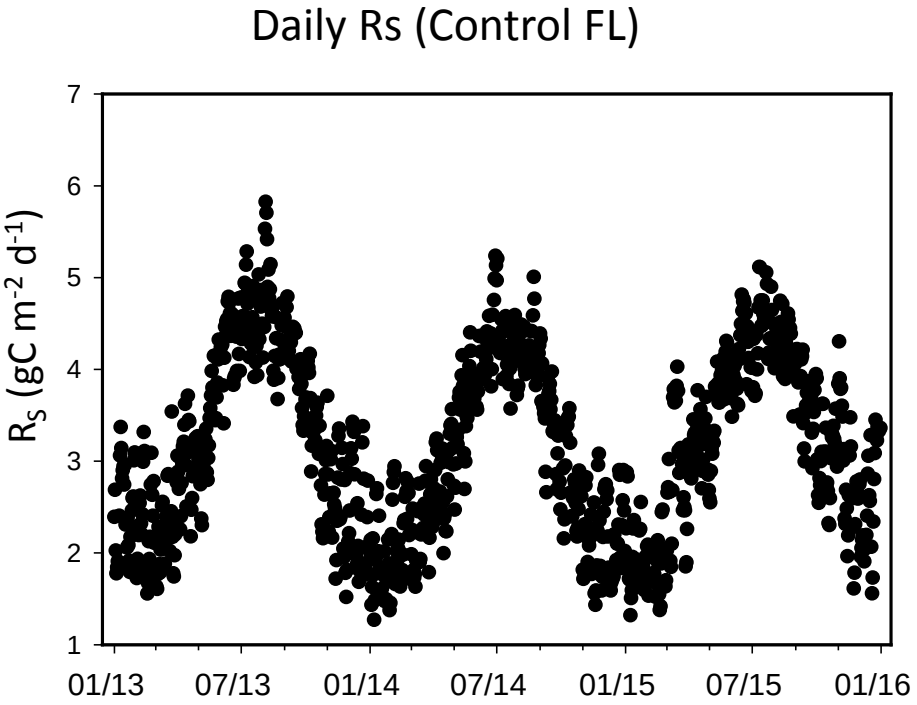
VA_Tier3. Treatment=Control

Analysis of Variance				
Source	Sum of Squares	Mean Square	F Value	Pr > F
Model	15.45724	15.45724	442.79	<.0001
Error	2.54835	0.03491		
Corrected Total	18.00559			

Root MSE	**0.18684**	**R-Square**	**0.8585**
Dependent Mean	2.73997	Adj R-Sq	0.8565
Coeff Var	6.81903		

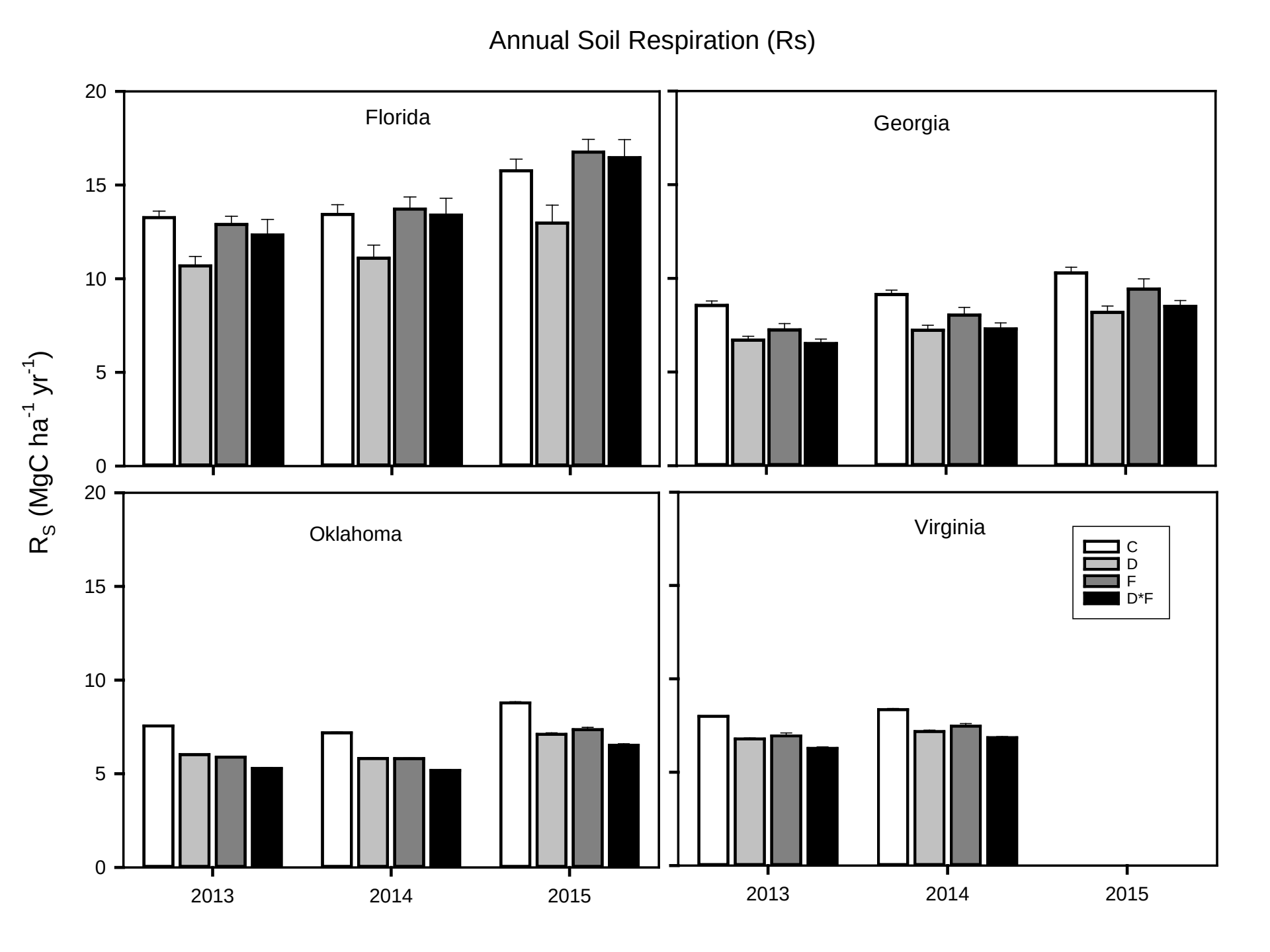
Parameter Estimates				
Variable	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1.81686	0.04889	37.16	<.0001
daily_Tair	0.05520	0.00262	21.04	<.0001

Soil C fluxes



Annual Soil respiration, 2013 (MgC ha^{-1} yr^{-1})

SITE	Control	Drought	Fertilized	F * D
FL	13.26312	10.68433	12.88935	12.32877
GA	8.554404	6.69927	7.242033	6.510947
OK	7.552679	6.020991	5.88519	5.284349
VA	7.991458	6.781768	6.942665	6.276846


Annual Soil Respiration (Rs)
Florida
Georgia
Oklahoma
Virginia
C
D
F
D*F
R_S (MgC ha^{-1} yr^{-1})
0
5
10
15
20
2013
2014
2015

Main effects: Site, Fertilization(F), rain reduction(D) were tested on Rs using mixed models (proc mixed, SAS 9.4), block as a random variable.

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Site	3	166	371.60	<.0001
F	1	166	1.09	0.2973
D	1	166	53.55	<.0001
F*D	1	166	13.13	0.0004

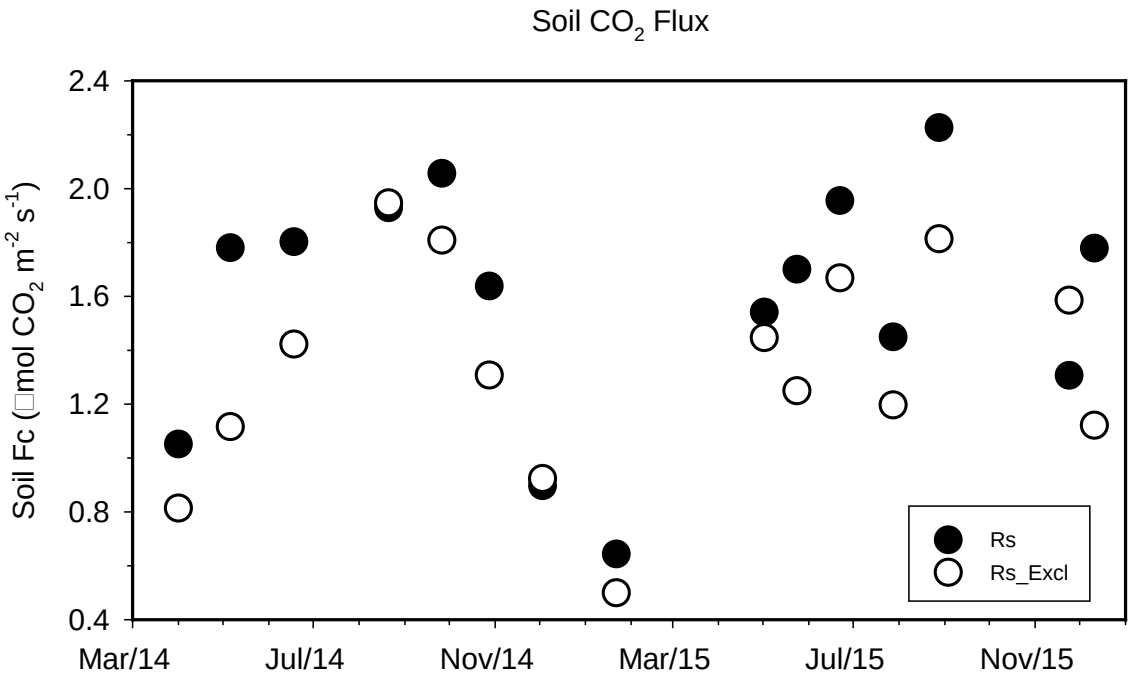
When tested by site, differences of least square means show
Opposite effects of fertilizer with increases in Florida and decrease at the other three sites.
Drought effect is negative for all sites.

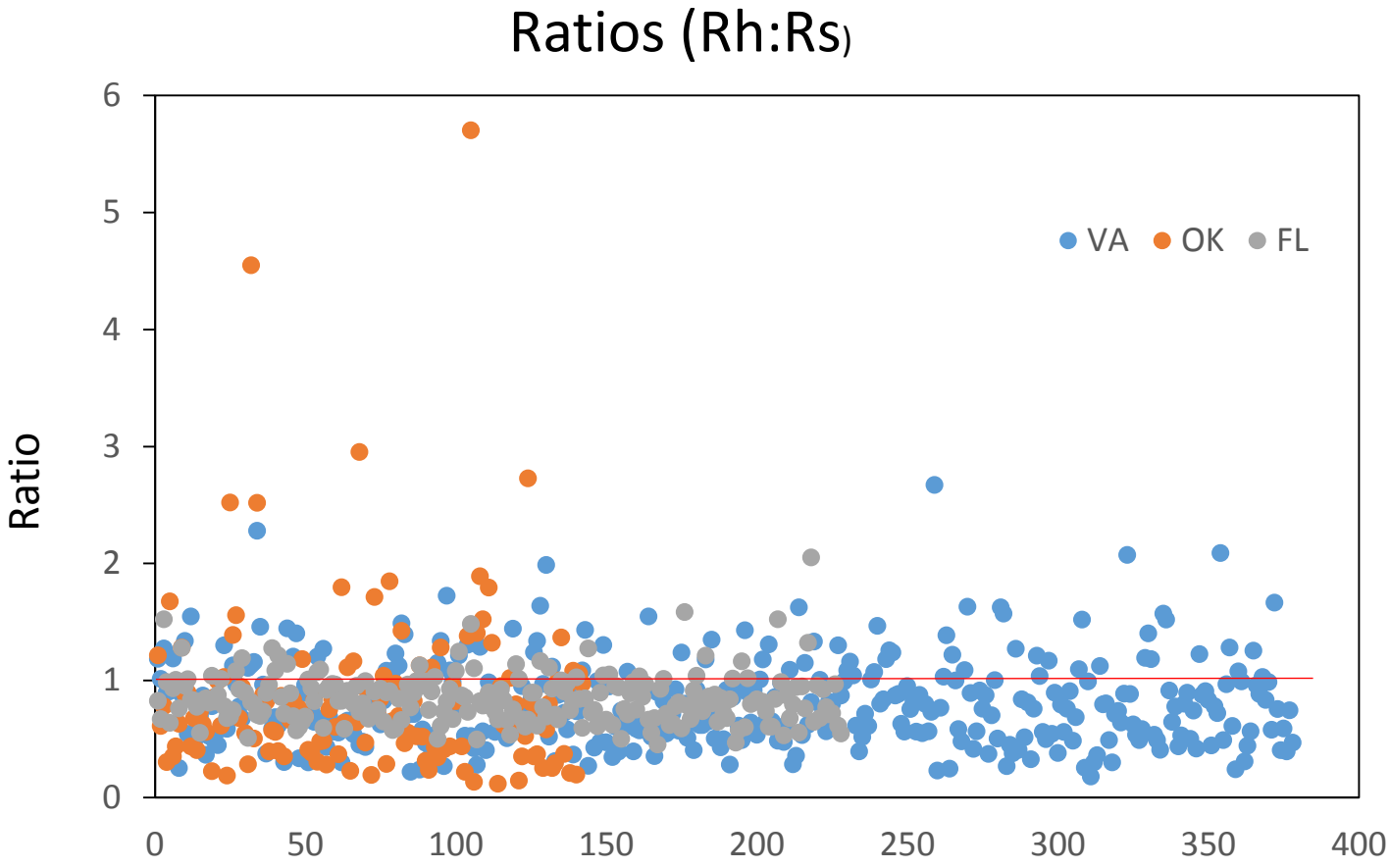
Heterotrophic respiration (R_H)

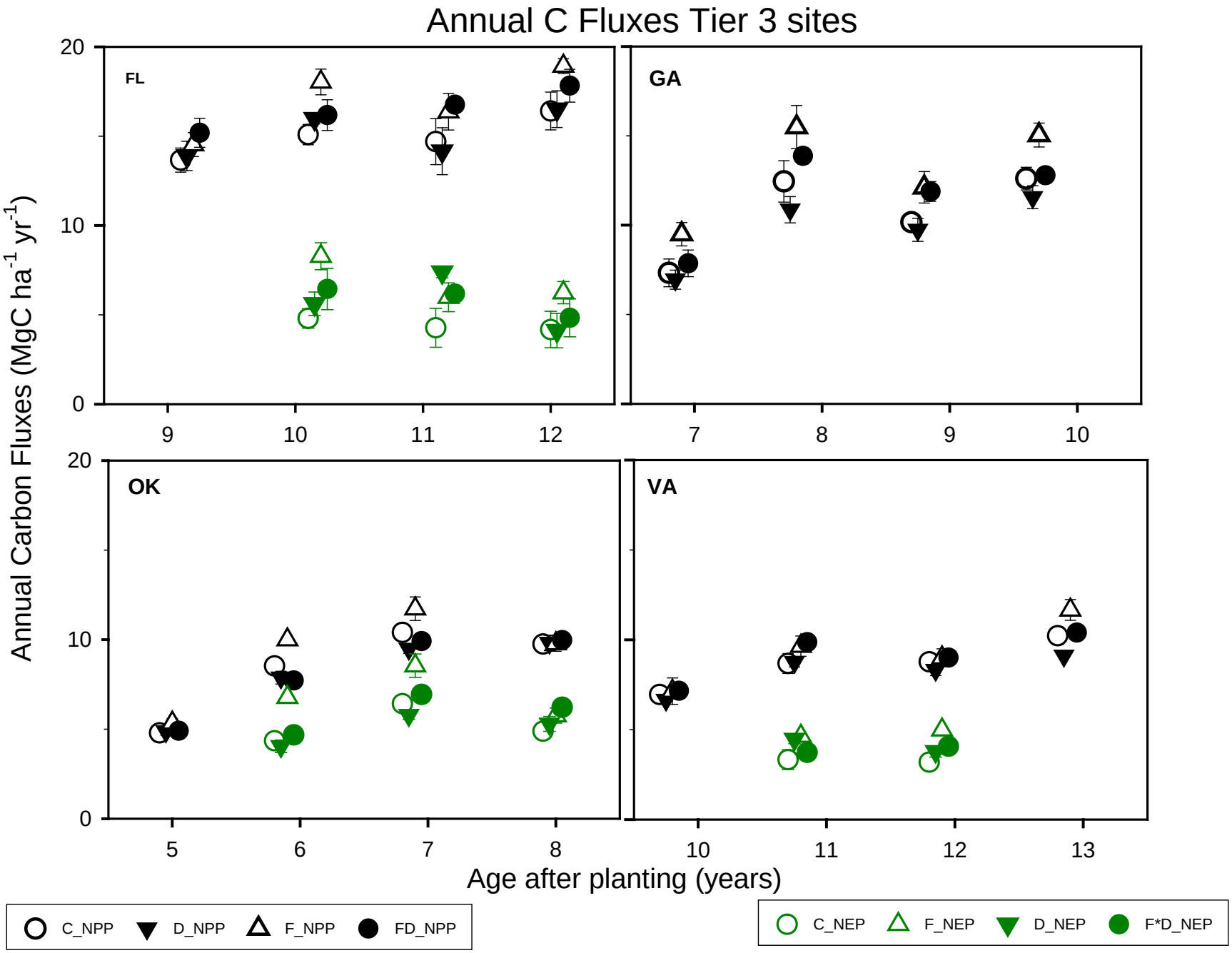
R_H ~Root severing collars

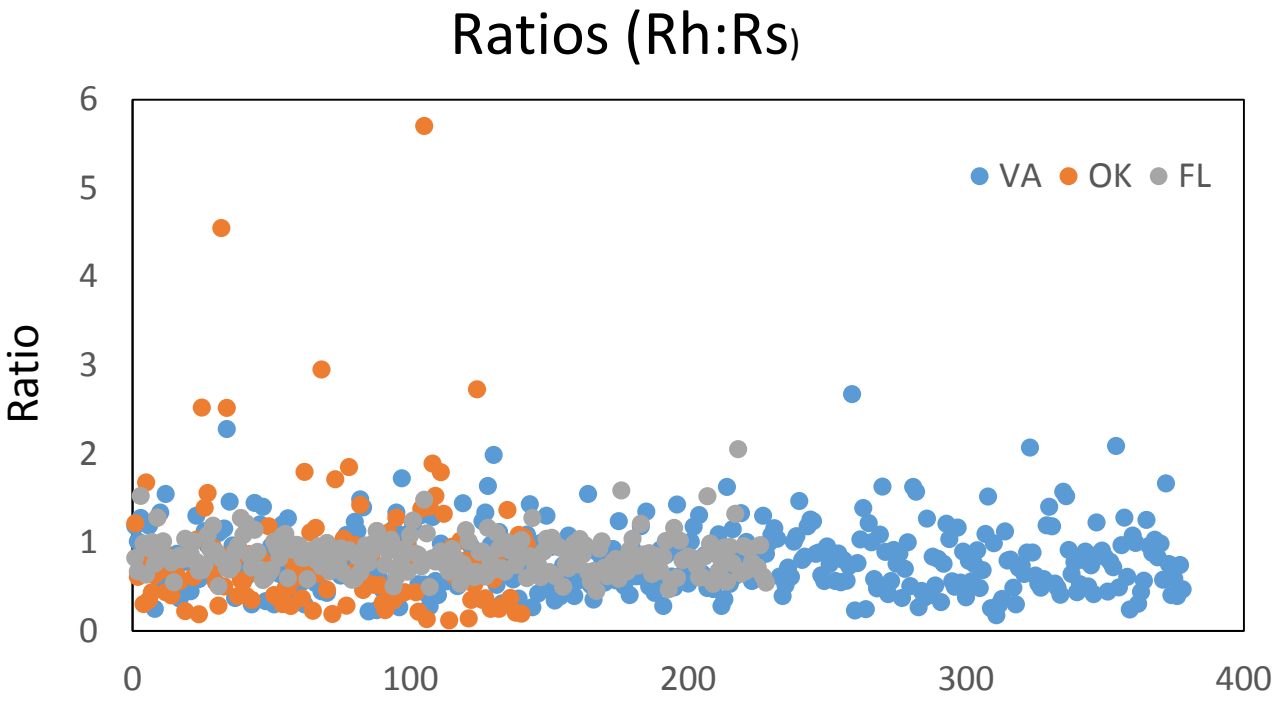
Paired R_S & R_H measurements: 60 – 90 days after installation:

Ratio (R_H:R_S)

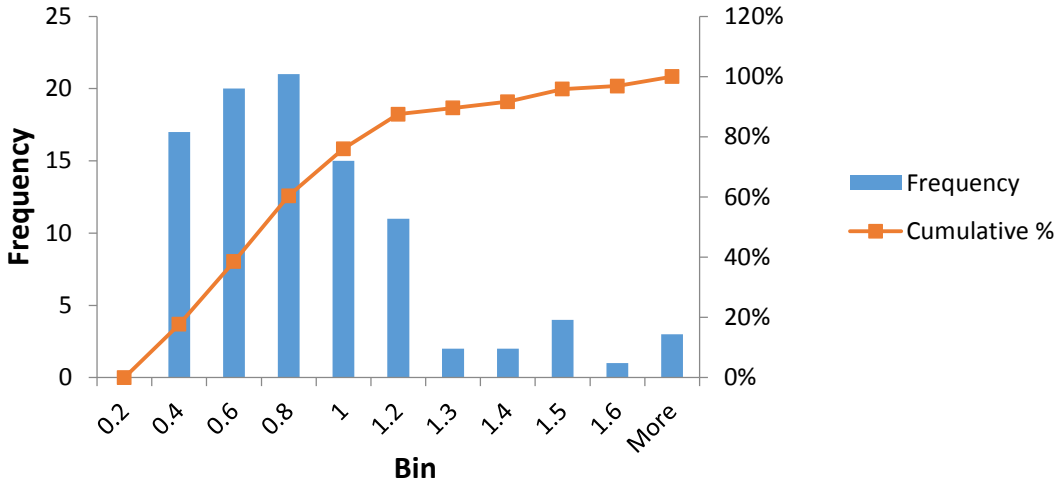


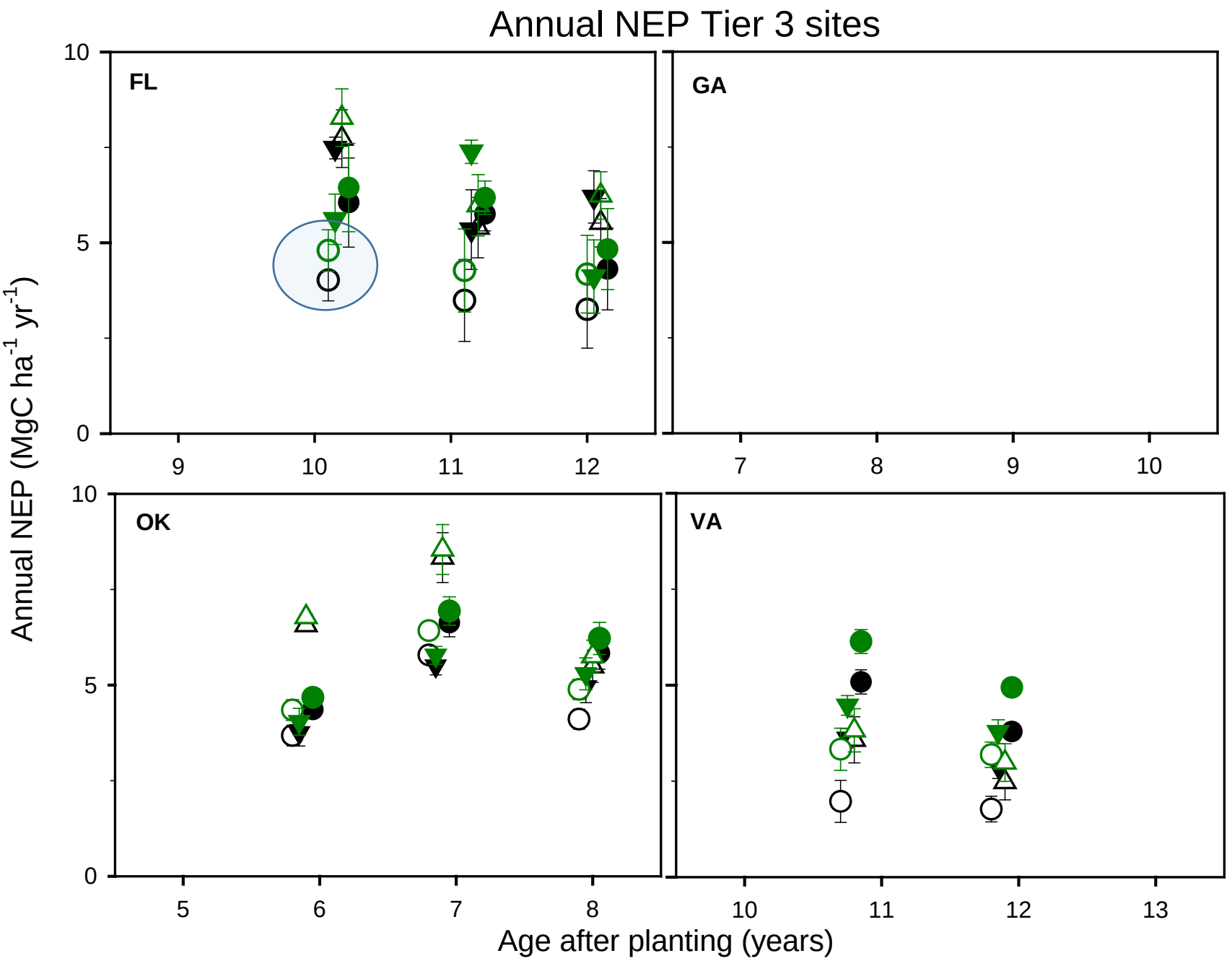

Ratios (Rh:Rs)
Ratio
0
1
2
3
4
5
6
0
50
100
150
200
250
300
350
400
VA
OK
FL


Annual C Fluxes Tier 3 sites
FL
GA
OK
VA
Annual Carbon Fluxes (MgC ha-1 yr-1)
Age after planting (years)
C_NPP
D_NPP
F_NPP
FD_NPP
C_NEP
F_NEP
D_NEP
F*D_NEP



Bin	Frequency	Cumulative %
0.2	0	0.00%
0.4	0	0.00%
0.6	6	10.53%
0.8	14	35.09%
1	22	73.68%
1.2	11	92.98%
1.3	2	96.49%
1.4	0	96.49%
1.5	1	98.25%
1.6	1	100.00%
More	0	100.00%
Total	57	




Annual NEP Tier 3 sites
FL
GA
OK
VA
Annual NEP (MgC ha-1 yr-1)
Age after planting (years)
10
5
0
9
10
11
12
7
8
9
10
5
6
7
8
10
11
12
13

DISCUSSION