

Modelling Forest Thinning Effects by Reduction of Leaf Area Index in JULES LSM

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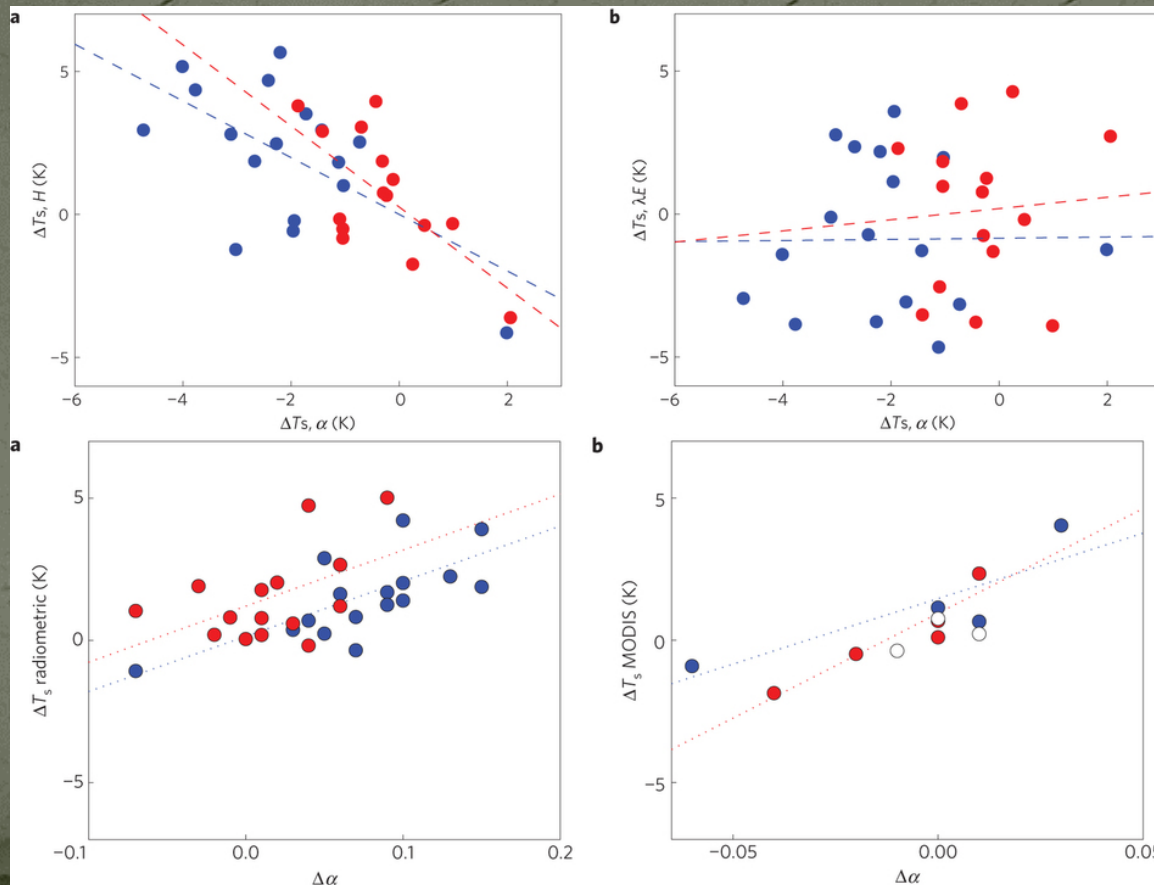


Outline

- Forest Management in Land Surface Model
- Thinning-induced changes of microenvironmental conditions
- The effects of thinning on stand transpiration and productivity
- Modelling thinning effects by modifying leaf area index

LMC Vs. LCC

- Impacts on surface temperature
 - Land Management Change (LMC) \equiv Land Cover Change (LCC) [Luyssaert *et al.* 2014]

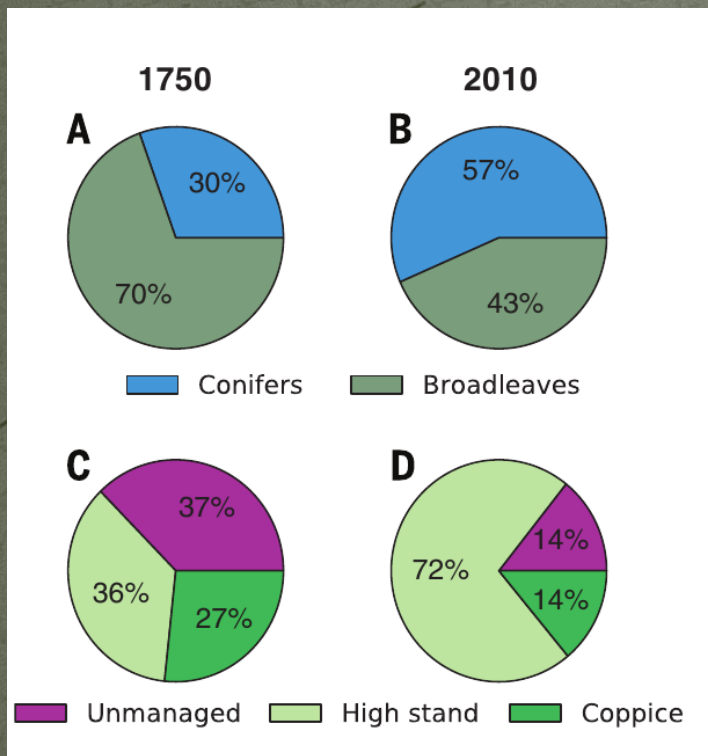


Biophysical effects of **land management change**, or **land cover change**

Forest Management Effects

- Biogeochemical changes
 - Carbon sink strength
 - Direct carbon uptake capacity
 - GHGs emissions
- Biophysical changes
 - Forest structural changes
 - Albedo, Energy partitioning to sensible heat flux
 - Water and Energy fluxes

Consequence of Forest Management



Contribution to changes since 1750

	ΔRF due to GHGs ($W m^{-2}$)	ΔRF due to surface change ($W m^{-2}$)	ΔT_a , summer (K)	Δ Precipitation, summer (mm per season)	Δ Atmospheric carbon (Pg C) [†]
Global					
Greenhouse gas emissions	2.98* [‡]	0.00	1.71* [‡]	-6	247§
European					
Land-use change	0.01*	0.11* [¶]	0.12* [#]	-3	3.1
Land-cover change	-0.01	0.12* [¶]	0.02* [¶]	0	-0.7**
Forest management	0.02	-0.01	0.10* [#]	-3* ^{††}	1.9
Species conversion	-0.01	0.00	0.08* [#]	-4* ^{††}	-0.6 ^{††}
Wood extraction	0.03	-0.01	0.02*	1	2.7

[Naudts et al. 2016]

Thinning?

- Partial removal of trees from forest plantations
- Objects
 - Reduce competition intensity among trees
 - Produce more valuable trees
 - Reduce natural fire risk
 - Promote the forest health

Before



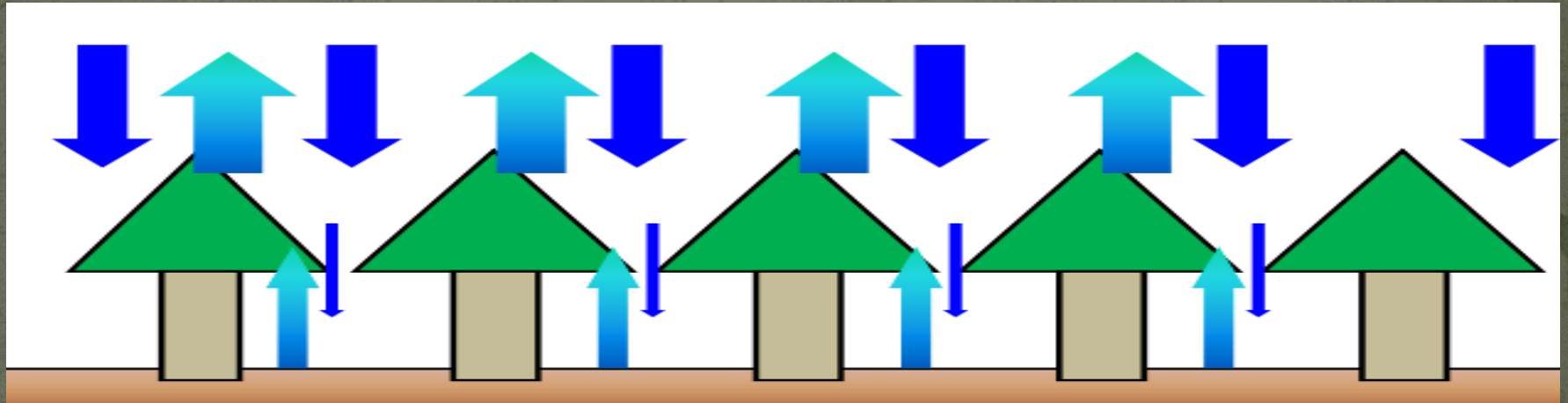
After



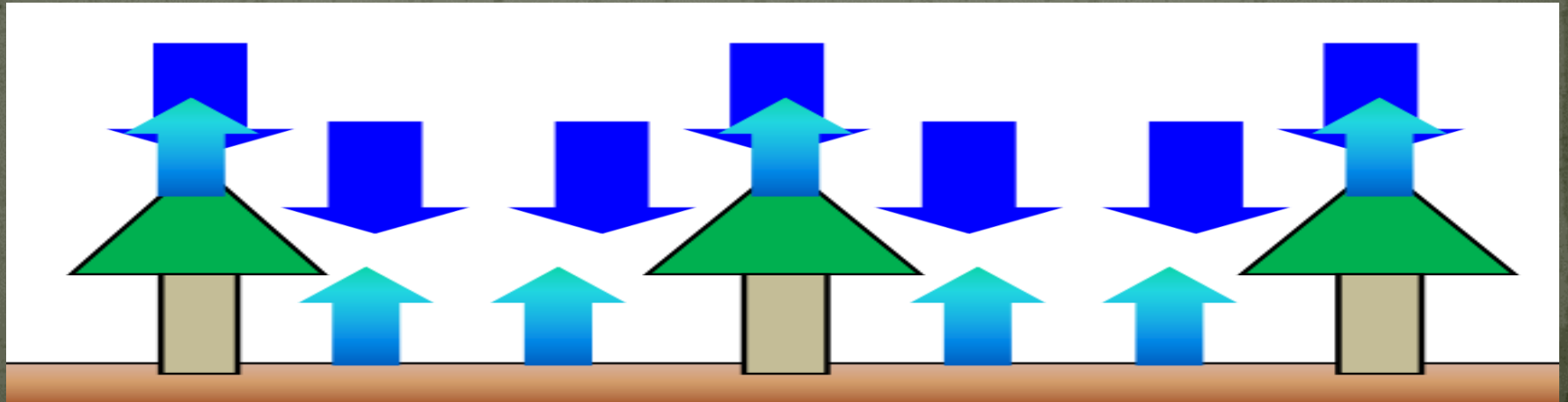
< Image source : www.qlg.org/pub/act/Inf/Inf1.htm >

Schematic Representation of Thinning

Before



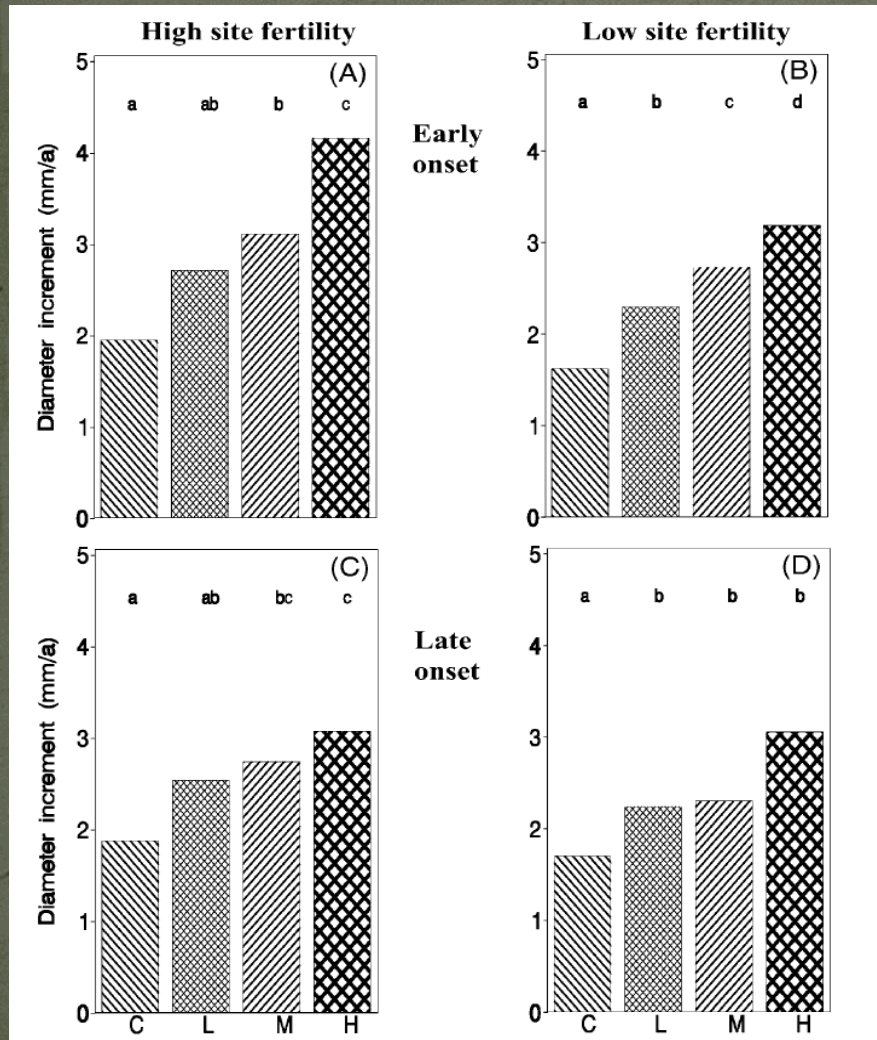
After



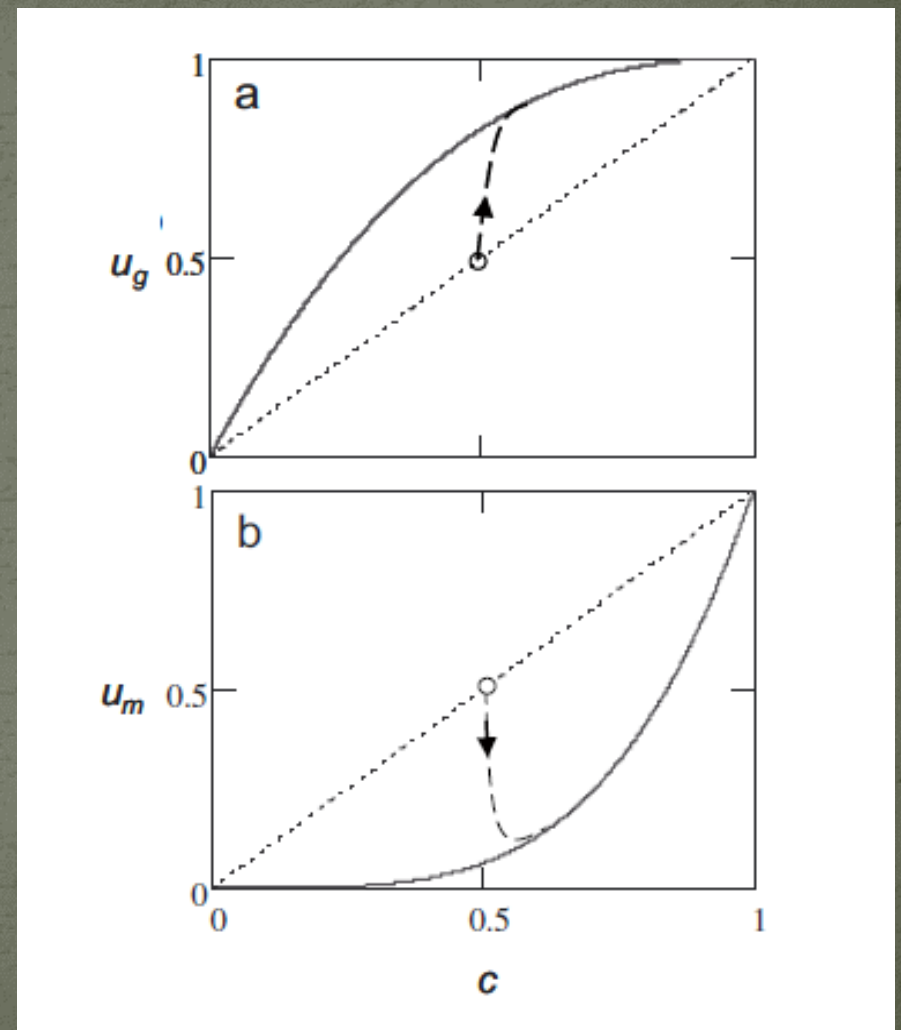
Changes of Environmental and Physiological Conditions by Thinning

+	-
Soil Water Content ↑ [Lagergren et al., 2008; Simonin et al., 2007]	Leaf Area ↓
Competition ↓	Basal Area ↓
Hydrological Conductivity ↑ [Shinozaki et al., 1964a; b]	Damage (Stress) [Harrington and Reukema, 1983]
Fertilization effect [Wollum and Schubert, 1975]	

Thinning Effects on Productivity



[Mäkinen *and* Isomäki, 2004]



[Franklin *et al.*, 2009] 9/30

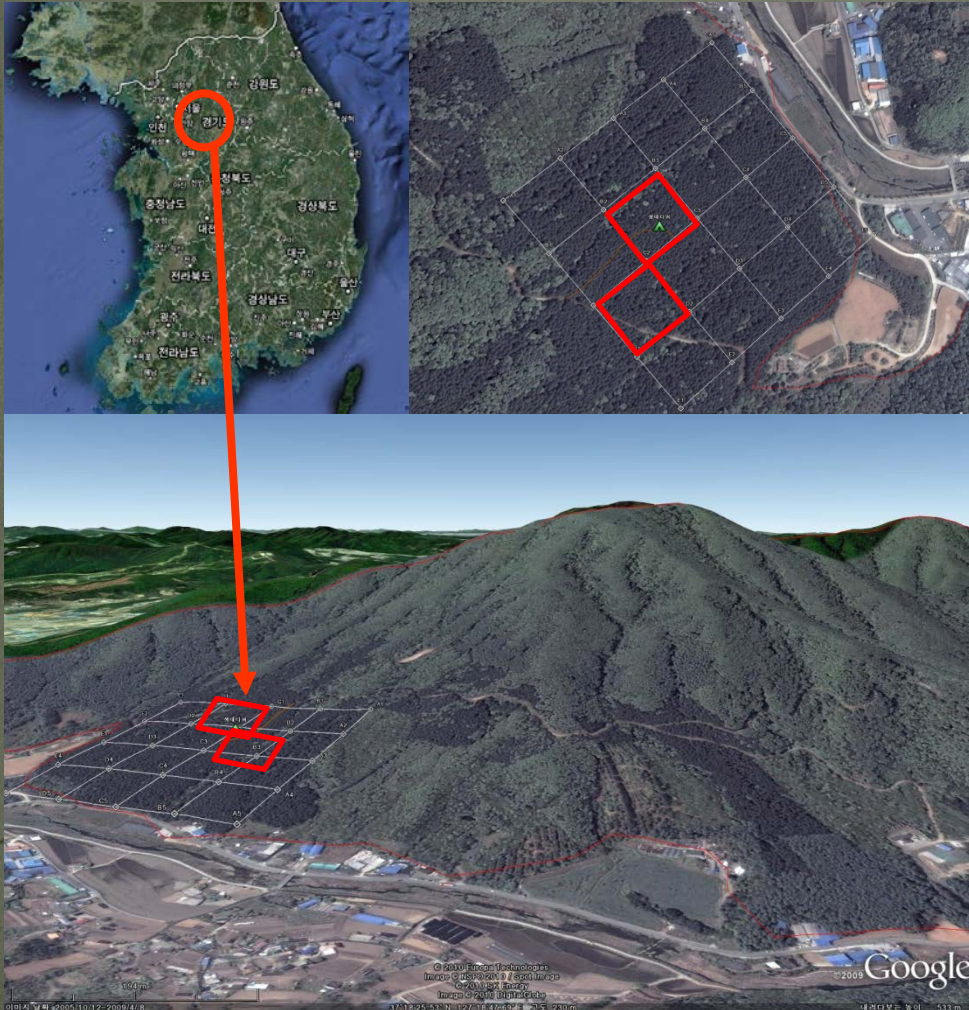
The Objectives

- Quantify the effects of thinning on stand transpiration and productivity
- Modelling thinning effects with JULES land surface model

Part 1.

Quantification of Thinning Effects on Stand Transpiration and Productivity

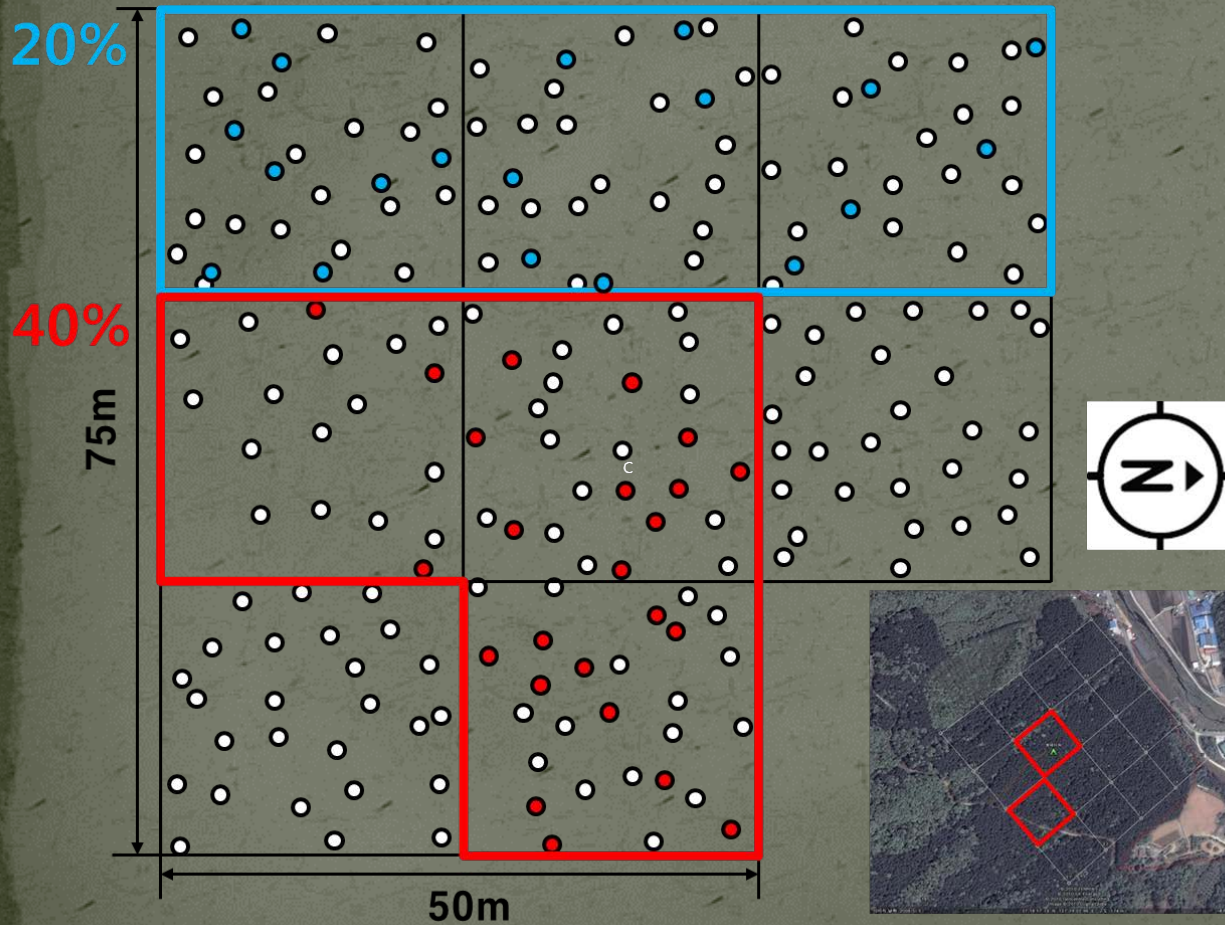
Study Site



Mt. Taehwa Gyeonggi-Do, Korea

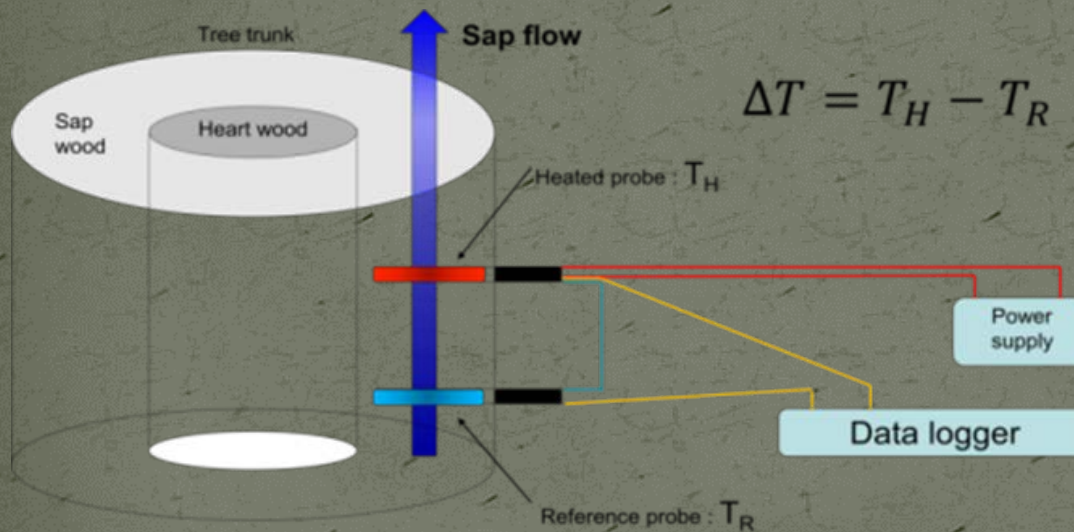
Thinning area (ha)	0.54
Altitude (m)	129~219
Aspect	NE 50~60
Annual precipitation(mm)	1329.2
Annual mean air temperature (°C)	10.3
Tree height (m)	19.1
Mean DBH (cm)	27.9
Stand density (no./ha)	440

Thinning Treatments



Stand Transpiration - Sapflux Density

- Thermal dissipation probe methods (Granier, 1985)



Stand Productivity

- Allometric equation

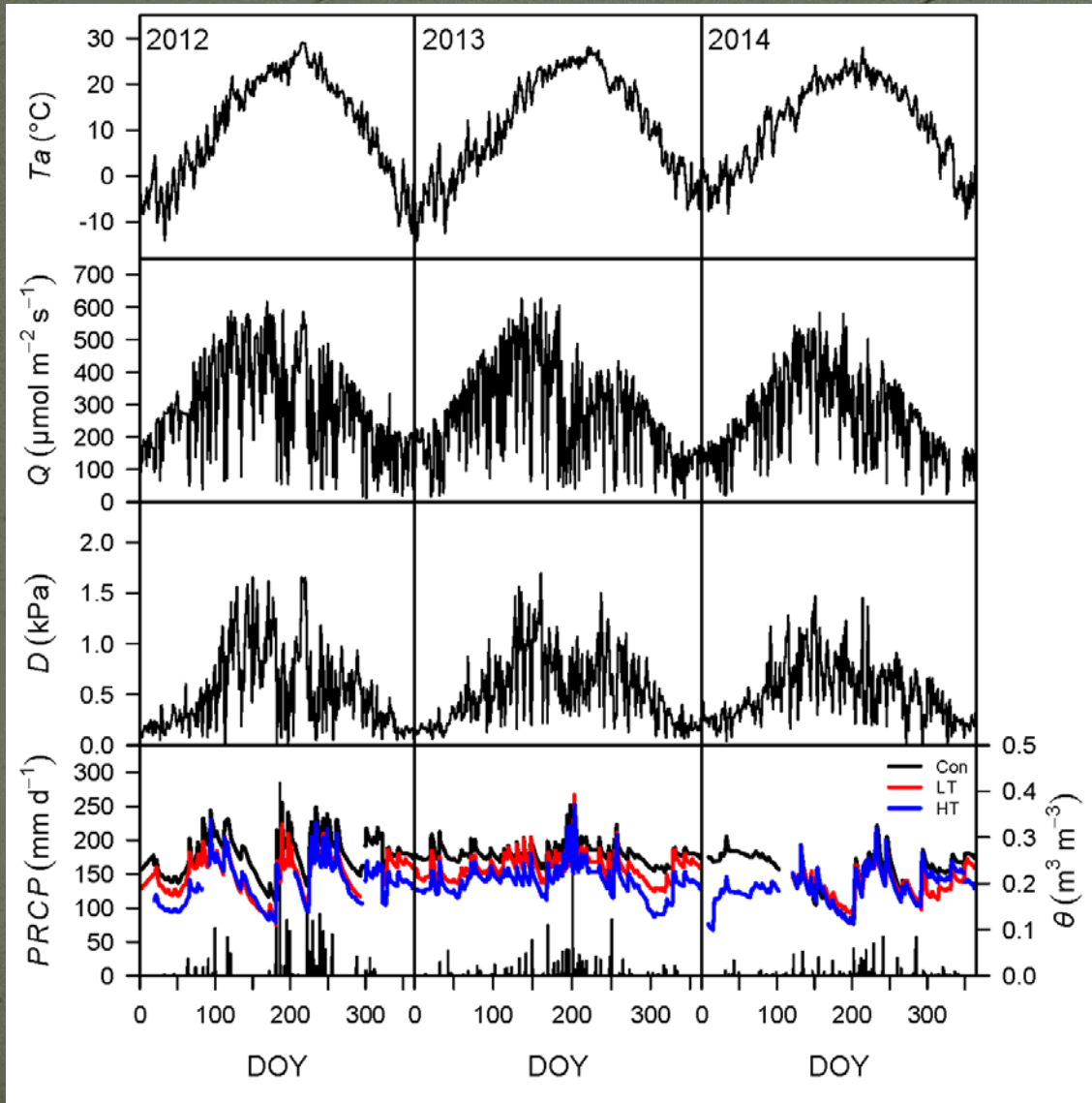
$$Y = 0.2849 * (DBH)^{2.0553}$$

[Ryu et al. 2014]

- Dendrometer

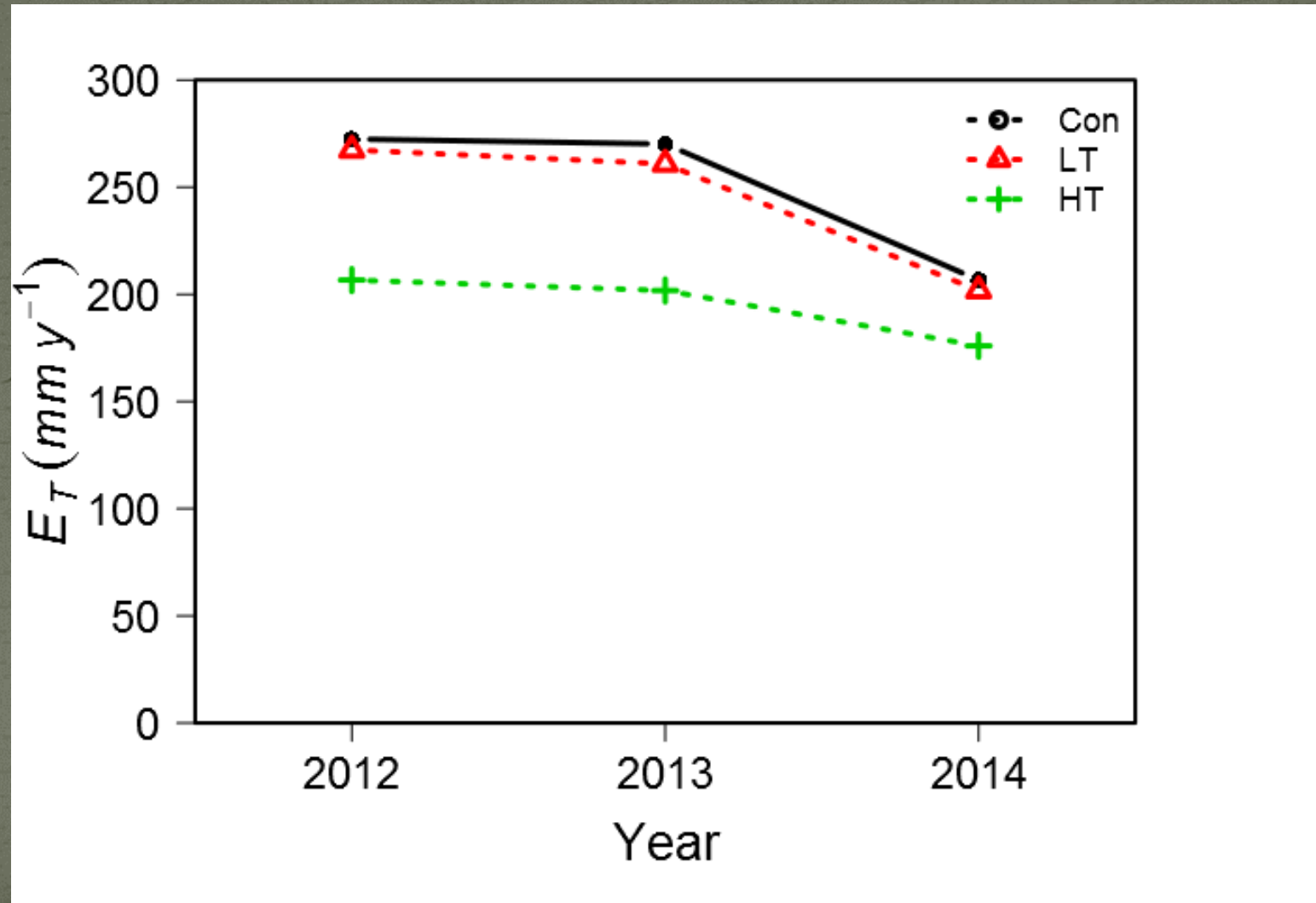


Environmental conditions

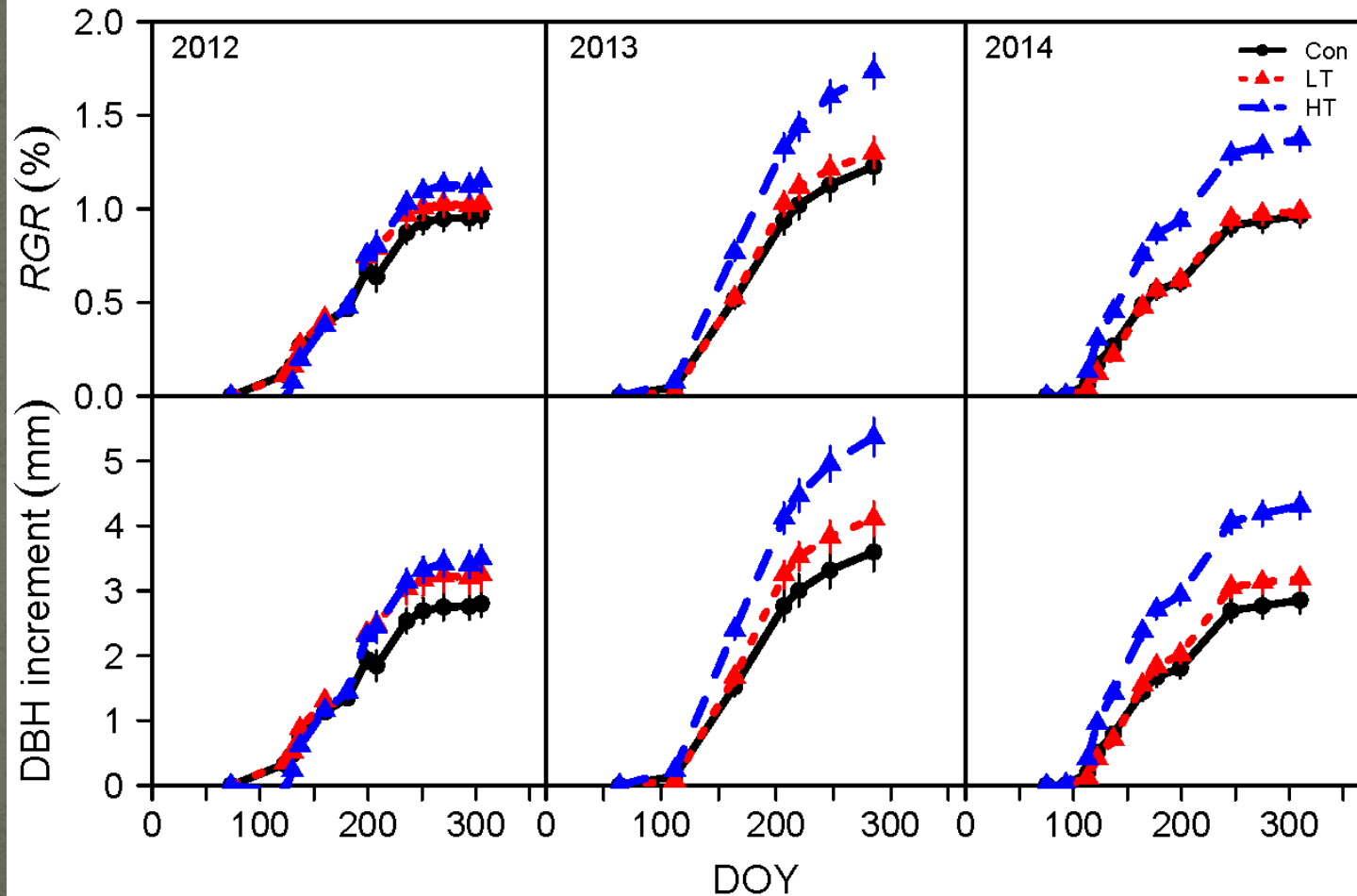


	2012	2013	2014
Ta	10.7	11.0	11.4
Q	293.4	271.1	262.4
D	0.53	0.53	0.52
PRCP	1685.6	1366.9	791.5

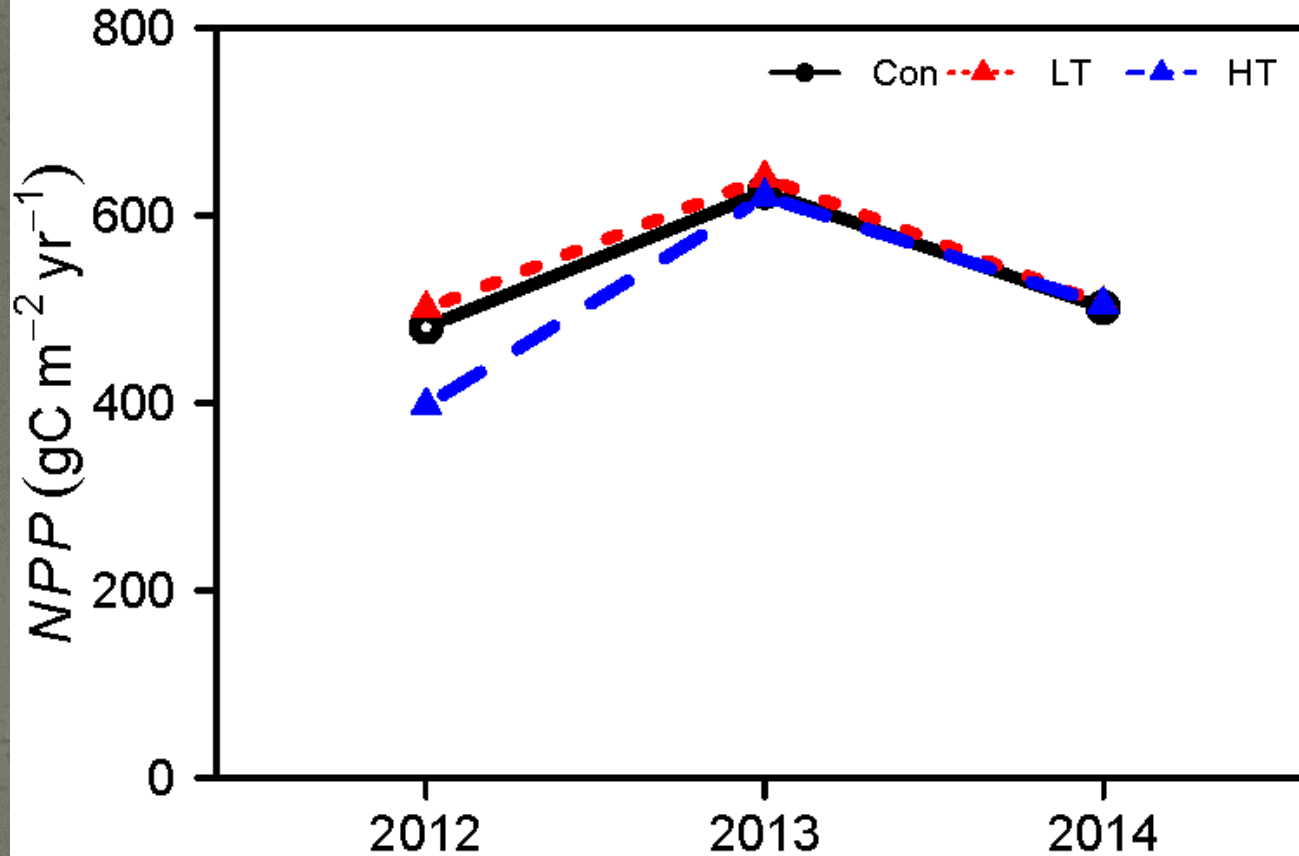
Thinning - Stand Transpiration



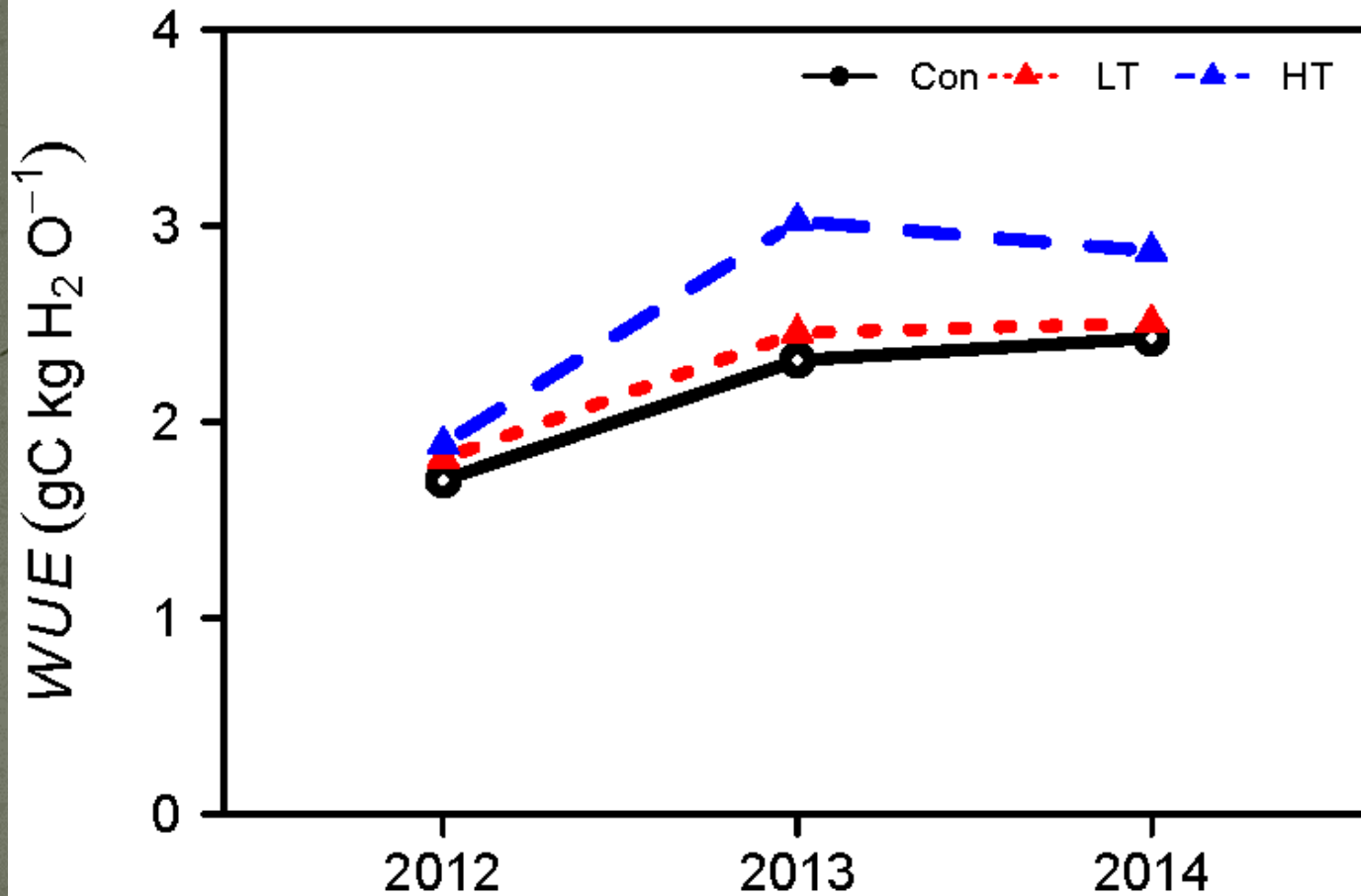
Thinning - Diameter Growth



Thinning - Stand Productivity



Thinning - Water Use Efficiency

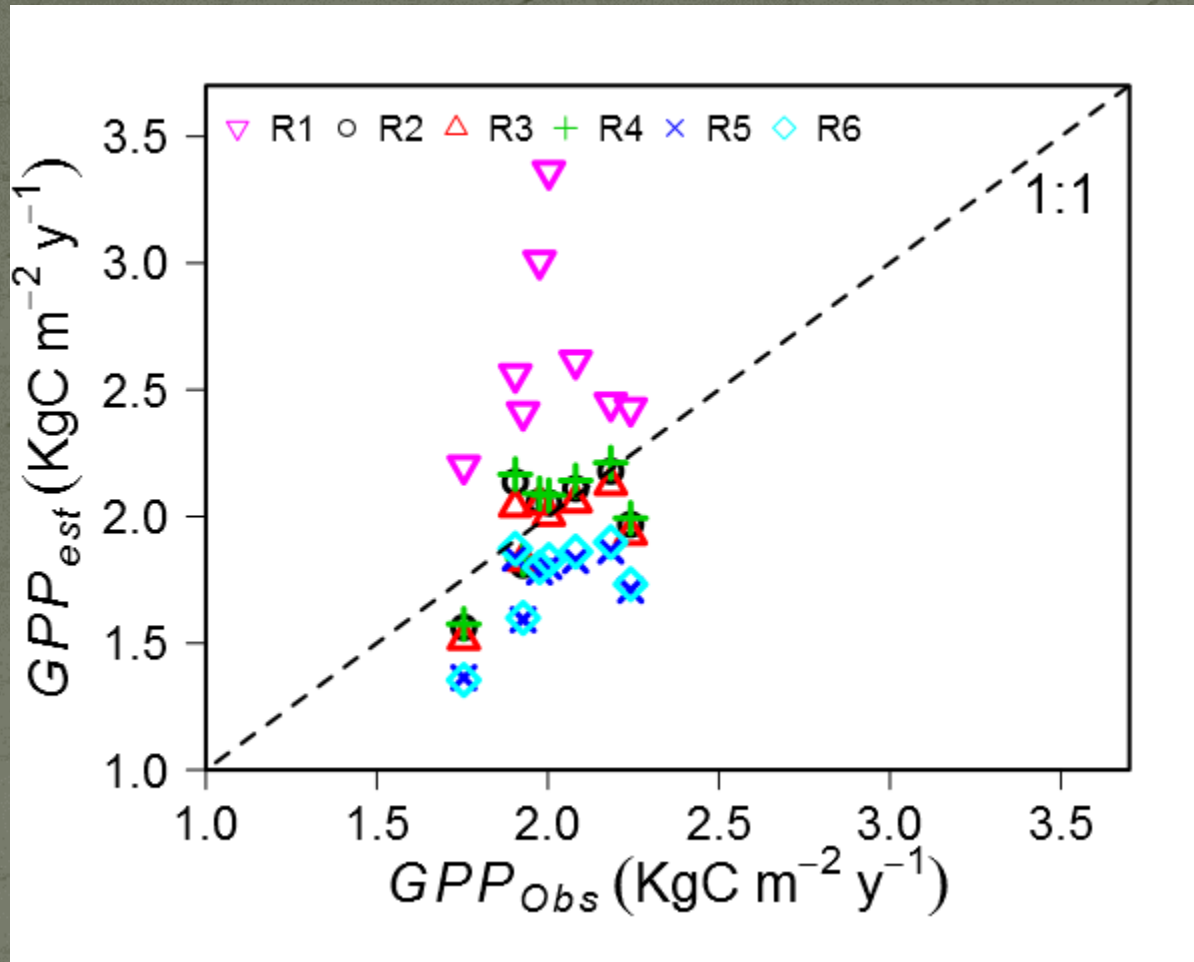


Part 2.
**Modelling Thinning Effects by
Reduction of Leaf Area Index**

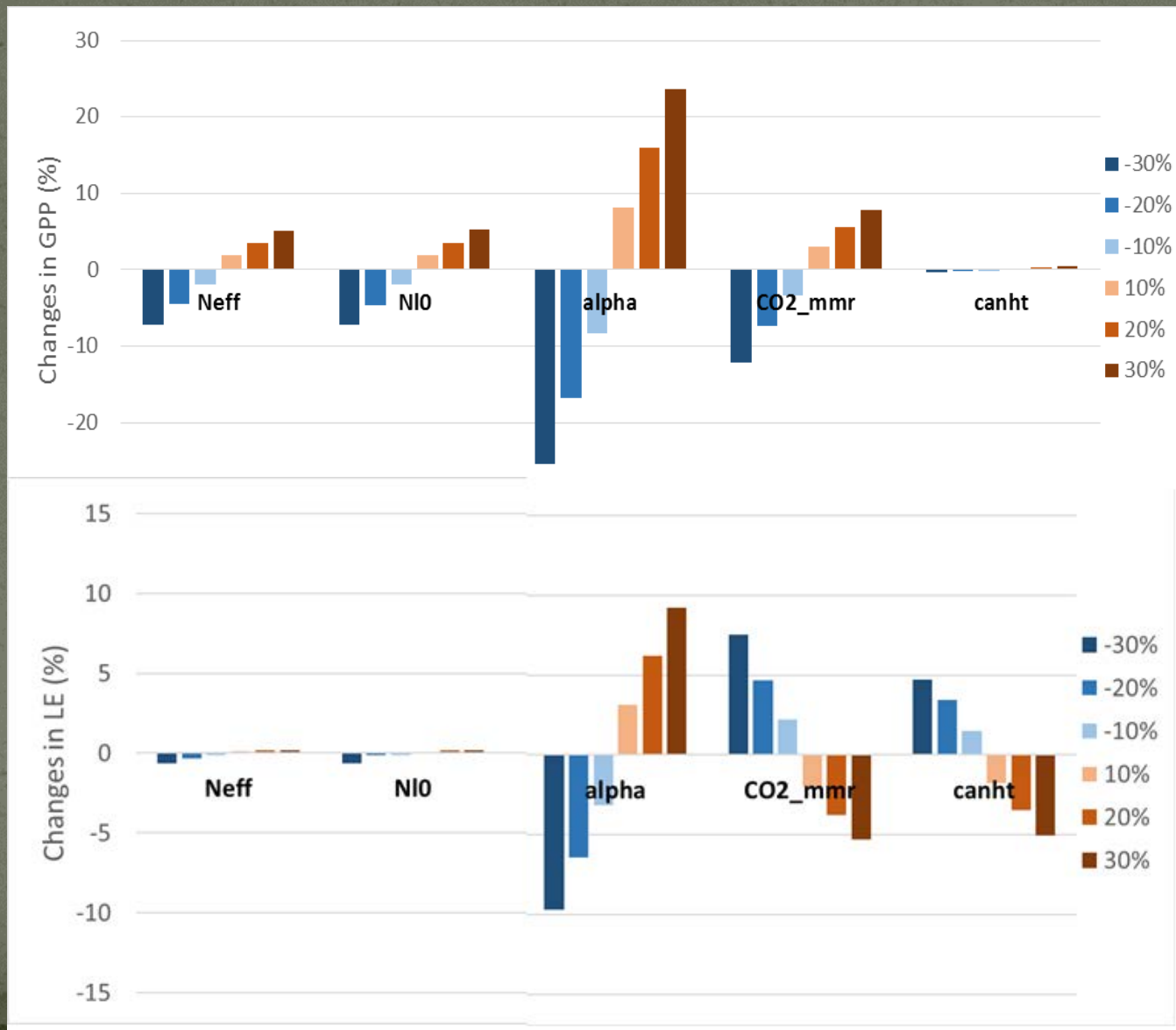
Procedure of Thinning Effects Estimation by JULES LSM

- **Site-specific Optimization of the Model**
 - Sensitivity of canopy radiation transfer model
 - Sensitivity test and modification of plant functional type related parameters
 - Model validation by comparing with EC flux data
- **Estimation of Thinning Effects**
 - Modification of LAI input data by measured thinning induced reduction and recovery of LAI

Sensitivity of Canopy Radiation Modules

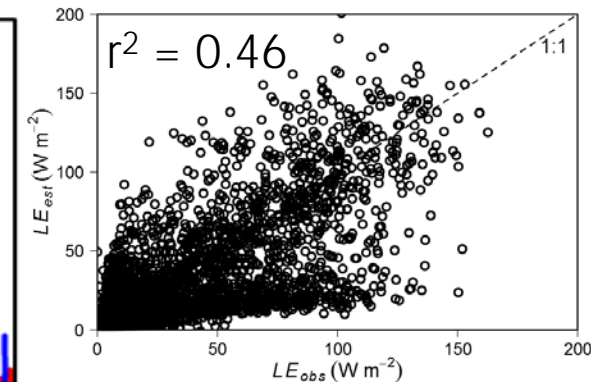
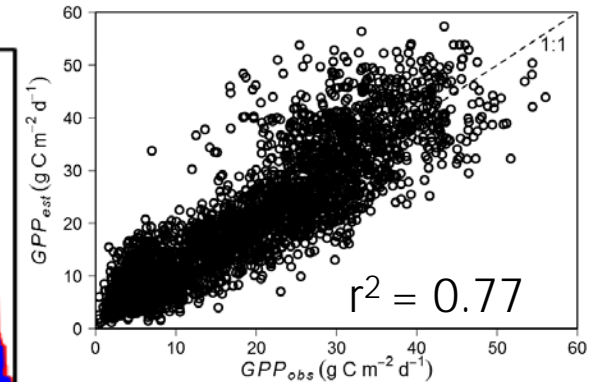
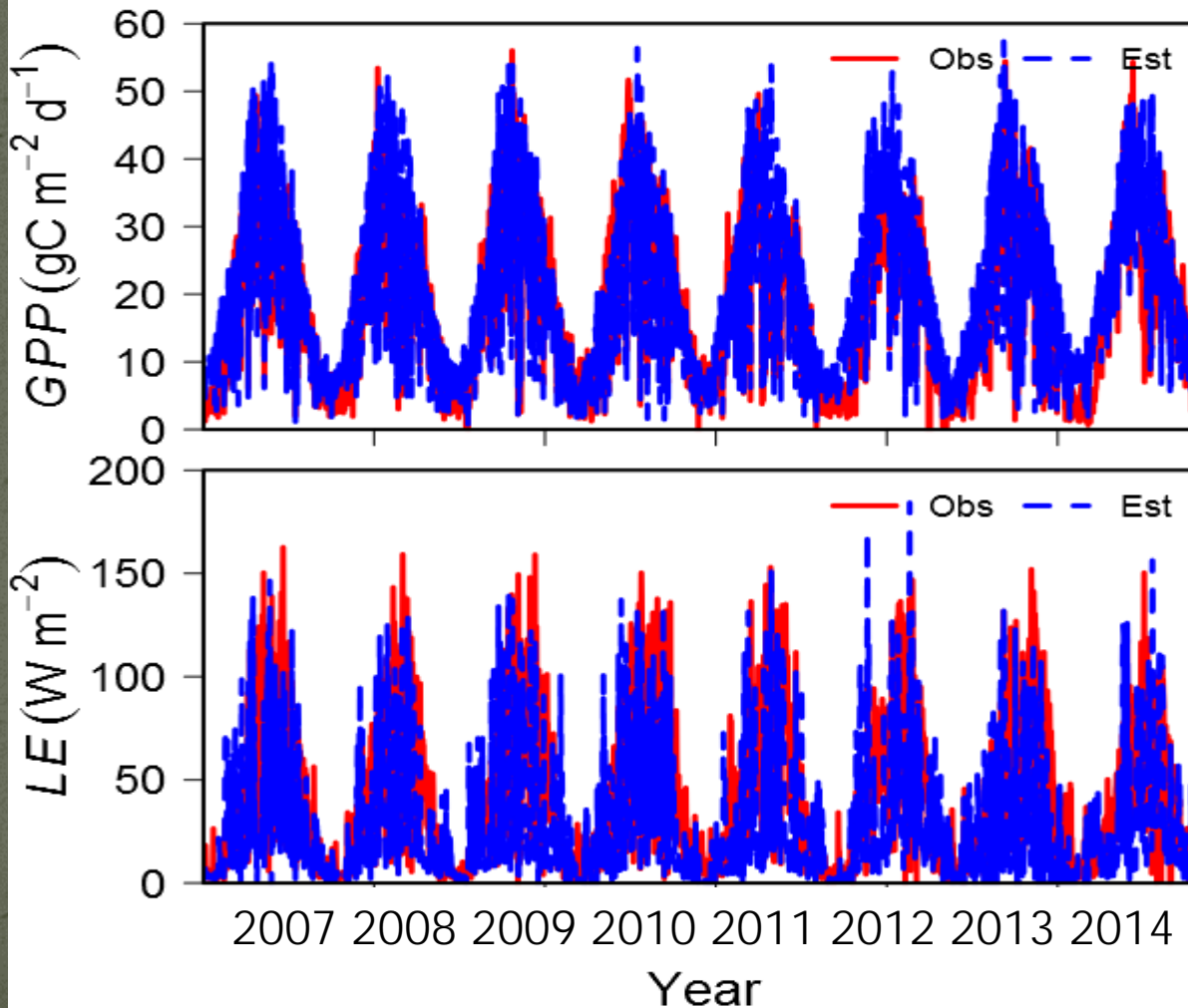


Parameter Sensitivity Analysis

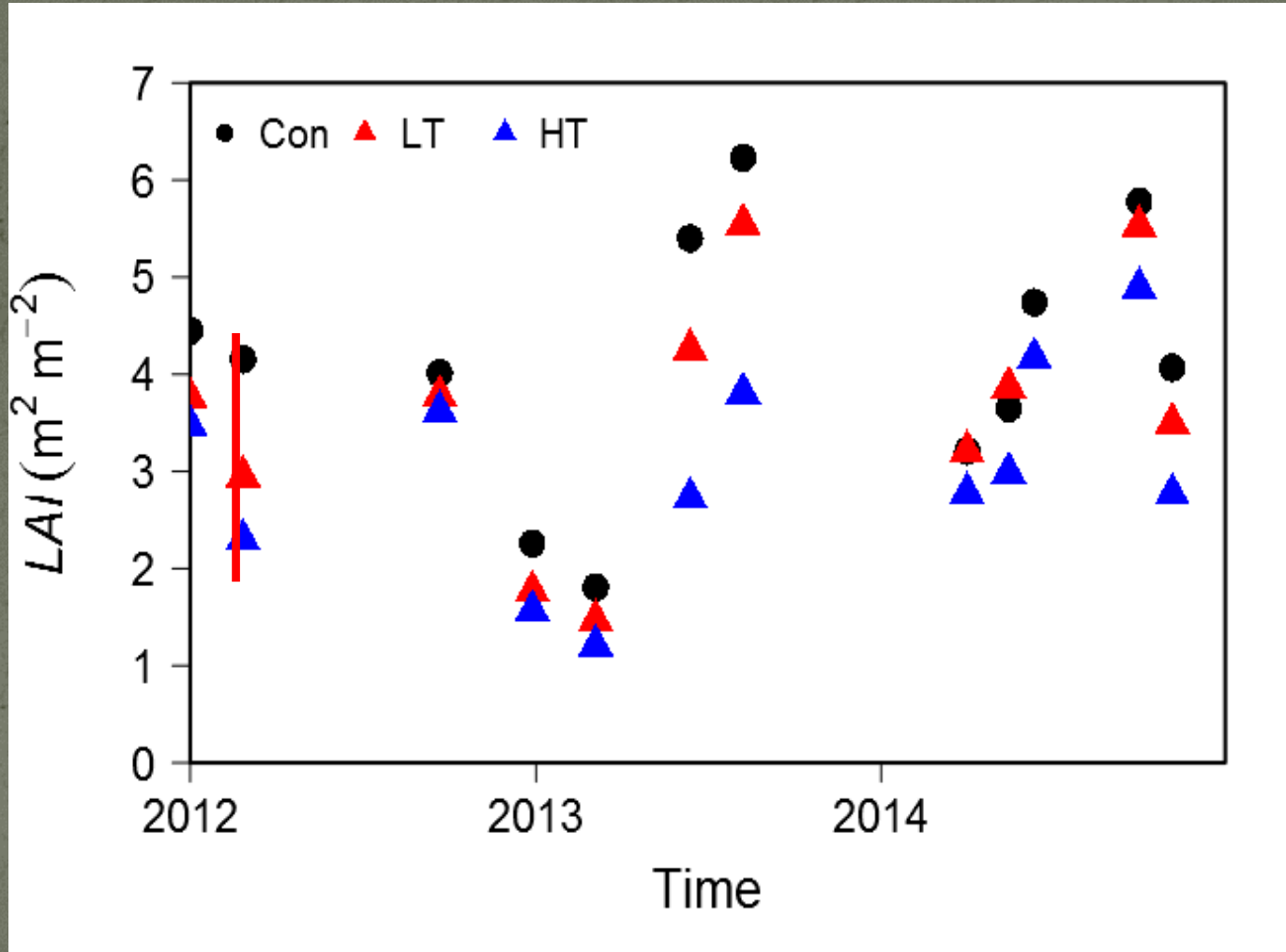


Model Validation

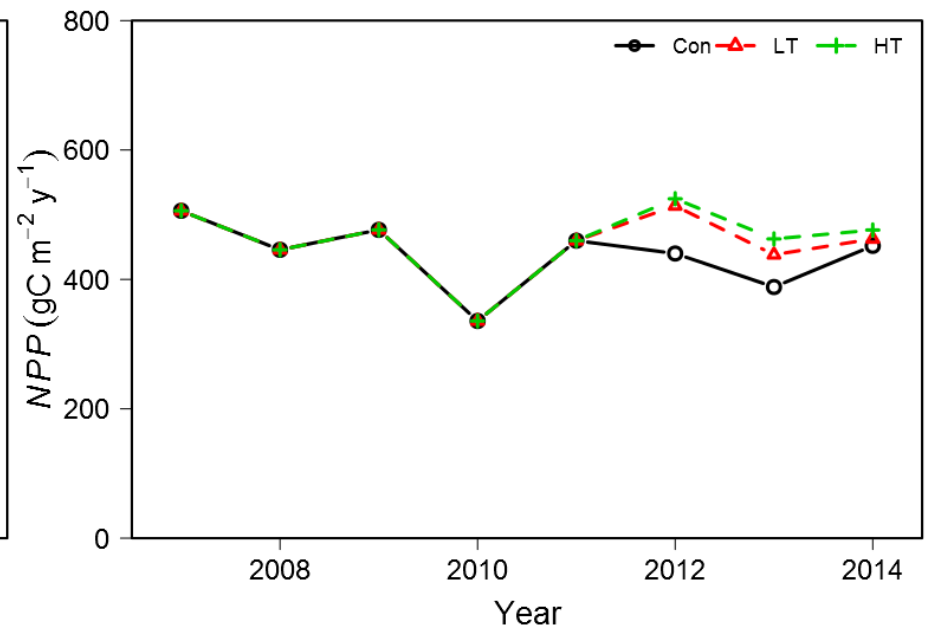
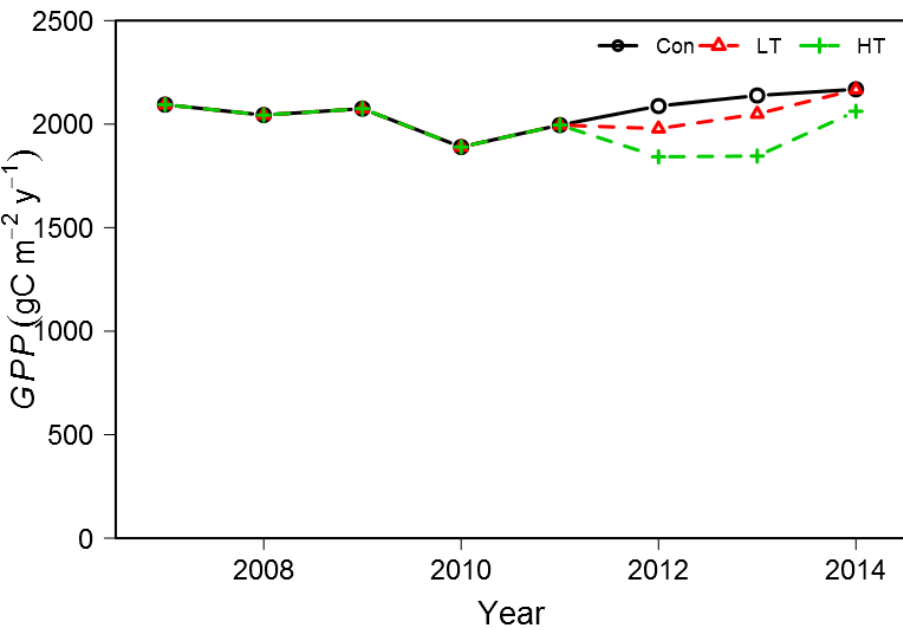
- Model estimation Vs. EC-measured flux



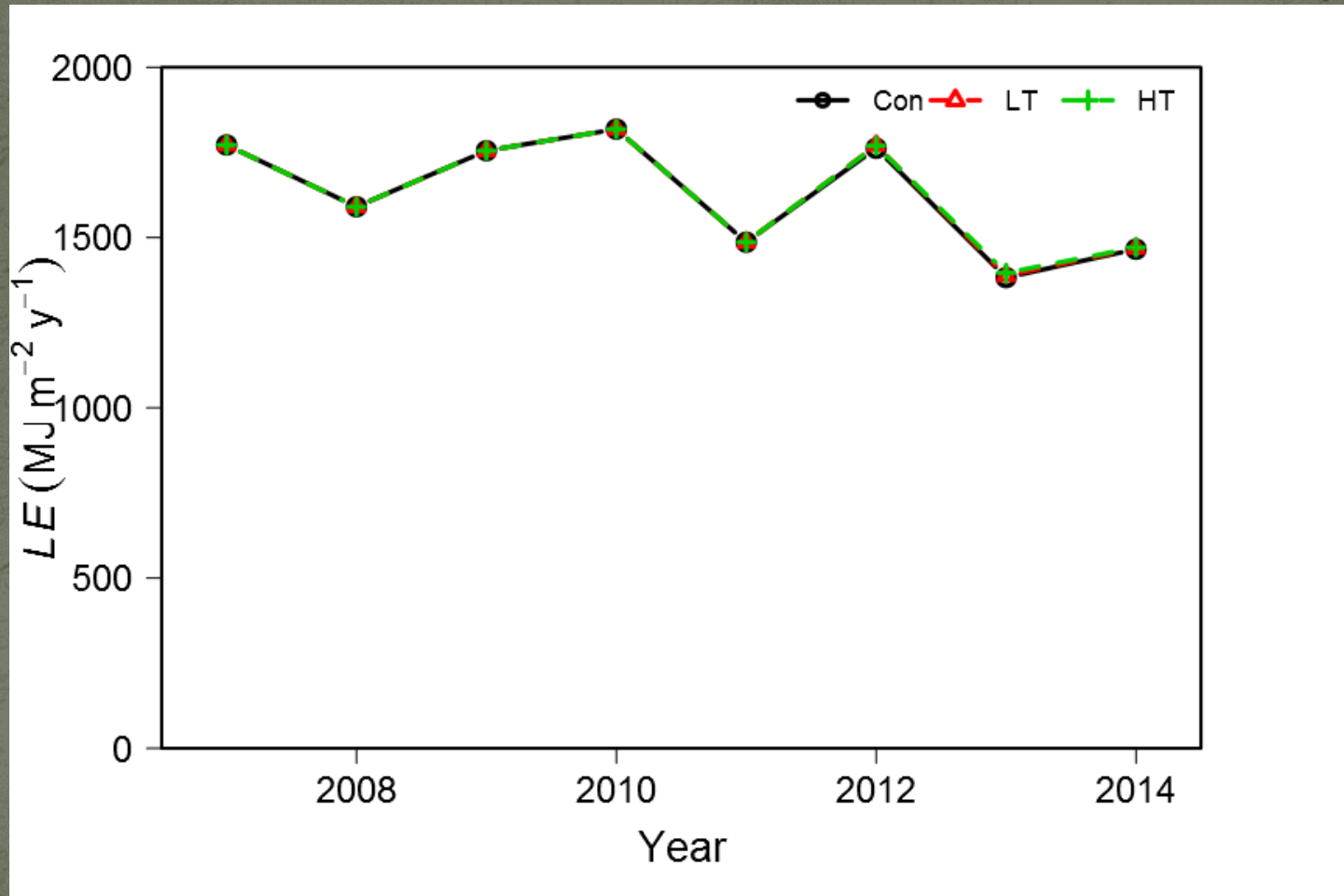
Leaf Area Reduction by Thinning



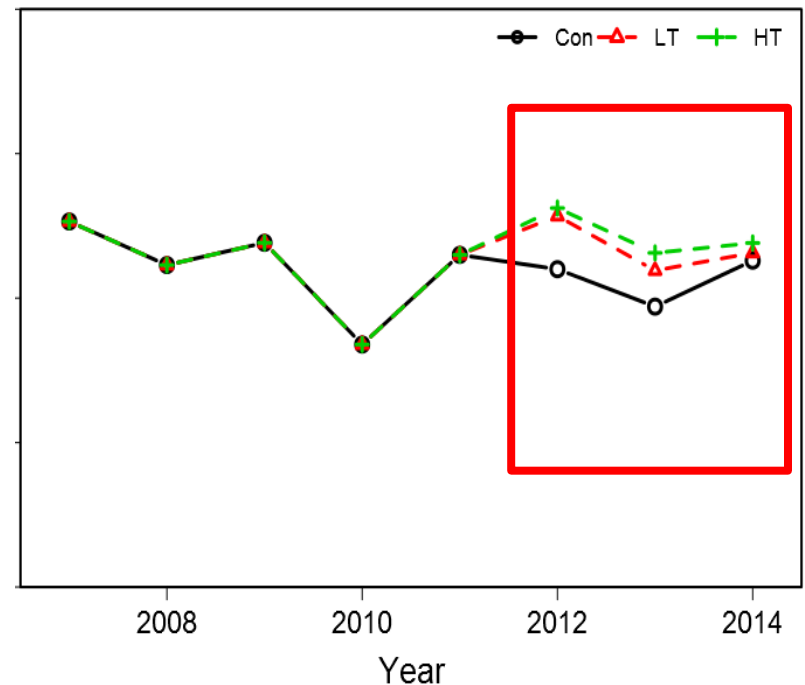
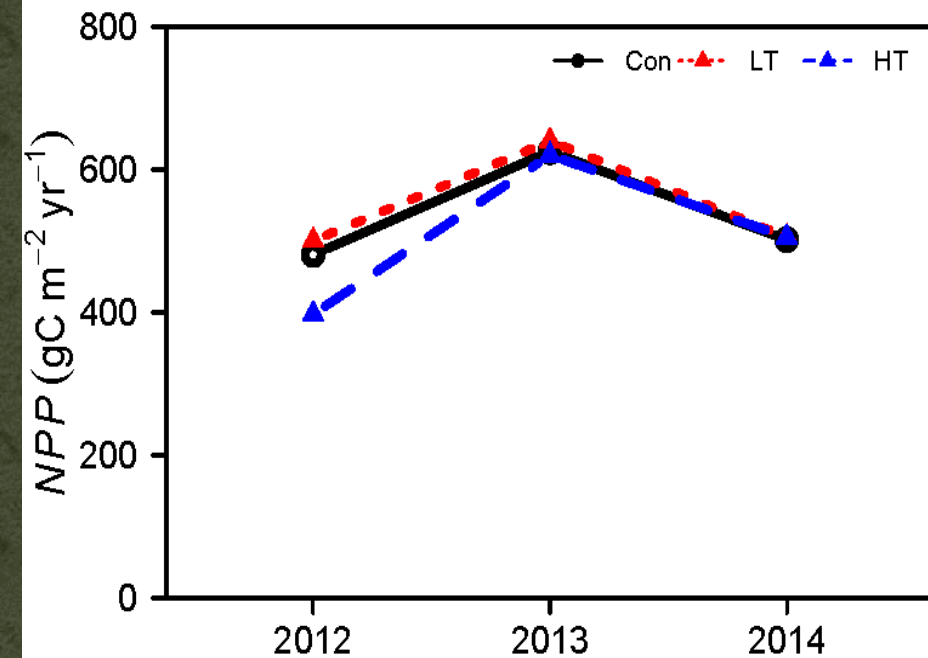
LAI Reduction – GPP/NPP



LAI Reduction - LE



Difference b/w Measurement and Modeling Results



Conclusion

- Initial reduction and gradual recovery of stand transpiration and productivity by heavy thinning
- Decrease of GPP, Increase of NPP, little change in LE by model estimation with reduced leaf area
- There is discrepancy between field measured thinning effects and model estimated thinning effects, which reveals thinning related changes are not constraint by leaf area reduction

Thank You

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