# The Disturbance and Recovery of Soil Respiration after a Growing Season Drought in Biofuel Crop Ecosystems

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## I. Introduction

- How the natural and anthropogenic **disturbances** impact the community structure and the **ecosystem functions** has been widely explored, especially the role of the biodiversity, species redundancy, and composition. The resistance and the recovery after disturbance has been used to evaluate the stability of an ecosystem (Fig. 1).

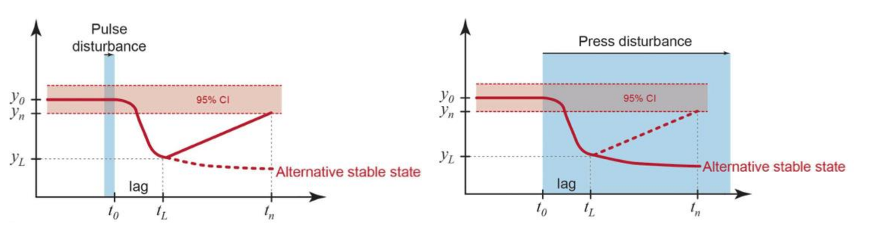
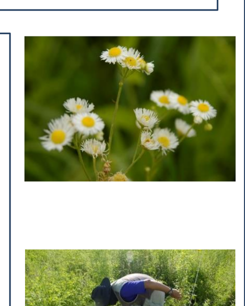



Figure 1. The schematic diagram of the shift of a ecosystem metric its recovery (Shade et al., 2015).

- However, most recent researches focus on the ecosystem production or yield. **Soil respiration ($R_s$)**, as one of the two important carbon processes, instead of gain through photosynthesis, largely determines the net ecosystem exchange (NEE) of carbon and decides the carbon source or sink of an ecosystem and the magnitude of carbon flux.
- The global climate change is changing the climate, not only the average annual temperature and precipitation, but also their patterns. Althogh the annual precipitation in W.K. Kellogg Biological Station (KBS) increased since 1998, **high intra-annual variations of precipitation** may impact ecosystem seriously. The **drought** impacts agricultural ecosystems in mid-July or even the growing season. It depresses the growth of crops, alters the grass composition and shifts important ecosystem functions, such as soil respiration depending on the amount and timing of precipitation.
- This study was designed to understand how the relationship between ***R<sub></sub>*** $R_s$ **and soil temperature (T)** respond to severe drought (2012) at three **bioenergy systems (corn, switchgrass, and prairie mixture)** by two **land use histories** (**LUHs**: Conservation Reserve Program (**CRP**) and corn-soybean rotation agriculture land (**AGR**)) and a non-disturbed reference CRP (Fig. 2).

## II. Methods

### A. Exp. design



Location

LTER sites of Kellogg Biological Station (42° 40'N, 85° 40'W) (Fig. 3).

Experimental design

- 3 **crops**: **corn**, **switchgrass** & **prairie mix**
- 2 **LUHs**: grassland of the Conservation Reserve Program (**CRP**) and corn-soybean rotation agricultural farms (**AGR**) (Fig. 2 & 3)
- 1 **Reference**: un0disturbed brome grass CRP

Dependent variables

***$R_s$***: Data were measured biweekly in GS and monthly in non-GS (Fig. 4)

Independent variables

Soil temperature (***$T_s$***), Soil moisture (***VWC***)

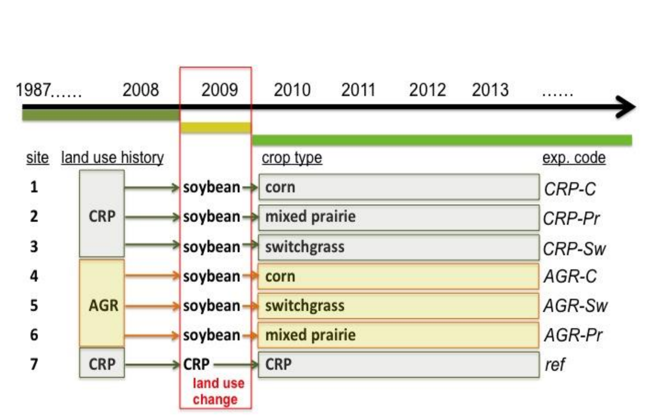



**Figure 2.** The experimental designs and timelines of seven experiment sites.

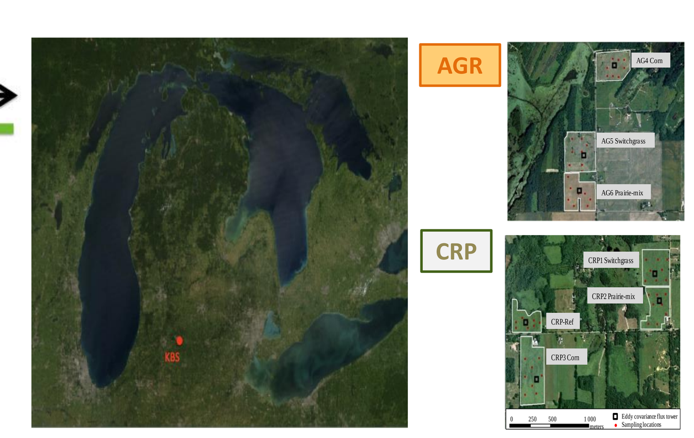



**Figure 3.** Study site location in southwestern MI, USA and experimental layout of scale-up field sites with location of sampling plots and EC flux towers.

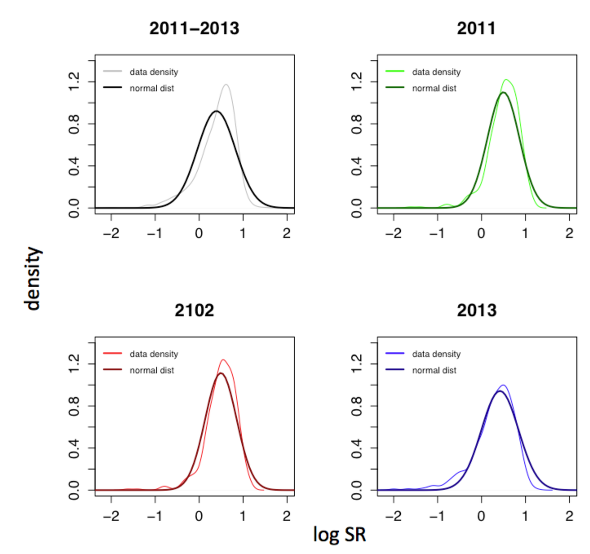
**Figure 4.** The measurements of $R_s$ and $R_h$. We used LI-8100 or LI-6400 to measure in situ *SR* with soil temperature and soil moisture.

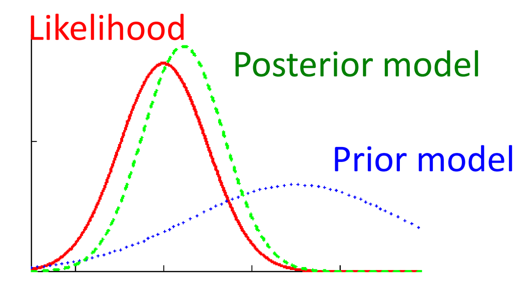
## II. Methods

### B. Bayesian models: R-T

$$Pr(H_a|D) = Pr(H_a) \times Pr(D|H_a)/Pr(D)$$

a. Prior model:
Maximum Likelihood Estimate (MLE)

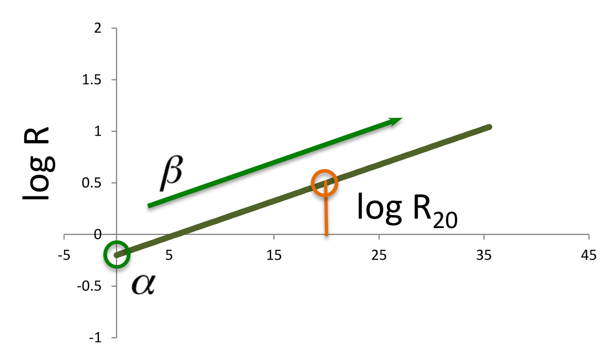



b. Likelihood (linear):
linear regression of drivers ($T_s$)

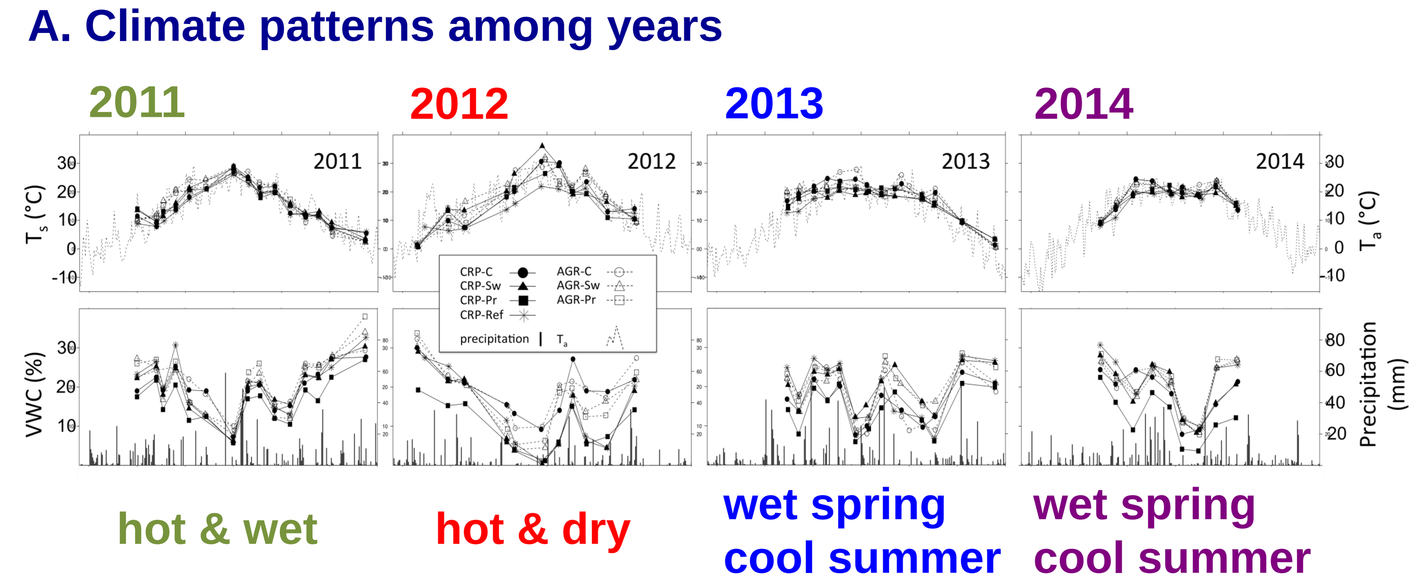
$$logR = \alpha + \beta T_s + site(latent) + \epsilon$$

c. Posterior models:
α: basal soil respiraiton (at 0°C)
β: temperature sensitivity of log R
$logR_{20}$: daytime R in growing season

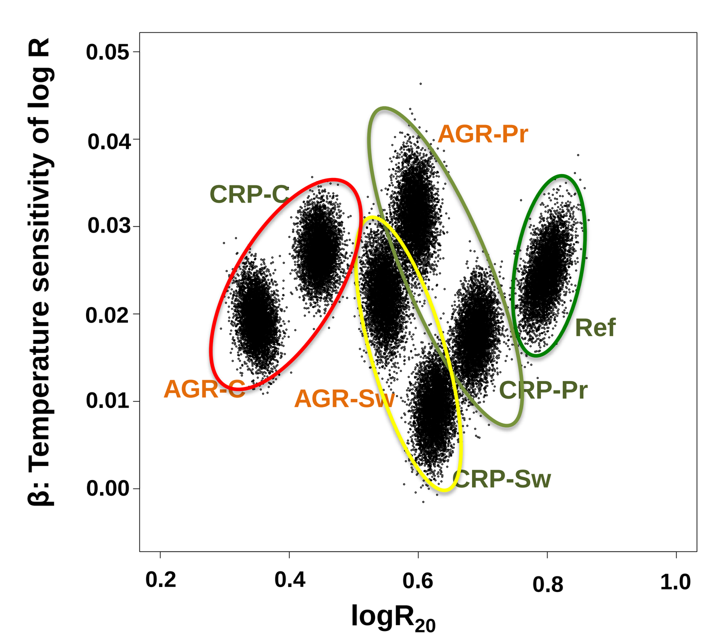



## III. Results

### A. Climate patterns among years

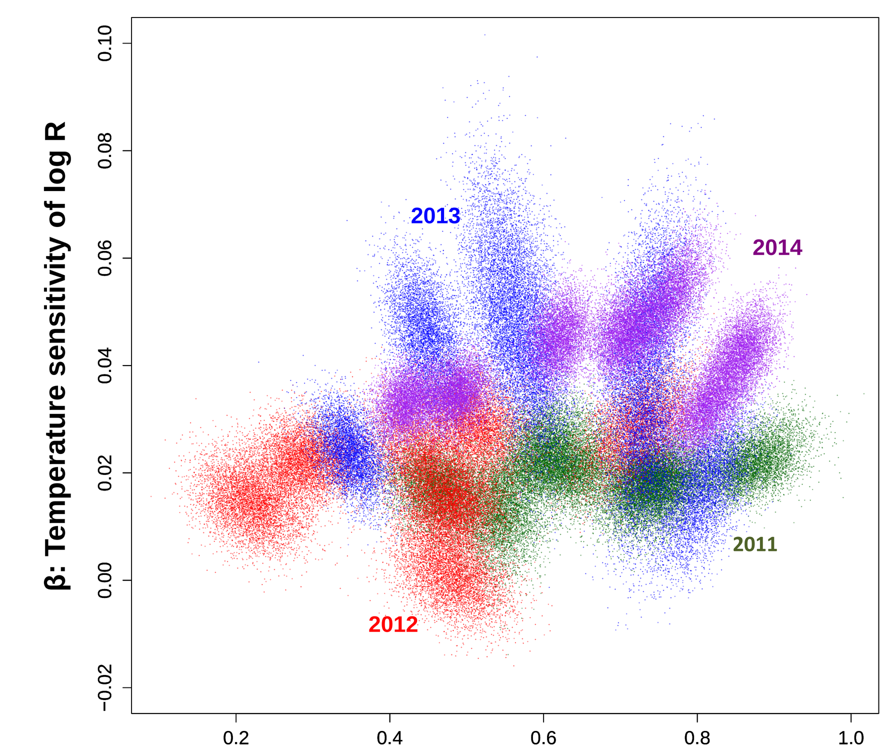



### B. LUH & CROP effects on β and $logR_{20}$ in 2011-2014

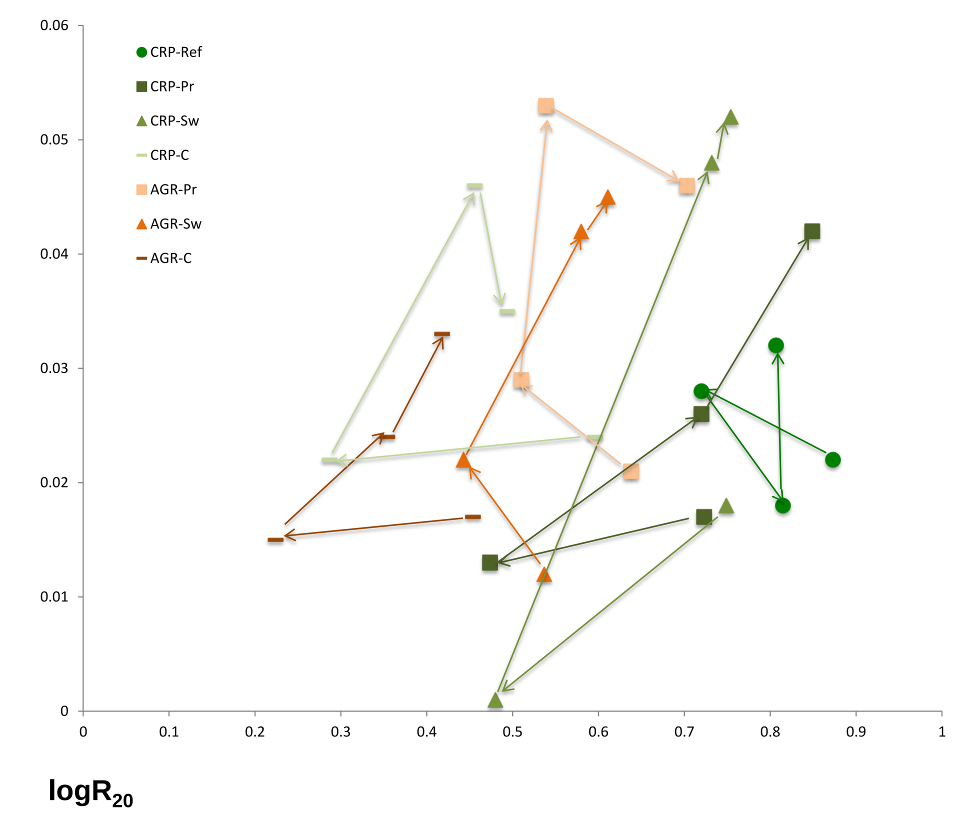



### C. The shift of R-T relationship after drought

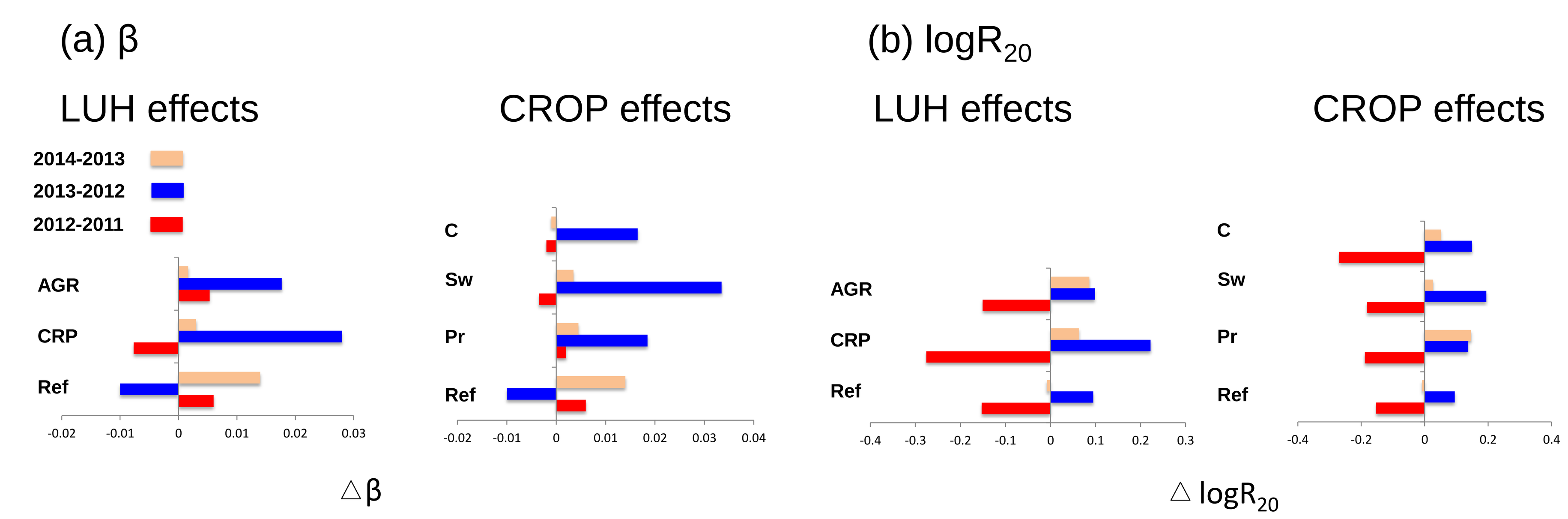
#### a. Bayesian predictions through years



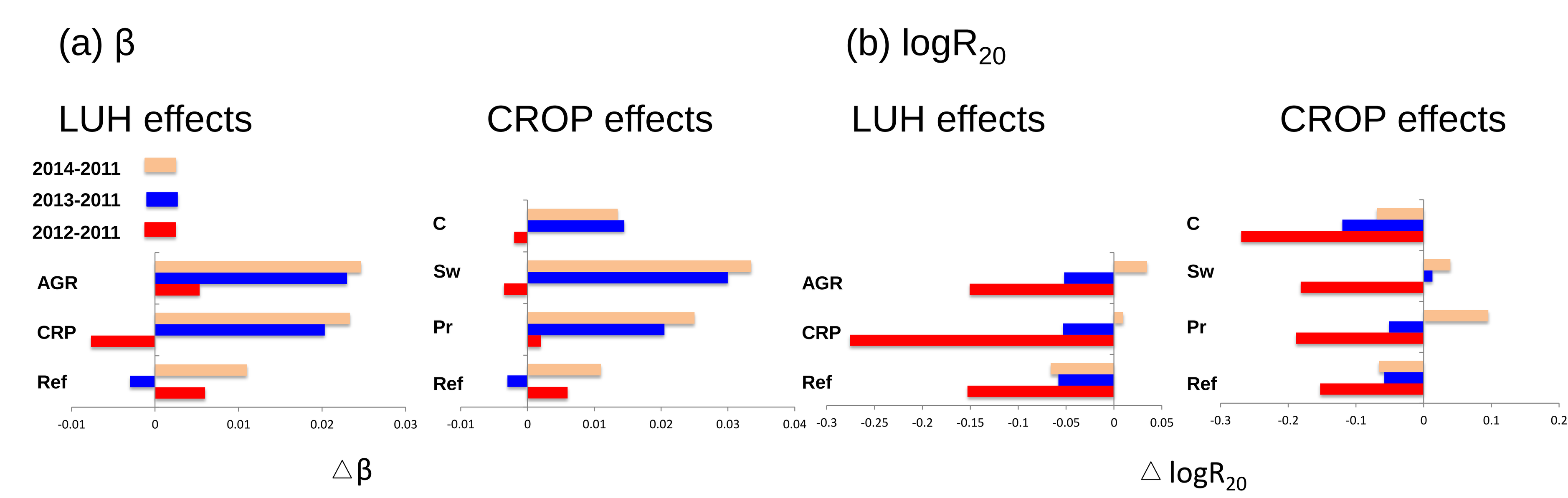

#### b. Mean of parameters between sites




#### c. The shift of β & $logR_{20}$ between years




#### d. The shift of β & $logR_{20}$ after drought




## IV. Conclusion & Discussions

- The R-T relationship are different between crop types and landuse histories.
- CROP effects:
Ref has high $logR_{20}$ with high β perennial crops (Pr & Sw) have lower $logR_{20}$ while corn has lowest $logR_{20}$.
- LUH effects:
AGRs have higher β than CRPs.
- The severe drought in 2012 decreased $logR_{20}$ in all sites. There is slightly decreased or no response of β. The within-sites variations of all sites increase.
- The 1st recovery year (2013) shows obviously recovery of in $logR_{20}$ all sites but the magnitudes were different.
The variation of β became very large in this yeaar.
- Most of the $logR_{20}$ in 2014 is toward the values in 2011, although Ref and corn is lower while Pr is higher.
- The responses of β in different sites is not very regular. It seems respond slower than $logR_{20}$. Ref has smallest change of β while all other sites increased a lot in 2013.
The magnitude of change:
Sw > Pr > C
- CROP effects:
Ref has strongest resistance of drought and recovery in 1 year. Perennial crops has similar resistance but Sw recovery in 1 year while Pr shows slower recovery.
Annual crop has low resistance with slower recovery.
- LUH effects:
$logR_{20}$ in CRP decreased a lot in 2012 but recovery fast in 2013 while that in AGR decreased less but rebound to high value in 2014.
β seems shift to an new static state which is higher than 2011.