柳杉人工林不同疏伐強度對地被層及林下小苗更新之影響




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Reporter：黃騰禾　東海大學生命科學系

Content

- Introduction
  - Plantation forests in Taiwan
  - Forest dynamics plot in Zenlun
  - Monitor methods
- Preliminary patterns in seeds and seedlings data
- Space-time interaction
- Seed limitation and establishment limitation
- Seedling survival and environmental variables
- Summary

Plantation forests in Taiwan

- Among forested area, about 14% (420,000 ha) are plantation forests.
- The species with largest planted area is *Cryptomerioid japonica* which has more than 40,000 ha.
- Plantation forests harvesting has been banned since 1991 when forest policy and management regulations was imposed .

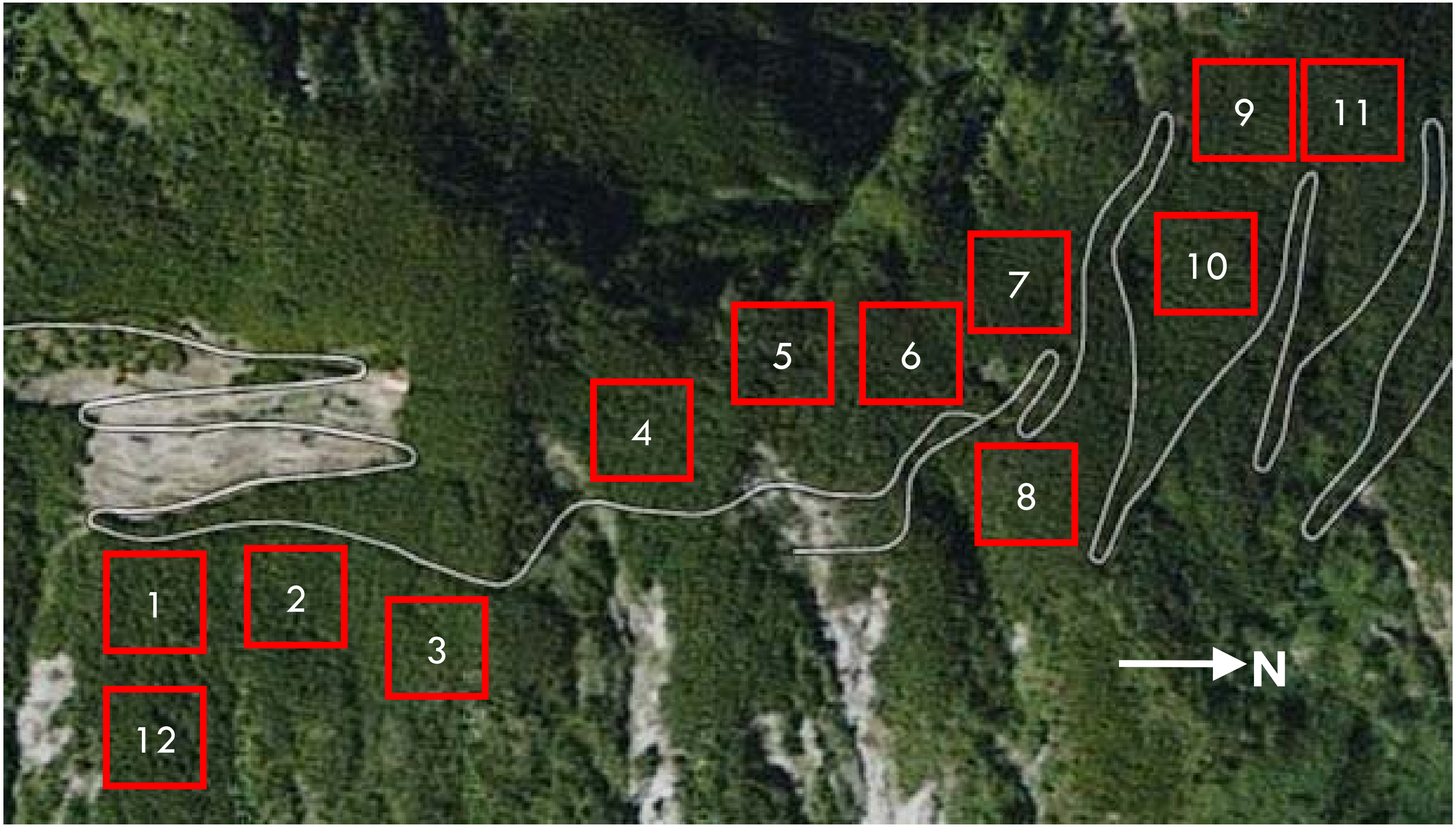
Forest management policy

- Public awareness on environmental issues has forced the government to shift forest management policy from timber production to conserve biodiversity and maintain ecosystem functions in the past 10 years.

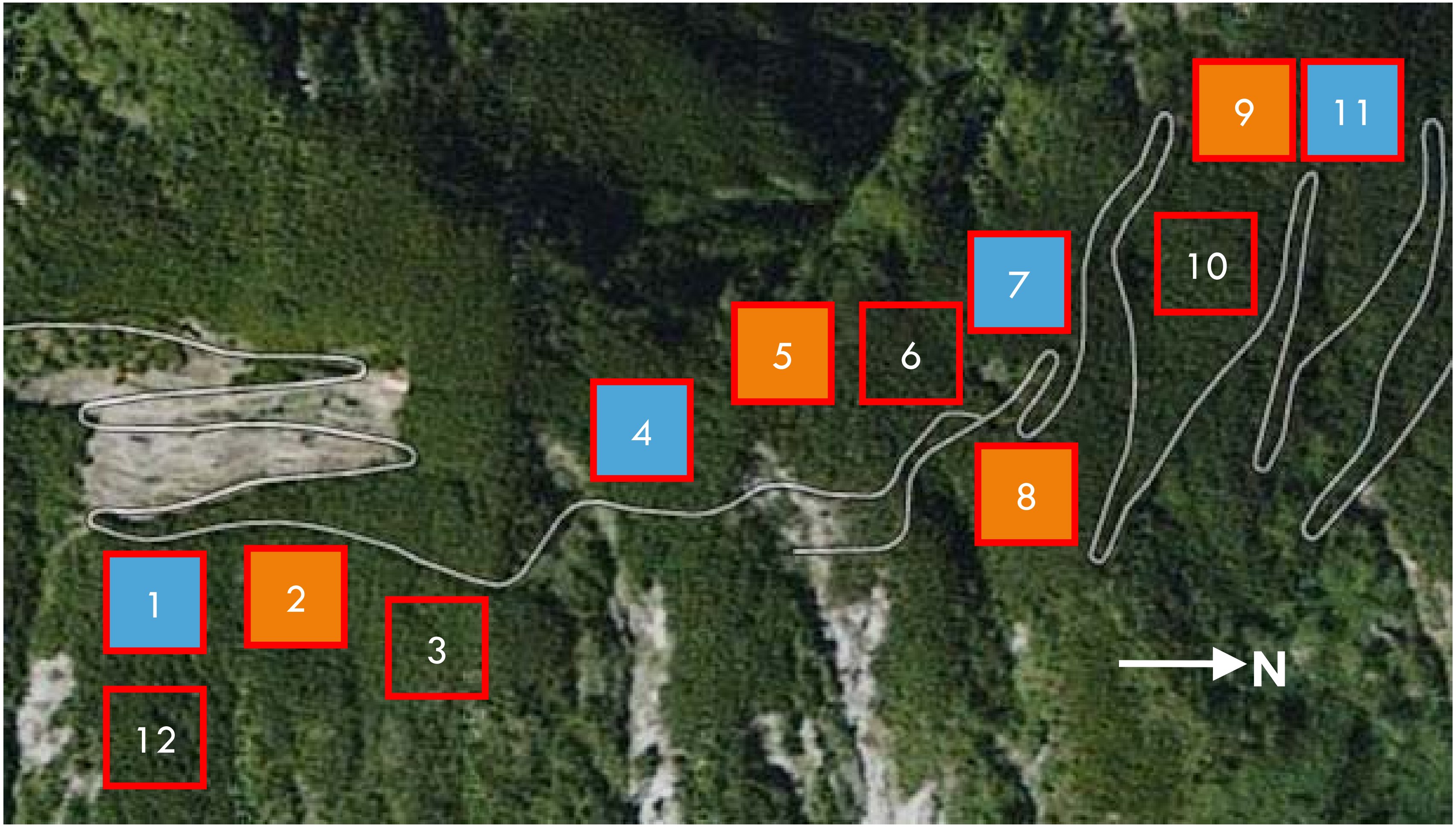
- The new goal is to provide reasonable timber production with consideration of its impact on climate changes, biodiversity losses, and ecosystem functions.

Zenlun forest dynamics plot

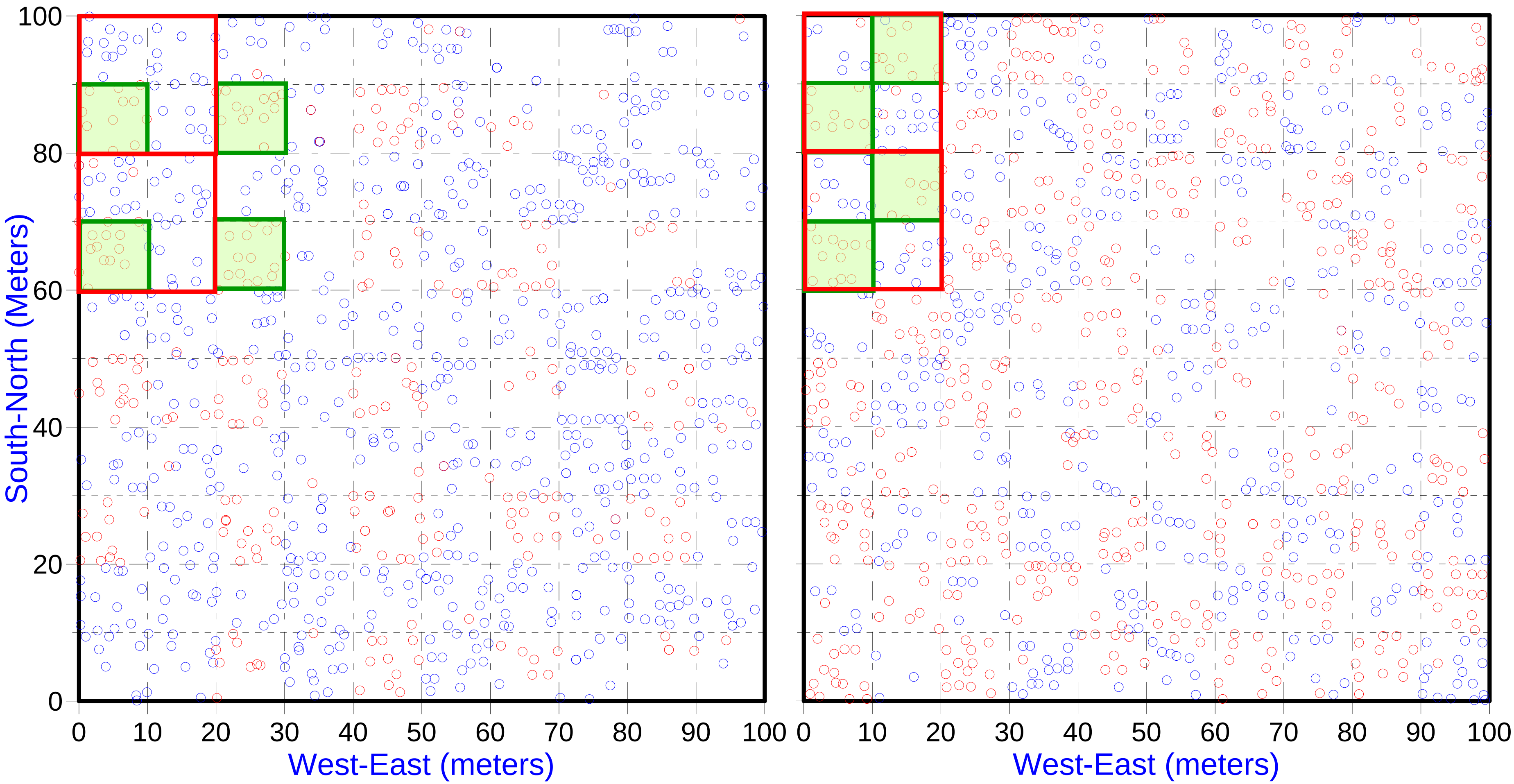
Plot design



Treatment design :25% :50%



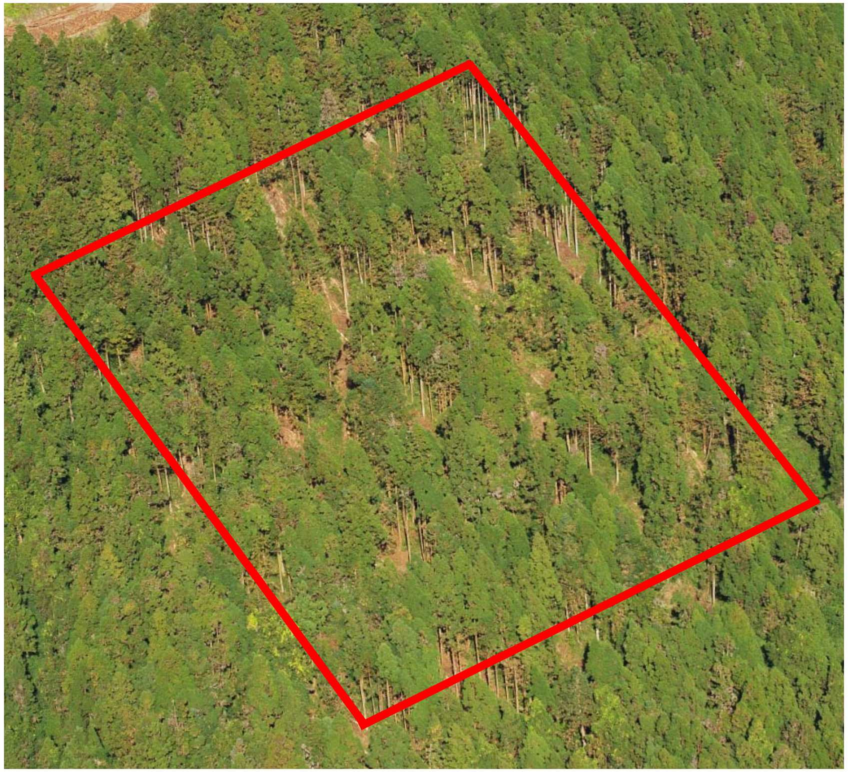
2 levels of thinning intensity



Plot 1 : 25% Thinning intensity

Plot 2 : 50% Thinning intensity

2 levels of thinning intensity



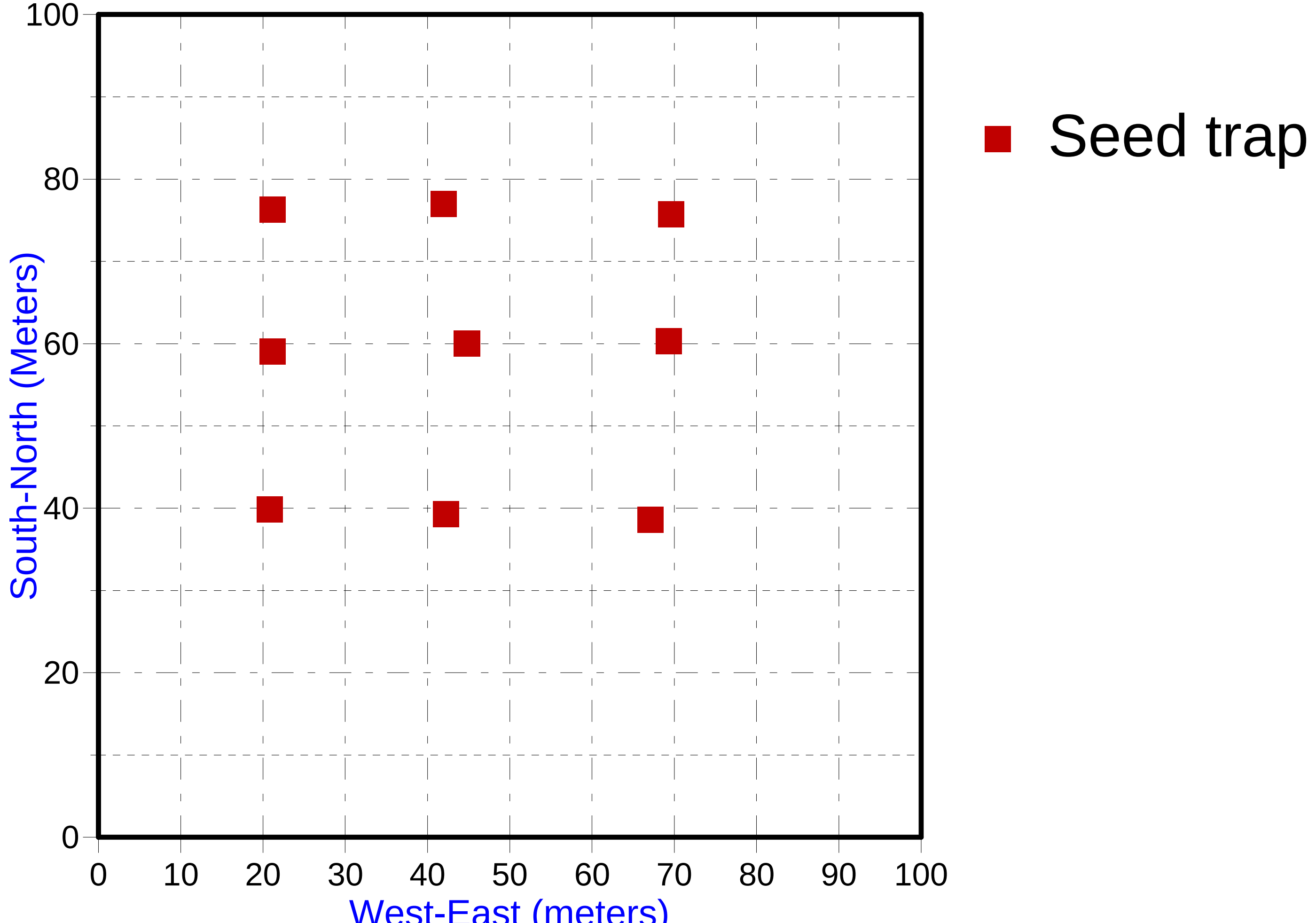
Plot 1 : 25% Thinning intensity

Plot 2 : 50% Thinning intensity

Data collection on seeds

- 108 seed traps in the Zenlun Forest Dynamics Plot
  - Established in Aug. 2006
    - Surface area: 0.5 m^2
    - Trap mesh: 0.8 mm
  - All reproductive parts (flowers, fruit, seeds) were sorted, counted, and identified to species biweekly
  - **Before thinning**
    Aug. 2006 – Apr. 2007 (19 censuses)
  - **After thinning**
    Nov. 2007 – Apr. 2009 (39 censuses)

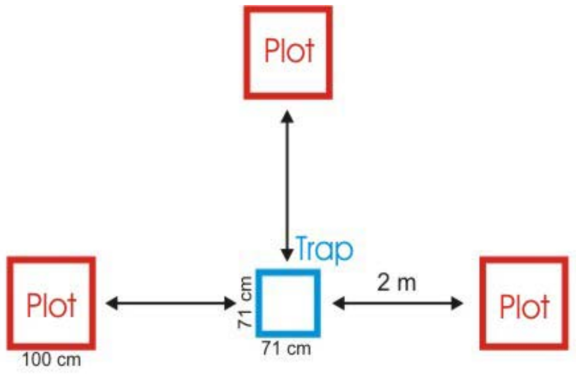
The locations of seed traps



Plot 1

Seedling plot

- All woody plants smaller than 1 cm DBH in the plot are tagged and identified to species.
- Survivors will be re-measured and new recruits will be tagged and identified at 6 months interval.



- **Before thinning**
  - Apr. 2007 (1 census)
- **After thinning**
  - Nov. 2007 – Jun. 2009 (4 censuses)

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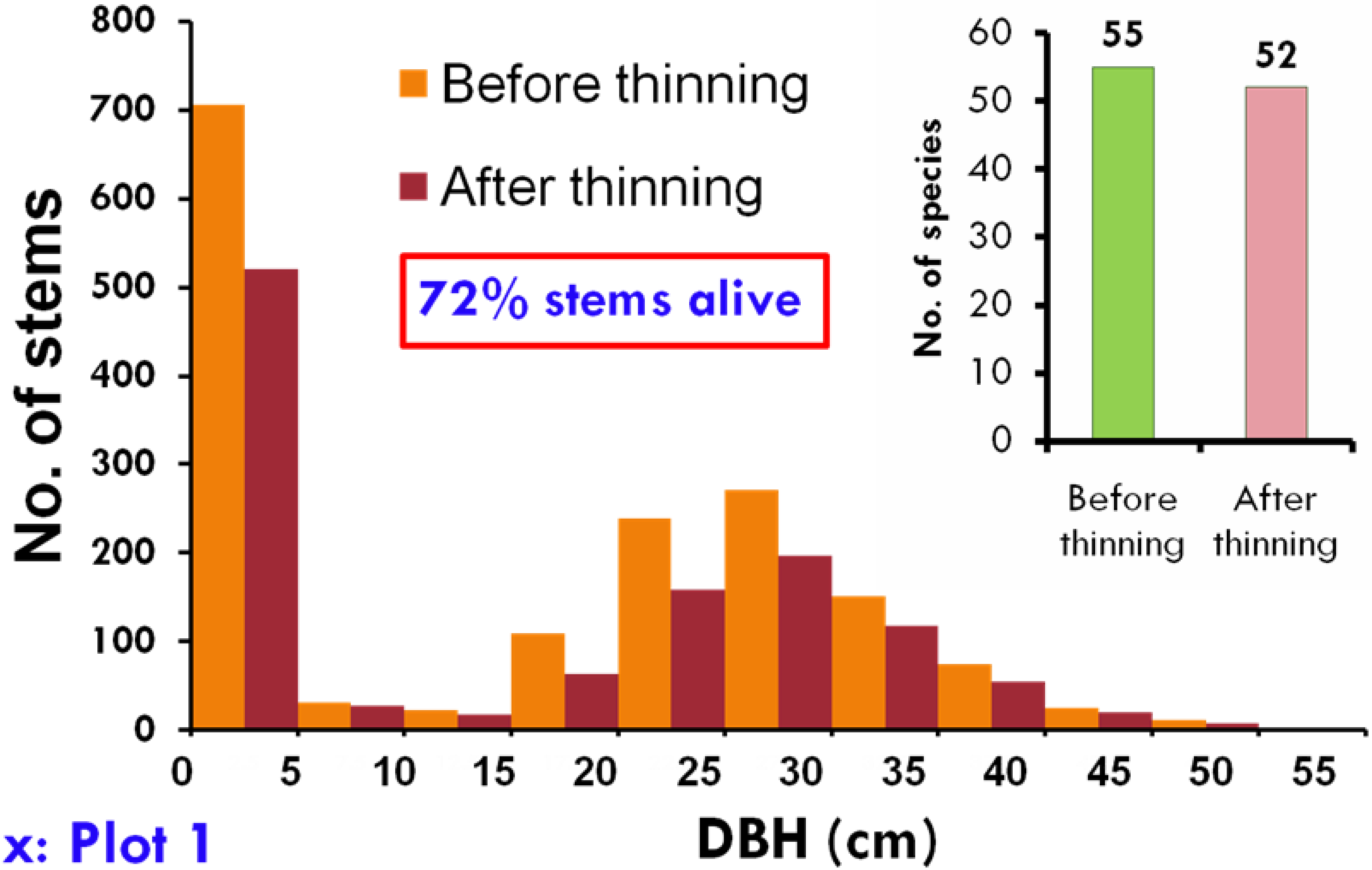
Abundance and diversity after thinning



Ex: Plot 1

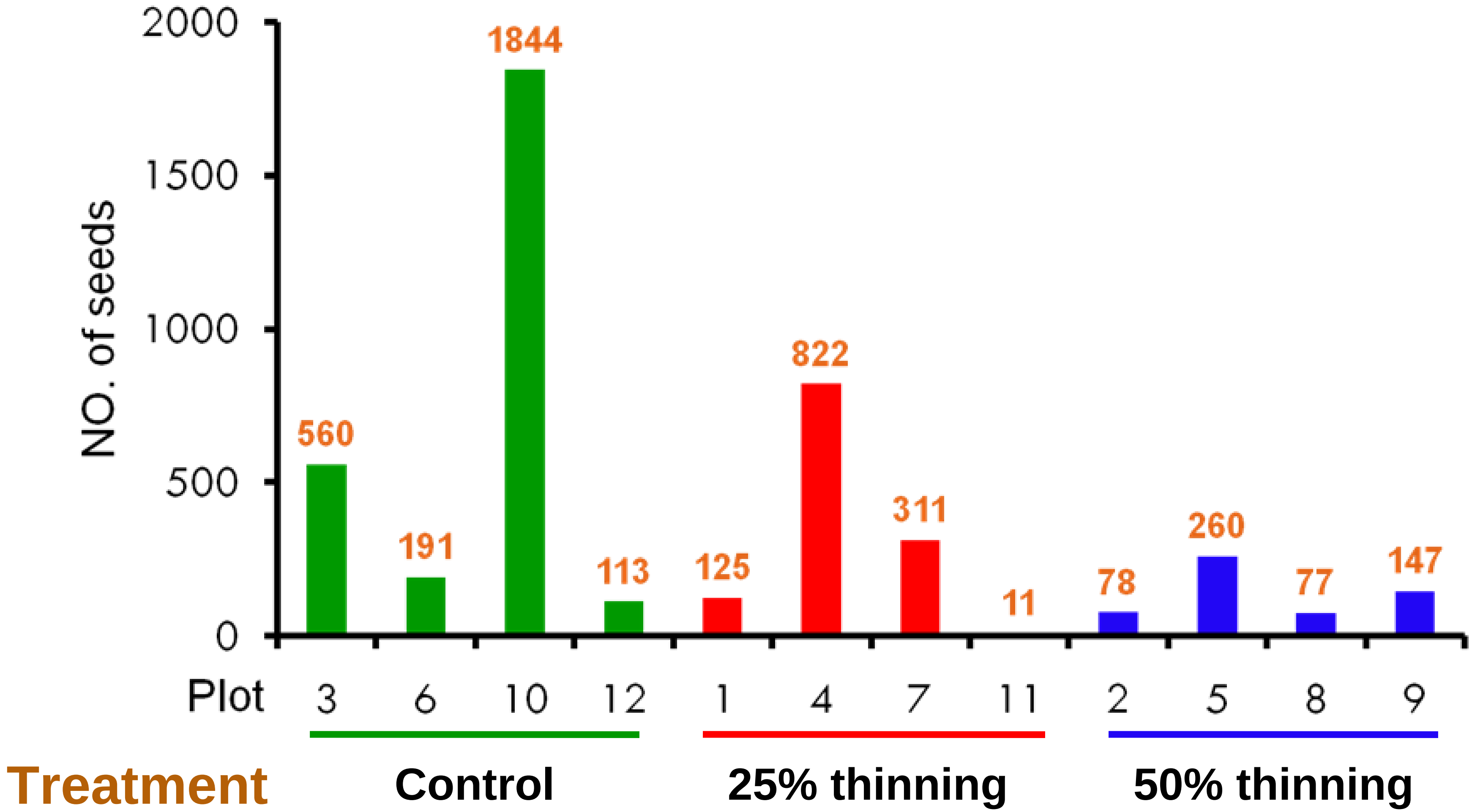
Abundance and diversity after thinning

Plot	Before thinning		After thinning		Abundance change	Diversity change
	Abundance	Diversity	Abundance	Diversity		
1	1642	55	1182	52	72%	95%
4	2551	52	1913	44	75%	85%
7	3759	59	2709	54	72%	92%
11	4049	53	3132	52	77%	98%
2	2049	34	899	29	44%	85%
5	2530	90	1551	85	61%	94%
8	3316	61	2149	58	65%	95%
9	3988	64	2180	62	55%	97%
3	2552	64	-	-	-	-
6	2694	46	-	-	-	-
10	3976	69	-	-	-	-
12	2184	36	-	-	-	-

The objective of research

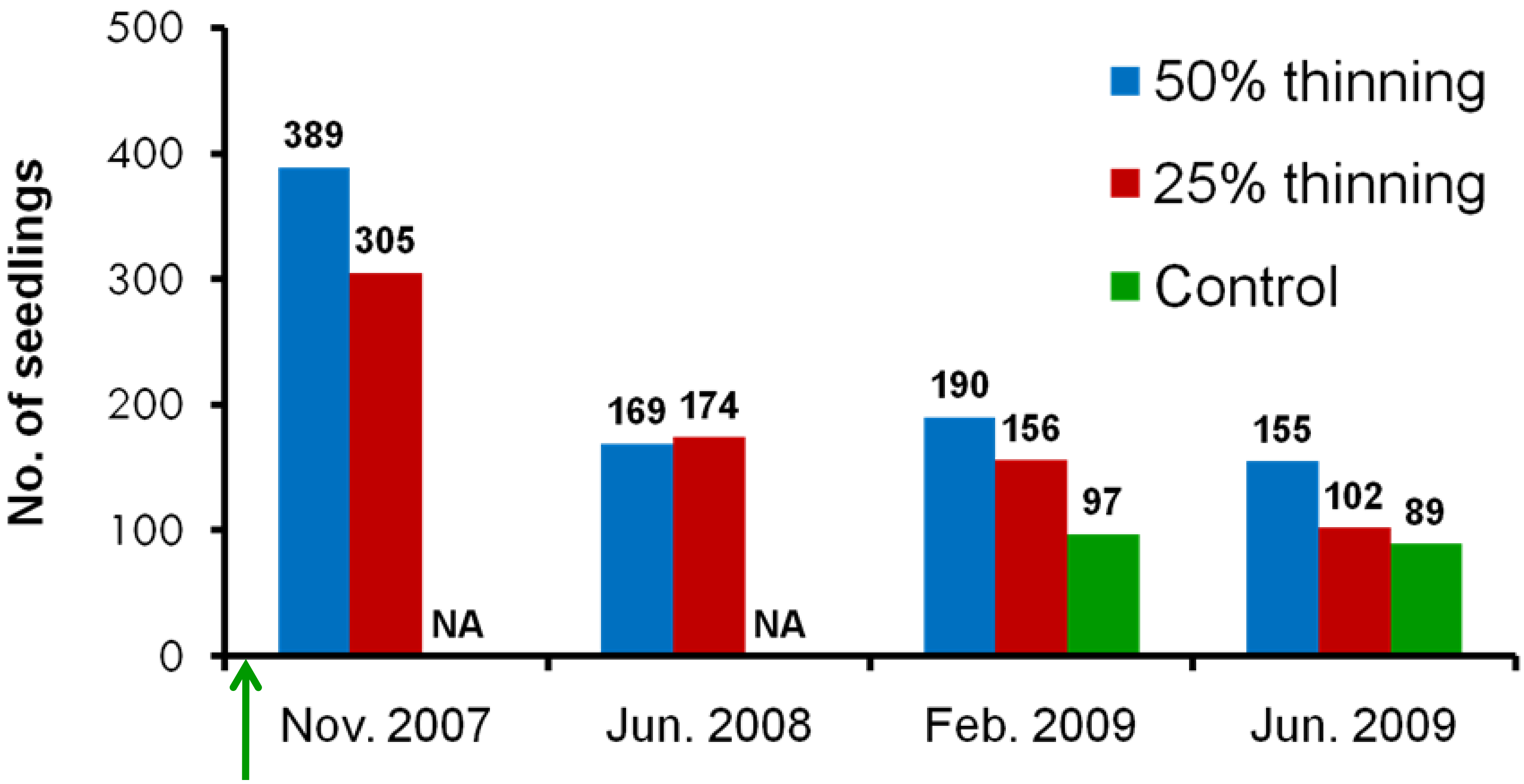
- Does different thinning intensity change the seed rain?
- Does different thinning intensity cause differences in the number of seedling recruits and their composition?

Seed production by different treatments



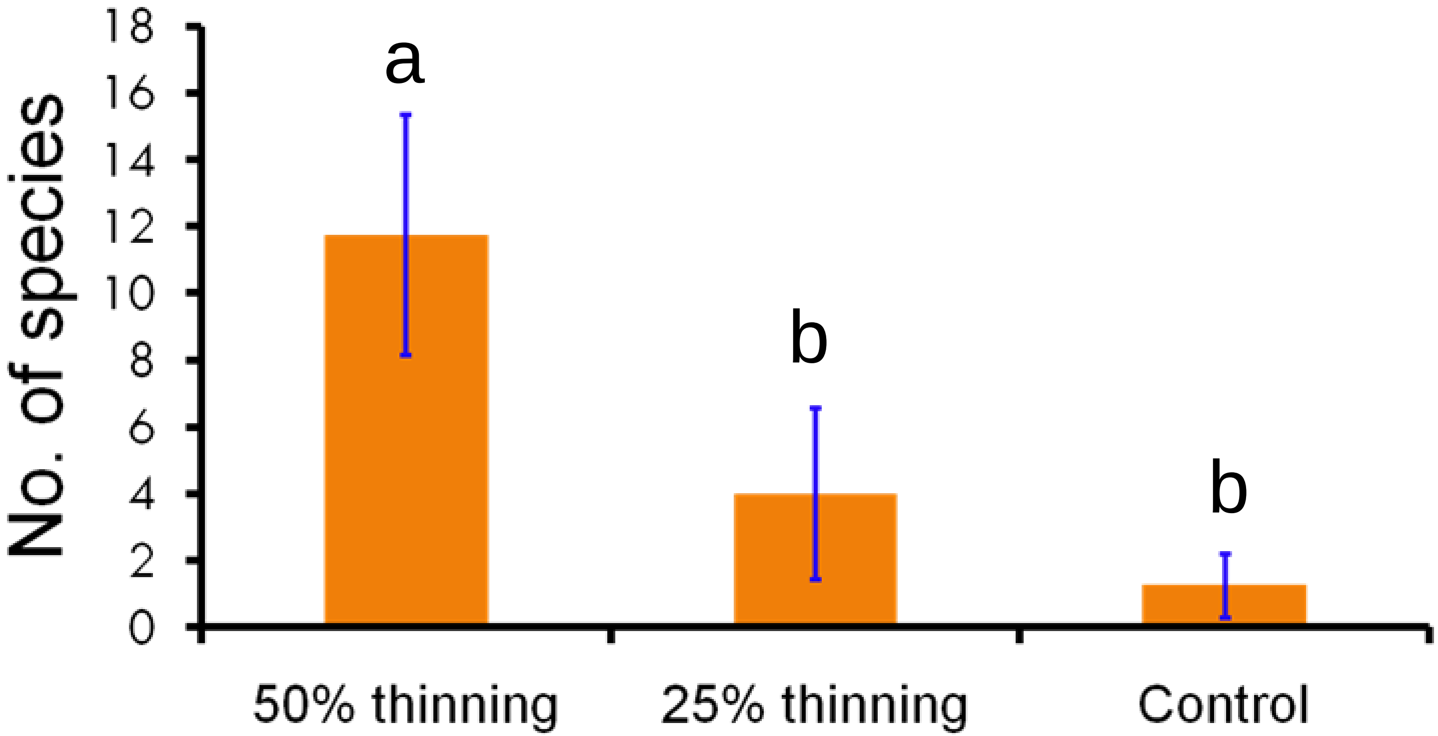
P-value = 0.35 (Nested ANOVA)

Seedling recruits by different treatments and time



Thinning operation (Jun. 2007~Oct. 2007)

New species after thinning



Tukey’s HSD Test

Brief summary

- Thinning would only reduce the abundance of species but bring little effect on the diversity.
- There is no significant difference between the number of seeds and seedlings with different thinning intensity.
- Different thinning intensity would affect the entry of species and further increase the diversity.

New question

- Is there any difference between the change of seedlings in spatial and temperol terms?
- To understand if the seedling establishment and seed source have been limited?
- Do the changes of micro-habitat and the features of species make difference to the distribution of every species?

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Space-time (S-T) interaction

- Space-time sampling
  - Un-replicated repeated-measures design
  - Two-way factorial design
- Space-time (S-T) interaction
  - A significant interaction would indicate that the temporal structures differ from site to site, and that the spatial structures differ from time to time.
  - Estimating an interaction sum-of-squares allows one to partial out its effect in statistical tests of the main effects.
  - Space-time ANOVA without replicates (Legendre, P. *et al*, In press)

Space-time (S-T) interaction

Factor	F value	R^2
Space	1.81***	0.63
Time	1.37***	0.42
Interaction	1.55***	0.24

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Seed limitation and establishment limitation

- Spatial variation in adult plant communities should reflect species filtering events occurring throughout plant ontogeny. (Grubb 1977; Nathan & Muller-Landau 2000)
- Dispersal limitation is an important factor determining successional dynamics, community diversity, and composition. (Tilman 1994)
- The successful establishment of a plant necessitates overcoming two consecutive ecological filters.
  - seed limitation (Muller-Landau *et al.* 2002)
  - establishment limitation

Seed limitation and establishment limitation

- The objectives of this research:
  - What is the relative strength of seed limitation and establishment limitation during seedling regeneration?

Quantitative records

- Seed production
  - No. of traps collected for each species
  - No. of seeds collected of each traps for each species
- seedling data
  - No. of stations investigated for each species
  - No. of seedlings investigated of each station for each species
- All analyses were restricted to species with ≥ 20 seeds and ≥ 15 seedlings.

Data analysis

- Dispersal limitation
  - Seed limitation
    - Fundamental seed limitation (Muller-Landau *et al* . 2002)
    - Source limitation (null model as a poisson) (Clark *et al.* 1998)
  - Establishment limitation
    - Realized establishment limitation (Muller-Landau *et al* . 2002)
    - Source limitation (null model as a poisson) (Clark *et al.* 1998)

Seed limitation

- Fundamental seed limitation (Muller-Landau *et al* . 2002)

$$= 1 - \frac{\text{sites reached by seeds}}{\text{total number of sites}}$$

- Source limitation (Clark *et al*. 1998)

(Uniform distribution stochastically as a Poisson)

Example: seed limitation $= 1 - \frac{3}{5} = 0.4$

Establishment limitation

- Realize establishment limitation (Muller-Landau *et al* . 2002)

$$= 1 - \frac{\text{sites in which establishment occurs}}{\text{sites reached by seeds}}$$

- Source limitation (Clark *et al*. 1998)

(Uniform distribution stochastically as a Poisson)

Example: Establishment limitation $= 1 - \frac{2}{3} = 0.33$

The strength index

- The strength of seed and establishment limitation among species.

$$\delta_{\text{seed}} = \text{Fundamental seed limitation - Source limitation}$$

$$\delta_{\text{seedlings}} = \text{Realized seed limitation - Source limitation}$$

(the value between -1 and 1)

(Norden *et al.* 2009)

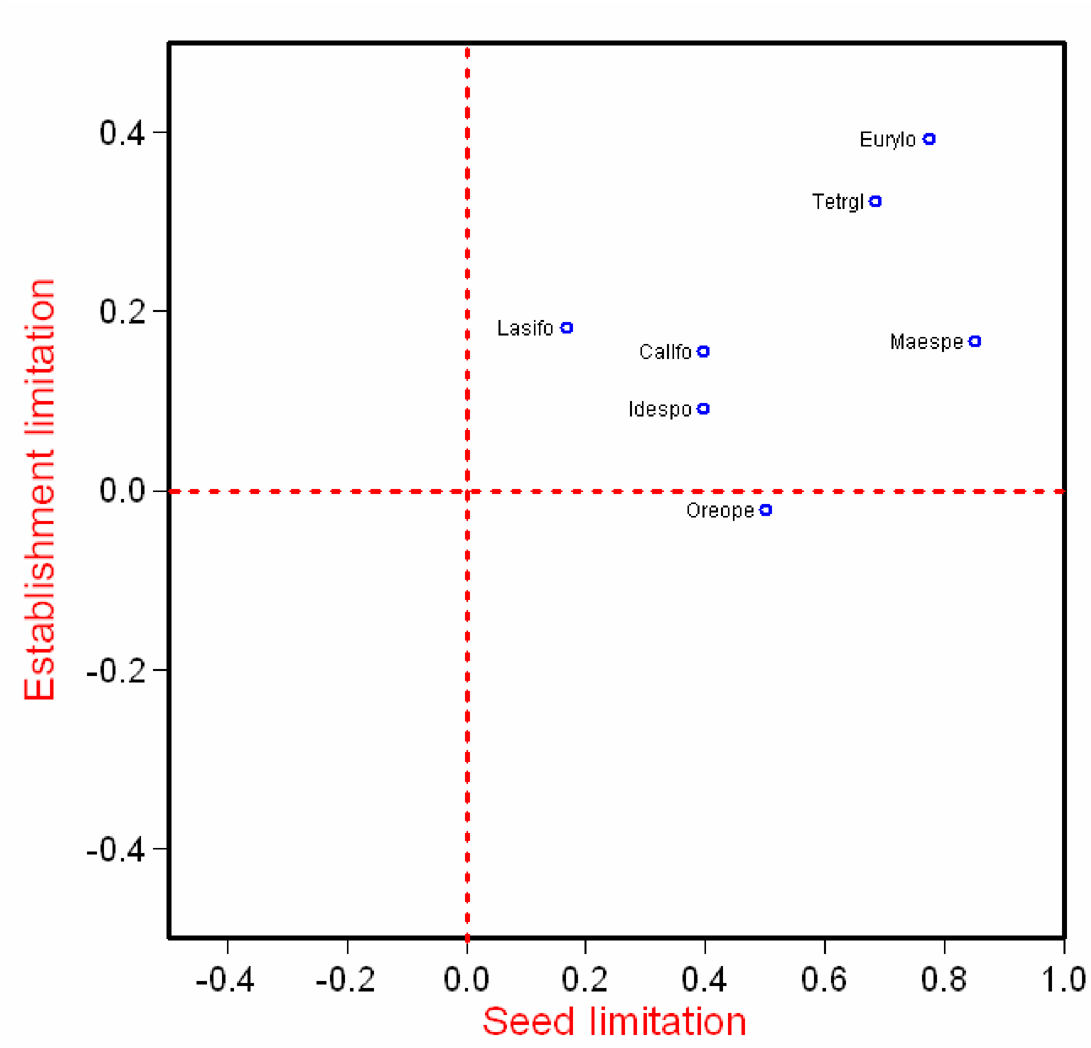
Species list for analysis

Species	Family	Growth form	No. of seeds	No. of recruits
Tetradium glabrifolium	RUTACEAE	Canopy	1842	57
Idesia polycarpa	FLACOURTIACEAE	Canopy	1639	16
Eurya loquaiana	THEACEAE	Shrub	378	186
Maesa perlaria	MYRSINACEAE	Shrub	332	32
Oreocnide pedunculata	URTICACEAE	Shrub	93	47
Callicarpa formosana	VERBENACEAE	Shrub	83	27
Lasianthus fordii	RUBIACEAE	Shrub	34	849

Results of dispersal limitation

Species	Number stations with seeds	Number stations with seeds and seedlings	Seed limitation	Source limitation (seeds)	Establishment limitation	Source limitation (seedlings)
Tetradium glabrifolium	34	3	0.69(+)	3.9E-08	0.91(+)	0.59(0.47-0.75)
Idesia polycarpa	65	3	0.40(+)	2.6E-07	0.95	0.86(0.75-0.96)
Eurya loquaiana	21	9	0.81(+)	0.03	0.57(+)	0.18(0.10-0.31)
Maesa perlaria	11	1	0.90(+)	0.05	0.91(+)	0.74(0.63-0.88)
Oreocnide pedunculata	8	3	0.93(+)	0.42	0.63	0.65(0.46-0.76)
Callicarpa formosana	15	1	0.86(+)	0.46	0.93(+)	0.78(0.66-0.87)
Lasianthus fordii	11	9	0.90(+)	0.72(0.60-0.87)	0.18(+)	3.9E-04

The strength index



Content

Seedling survival vs. environmental variables

- Some species were found in seedlings plot but were not found in seed trap.
  - Pioneer species
- Recruits of Seedling ≧ 40 in all plot

Seedling survival vs. environmental variables

- Logistic regression
  - Individual-based analysis for each species
  - Seedling survival (alive = 1 , dead=0)
  - Environmental variables
    - Destroy area (4 levels: 0%-25%, 25%-50%, 50%-75%,75%-100%)
    - Herb coverage area (4 levels: 0%-25%, 25%-50%, 50%-75%,75%-100%)
    - Litter coverage area (4 levels: 0%-25%, 25%-50%, 50%-75%,75%-100%)
    - Light level (Gap, Edge-Gap, Understory-Gap, Understory)
- Stepwise procedure
  - Select a best model by Akaike Information Criterion (AIC)

Seedling survival vs. environmental variables

Species	Destroy area			Herb coverage			Litter coverage			Light level			R^2_{adj}
	L	M	H	L	M	H	L	M	H	G	U	UG	
Trema orientalis	0.04	0.21***	0.09**	-0.05	-0.01	-0.05	-	-	-	-	-	-	0.08
Lasianthus fordii	0.26**	0.40***	0.16*	-	-	-	-	-	-	-0.01	-0.21***	0.25	0.15
Mallotus japonicus	0.02	0.24**	0.13*	0.18**	0.04	0.04	-	-	-	0.11*	-0.12*	0.03	0.14
Eurya loquaiana	-	-	-	-	-	-	0.08†	0.13***	0.04	-	-	-	0.04
Tetradium glabrifolium	-0.004	0.11**	0.08***	-	-	-	-	-	-	-	-	-	0.05

(***P ≤ 0.001, **P ≤ 0.01, *P ≤ 0.05, †P ≤ 0.1)

L : 25%~50%
M : 50%~75%
H : 75%~100%

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Summary

- Seed limitation and establishment limitation are higher in Zenlun forest dynamics plot.
- The destruction of thinning removes the ground cover and makes up more space. The removement of stems also change the light environment in plot. Pioneer species are therefore able to regenerate and further increase the diversity of the forest.


Thank you for your attention