Seed dispersal functions in the Kenting FDP

Yi-Ching Lin [1], Chia-Yu Lin [2], Pei-Jung Lin [2]
Hsiang-Hua Wang [3], and I-Fang Sun [1]

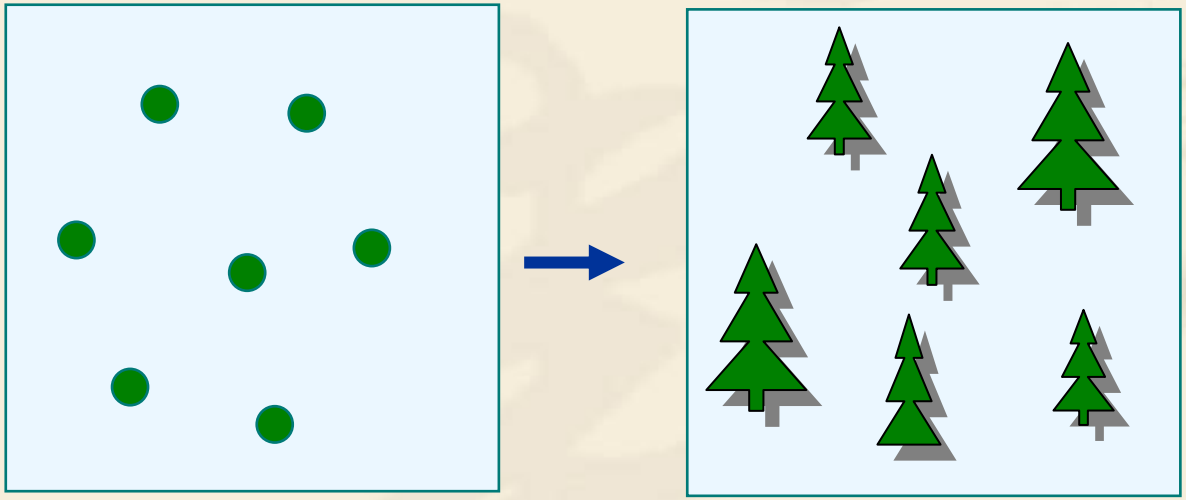
1 Department of Life Science,
Tunghai University

2 Faculty of Biomedical Science and Environmental Biology,
Kaohsiung Medical University

3 Forest Biology Division,
Taiwan Forestry Research Institute

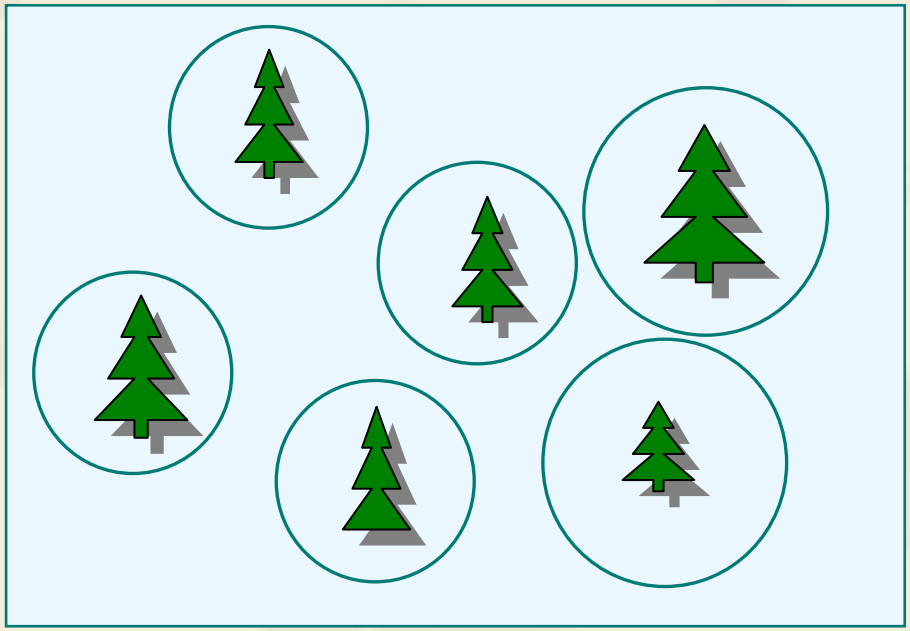
Spatial patterns of seeds

- **Spatial templates for tree populations**
- **Spatial relationships among individuals**
  - **Species coexistence**
  - **Genetic structure**

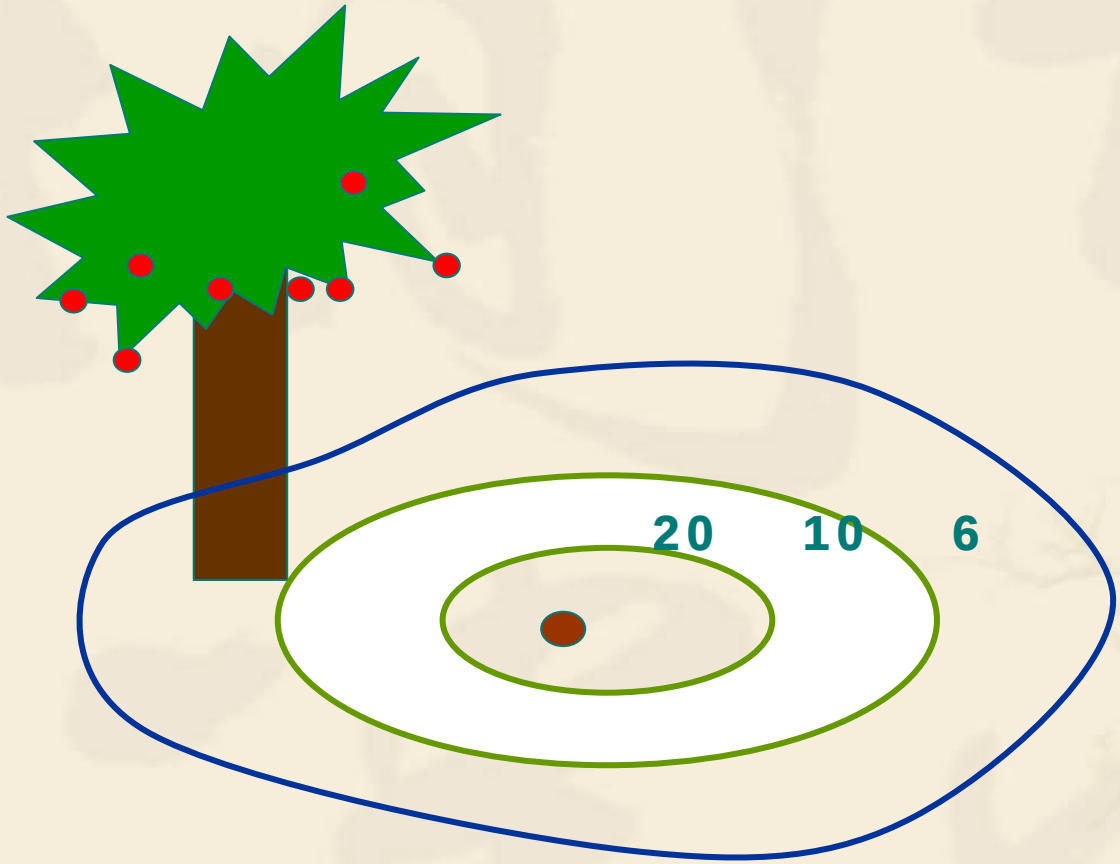


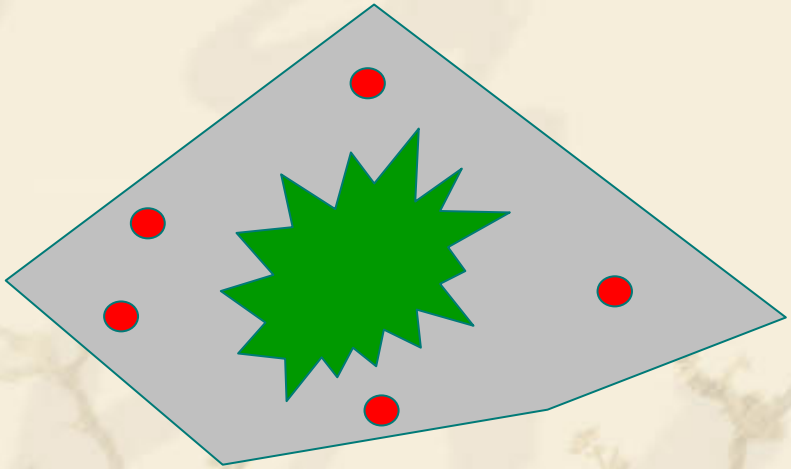
Seed dispersal

- **Underlying processes**
- **Linkage to spatial patterns of two generations**



Seed shadow

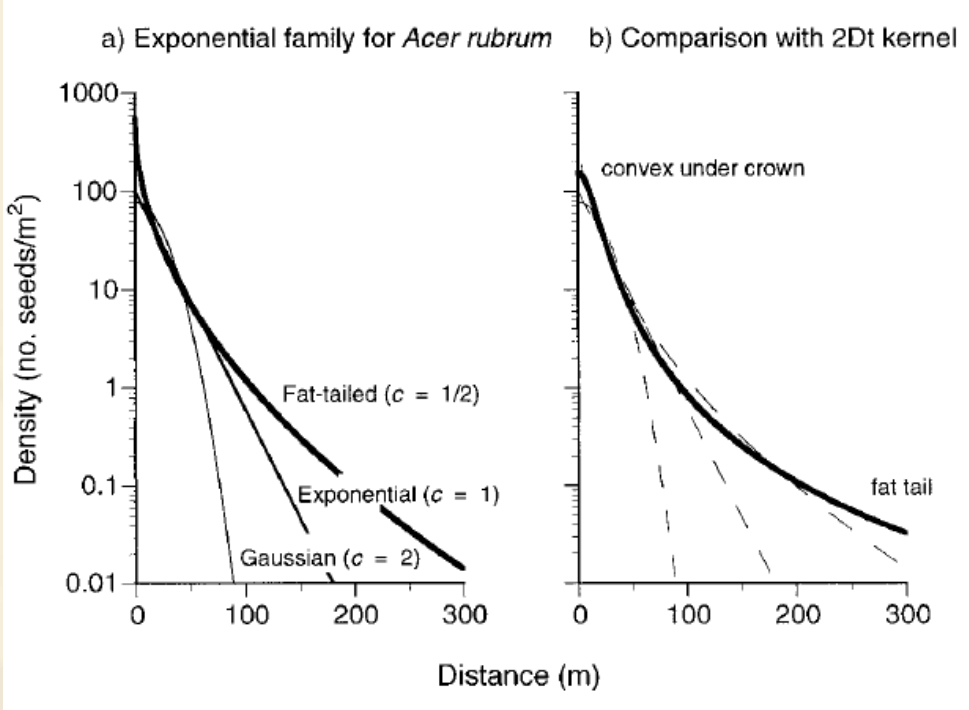




Quantifying a seed shadow

- **Mathematical description**
  Seed shadow
  = Fecundity x Dispersal kernel

- **Fecundity**
  Seed production
- **Dispersal kernel**
  Probability density function



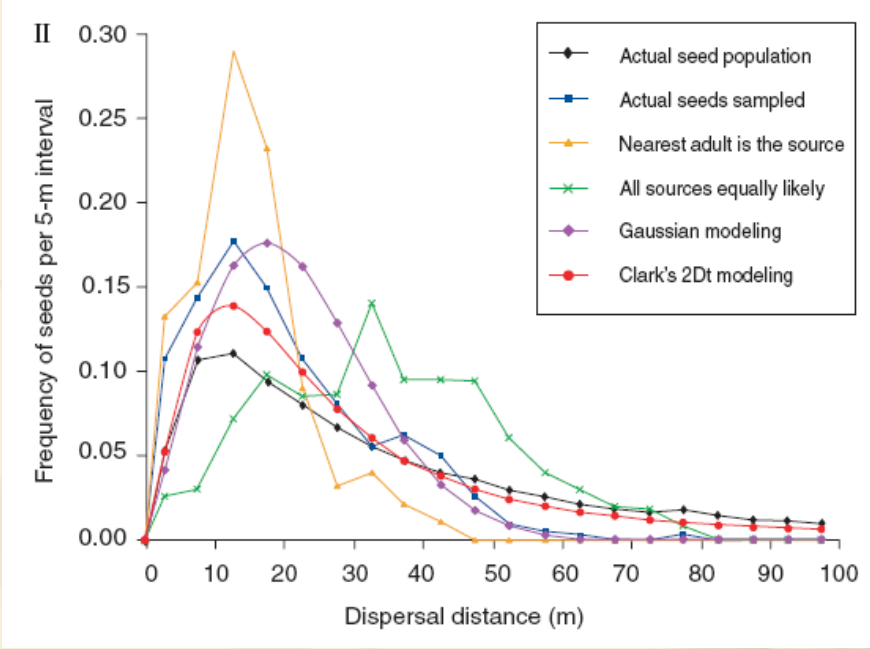
Clark *et al. 1999*

A long standing debate

- **What is the best descriptor of a seed shadow?**

e. g. Negative exponential, Weibull, Lognormal,

Clark 2 DT….. Etc.

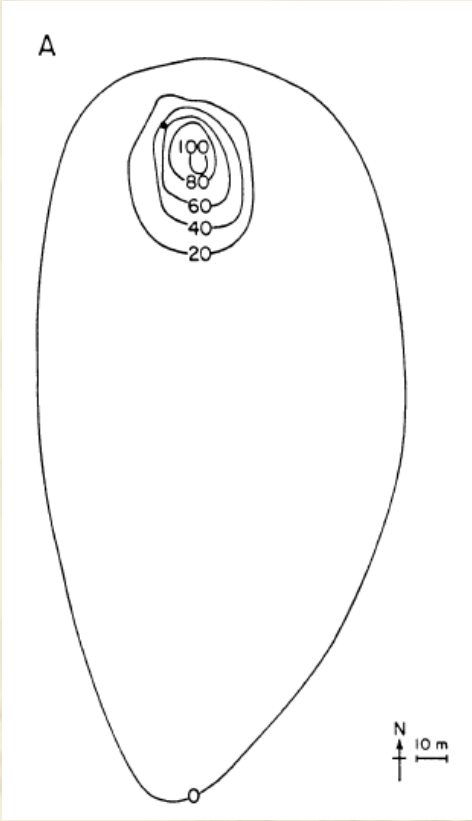


Nathan and Muller-Landau 2000

Seed shadows

- **Intensively studied in the 1980s**
  Mapping seeds around isolated parent trees

- **Constrains**
  Small sample size
  Unusual trees
  Large trees with high seed production



Kitaima and Augspurger *1989*

Seed shadows

- **Methodology advances in the past two decades**

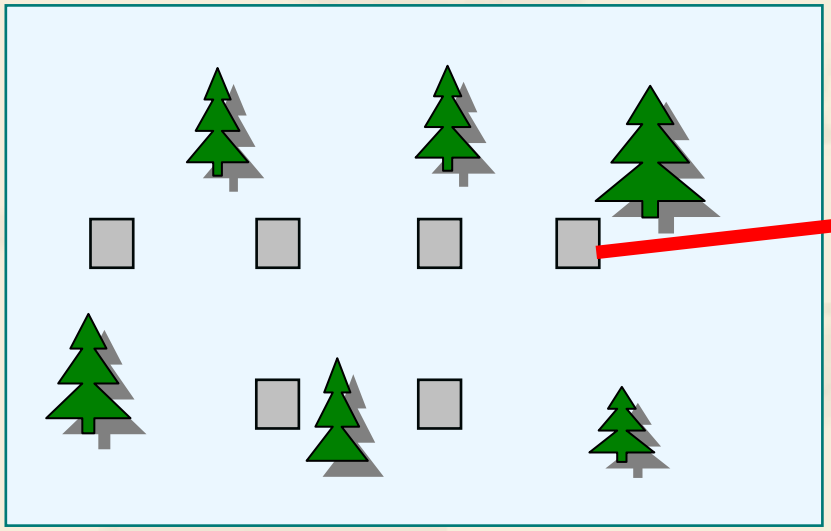
- **Inverse modeling**
  - **Less labor intensive**
  - **Population level**
  - **Individual differences**

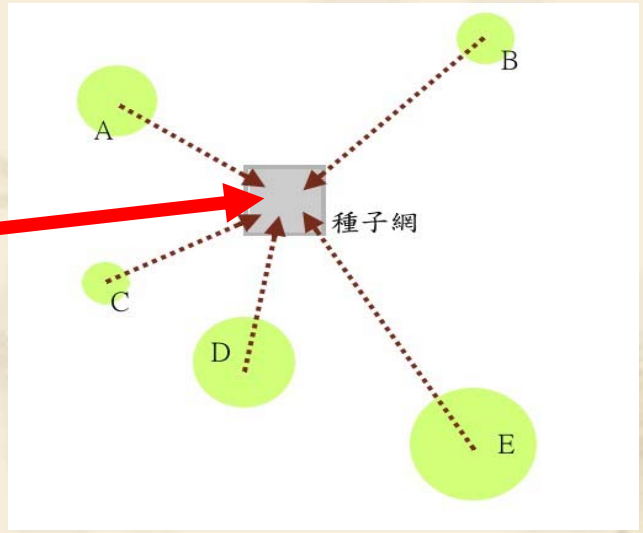
Inverse modeling

- **A likelihood approach**
- **Data requirements**

  Locations of parent trees

  Locations of seed traps

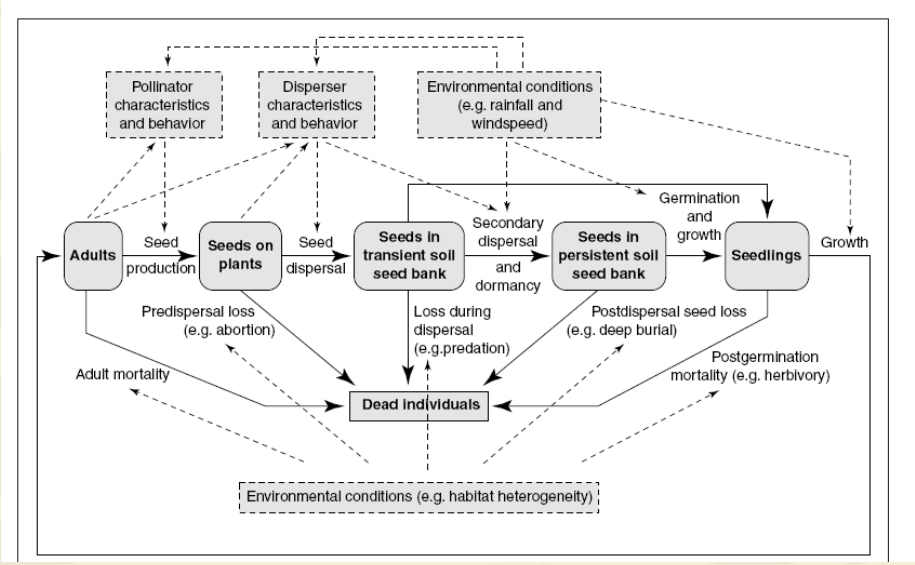




Lin and Lin *2007*

Seed shadows derived an inverse modeling approach

- **Phenomenological**
- **Net results of multiple processes**

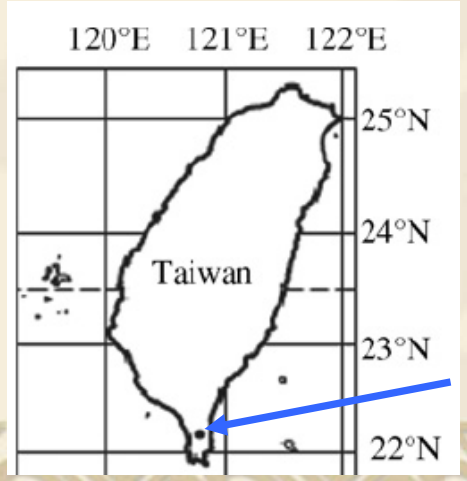


Nathan and Muller-Landau 2000

Objectives

- **Applying an inverse modeling approach to characterize seed shadows in the Kenting FDP**
- **Identifying the best fit seed dispersal functions**
- **Comparing seed dispersal functions of wind- and animal-dispersed species**

Study site



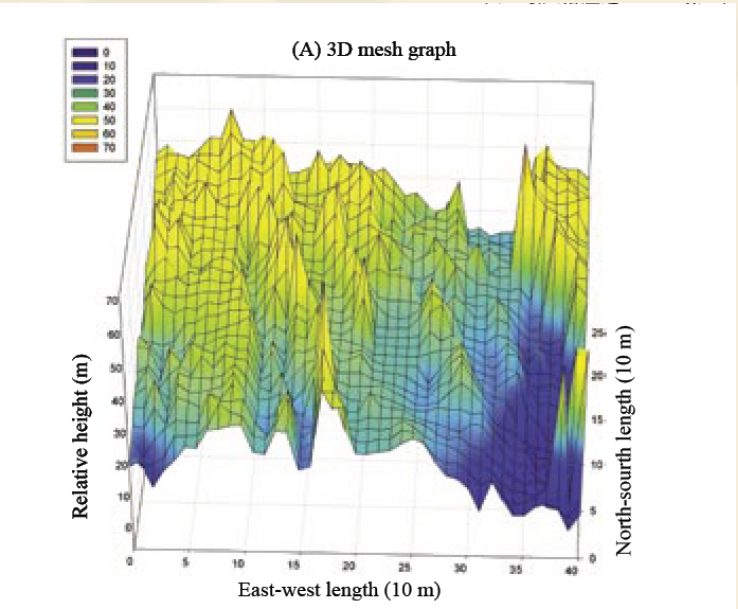
- **Kengting Uplifted Coral Reef Nature Reserve**
  - **Kenting National Park**
  - **Hengchun Peninsula**
  - **138 ha (20˚58N, 120˚48'E)**
  - **Elevated coral reef**
  - **Seasonal forest**
    - ***Monsoon: October ~ April***

- **Ebenaceae and Euphorbiaceae**
  - **Coast persimmon (*Diospyros maritime*)**

KUCRNR

Liao *et al.* 2006

The Kenting forest dynamics plot



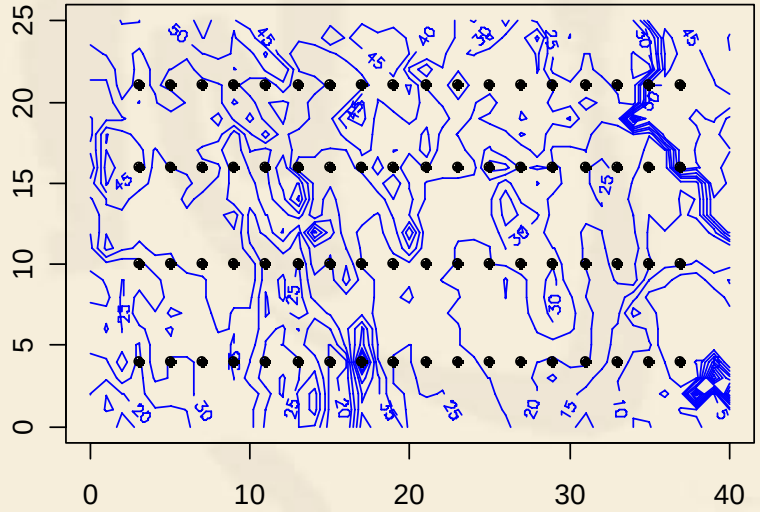
Wang *et. al.* 2004

- Dr. I-Fang Sun established in 1996
- First forest census (1996~2002)

  Dr. I-Fang Sun: Tunghai University

  Dr. Hsiang-Hua Wang: Taiwan Forestry Research Institute

Methods

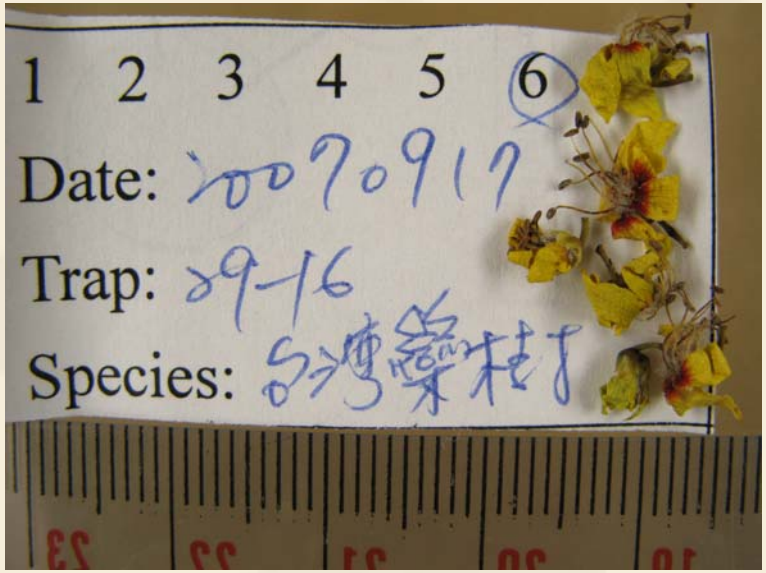


- Four transects, 20 m intervals, 72 seed traps
- 1-mm mesh, 0.5 m^2, 1 m above the ground
- Weekly collections since August 16, 2006
- Reproductive parts

Methods

- **Category**

  Flower, fruit, seed, capsule, fragment, immature flower&fruit
- **Species identity and quantity of fruits and seeds**
- **Viability**
- ***Ficus* species are not counted**



Target species

Species	Chinese name	Family
Laportea pterostigma	咬人狗	蕁麻科
Bischofia javanica	茄苳	大戟科
Macaranga tanarius	血桐	大戟科
Pisonia umbellifera	皮孫木	紫茉莉科
Mallotus phillipinensis	粗糠柴	大戟科
Radermachia sinica	山菜豆	紫薇科
Lagerstroemia subcostata	九芎	千屈菜科
Fraxinus formosana	白雞油	木犀科

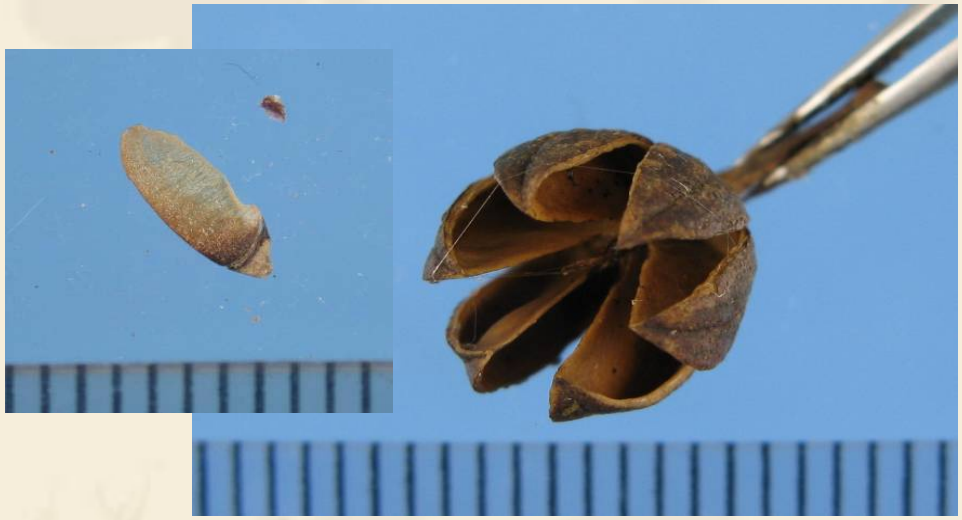
Species	Chinese name	Family
ANIMAL-DISPERSED SPECIES		
Laportea pterostigma	咬人狗	蕁麻科
Bischofia javanica	茄苳	大戟科
Macaranga tanarius	血桐	大戟科
Pisonia umbellifera	皮孫木	紫茉莉科
Mallotus phillipinensis	粗糠柴	大戟科
WIND-DISPERSED SPECIES		
Radermachia sinica	山菜豆	紫薇科
Lagerstroemia subcostata	九芎	千屈菜科
Fraxinus formosana	白雞油	木犀科

Animal-dispersed species

Animal-dispersed species

- **Damage**
- **Animal droppings**

Wind-dispersed species



http://www.hljh.tcc.edu.tw/teach.htm

Data analysis

- Inverse modeling
- Seed shadow model

Dispersal kernel

$$\text{Seed rain}\,(\#/\text{m}^2) = \sum_{i=1}^{N} f(size_i)\,g(dist_i)$$

A normalizer is included

DBH-Fecundity relationship

Inverse modeling

- **Step 1: Model specification**
- **Step 2: Error specification**
- **Step 3: Parameter estimation**
  - **Maximum likelihood estimation**
  - **Optimization**
- **Step 4: Model selection**

Model specification

- **Clark's 2 DT Model**
- **Lognormal Model**
- **Negative exponential Model**

- **Null model**

  Uniform distribution

  Average number of seeds / quadrat

Inverse modeling

- **Error specification**

  Poisson, Negative binomial

- **Model selection**

  Akaike's Information Criterion (AIC)

$$AIC = -2\,ln(\,L(\,\theta \mid y\,)) + 2K$$

Likelihood ratio test (Statistical significance)

Results

- 2006.8.16.~2007.9.24
- Parent trees (The Kenting First Census)
- Dioecious: *Bischofia javanica (Excluding male trees)*

Species	Chinese name	Seed	Parent
Radermachia sinica	山菜豆	2588	17
Lagerstroemia subcostata	九芎	466	11
Fraxinus formosana	白雞油	179	4
Laportea pterostigma	咬人狗	8189	1507
Bischofia javanica	茄苳	3677	176
Macaranga tanarius	血桐	906	327
Pisonia umbellifera	皮孫木	602	325
Mallotus phillipinensis	粗糠柴	405	56

Model		*Bischofia javanica*	*Laportea pterostigma*	*Macaranga tanarius*	*Mallotus phillipinensis*	*Pisonia umbellifera*
Seeds/ m2	Negative expontial	218.08	2284.14	3.35E+21	4787.07	1.58E+12
	Lognormal	218.33	995.67	1.81E+12	3669342.85	127.69
	2Dt	206.80	6.75E+09	1.02E+16	6.98E+07	735879.53
Dispersal parameter1	Negative expontial	4.86	95.05	81205145.79	14.75	1779409.56
	Lognormal	8.74	9.24	5.02E+22	2.70E-06	94.46
	2Dt	147.54	12198.59	3.96E+12	4.04E-17	2.15E+14
Dispersal parameter 2	Lognormal	0.62	0.30	7.01	6939.18	0.43
	2Dt	1.81	1.50E-07	198.09	8.15E-06	2271935.93

Model selection

Model		*Bischofia javanica*	*Laportea pterostigma*	*Macaranga tanarius*	*Mallotus phillipinensis*	*Pisonia umbellifera*
Likelihood	Negative expontial	-930.46	-16821	-327.2	-74.64	-123.58
	Lognormal	-921.19	-774.23	-337.67	-76.48	-121.41
	2Dt	-917.91	-16361.01	-331.42	-77.43	-122.99
AIC	Negative expontial	1798.11	32387.49	657.39	142.66	234.59
	Lognormal	1779.65	1492.87	666.60	132.67	228.18
	2Dt	1774.62	31559.54	676.95	133.87	241.66
P	Negative expontial	<0.001	<0.001	0.99	0.22	0.43
	Lognormal	<0.001	<0.001	0.30	0.04	0.36
	2Dt	<0.001	<0.001	0.96	0.02	0.5

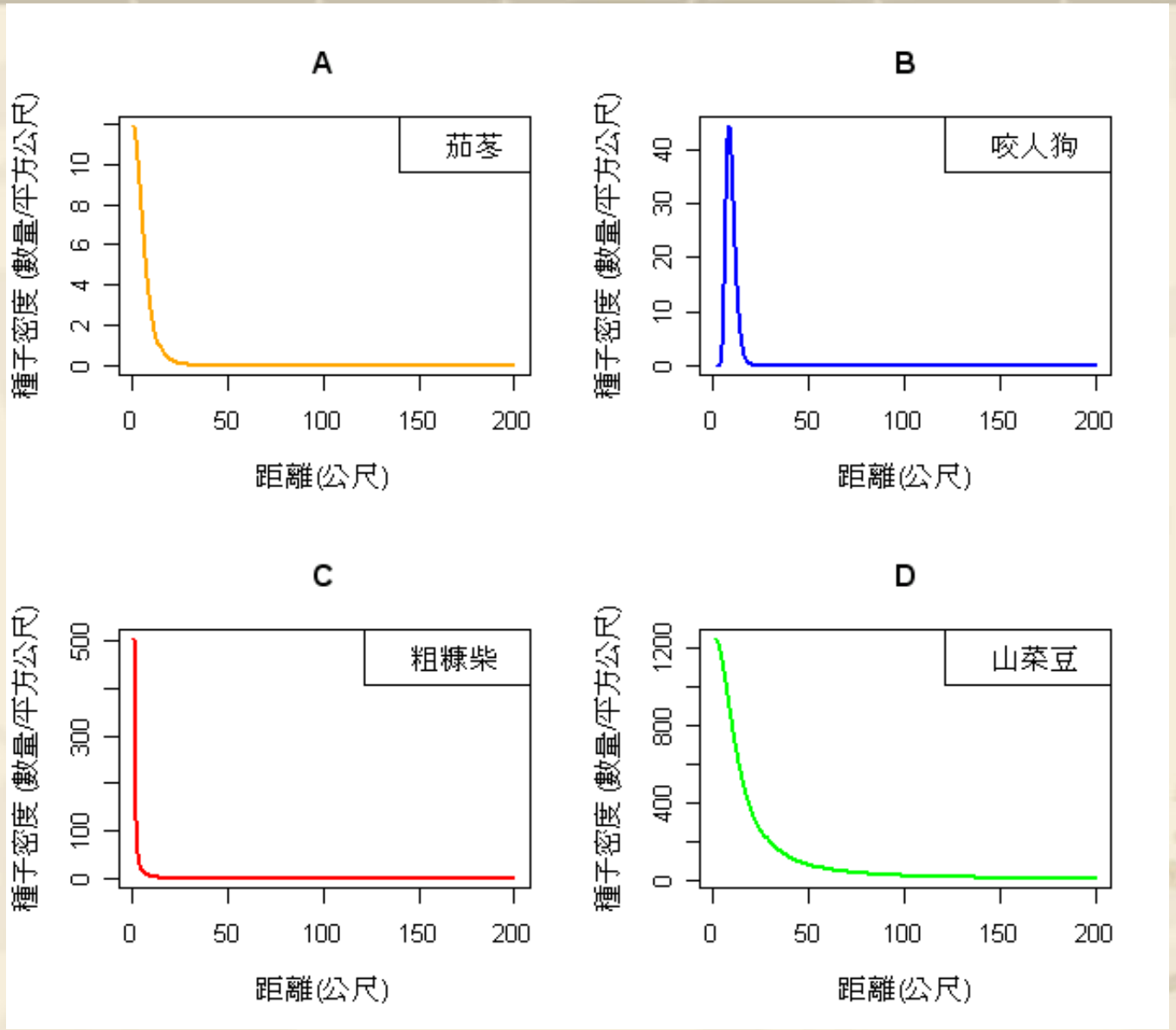
Model		*Radermachia sinica*	*Lagerstroemia subcostata*	*Fraxinus formosana*
Seeds/ m2	Negative expontial	3837.73	115470616	493.36
	Lognormal	407493.81	1.68E+61	6592.59
	2Dt	2.30E+08	3.65E+10	3.21E+09
Dispersal parameter1	Negative expontial	35.25	18507.47	38.98
	Lognormal	86665509.14	1.62E-47	229.45
	2Dt	160.58	5.26	35302662
Dispersal parameter 2	Lognormal	177.11	7.57	14.49
	2Dt	0.0002	0.0005	11512.58

Model selection

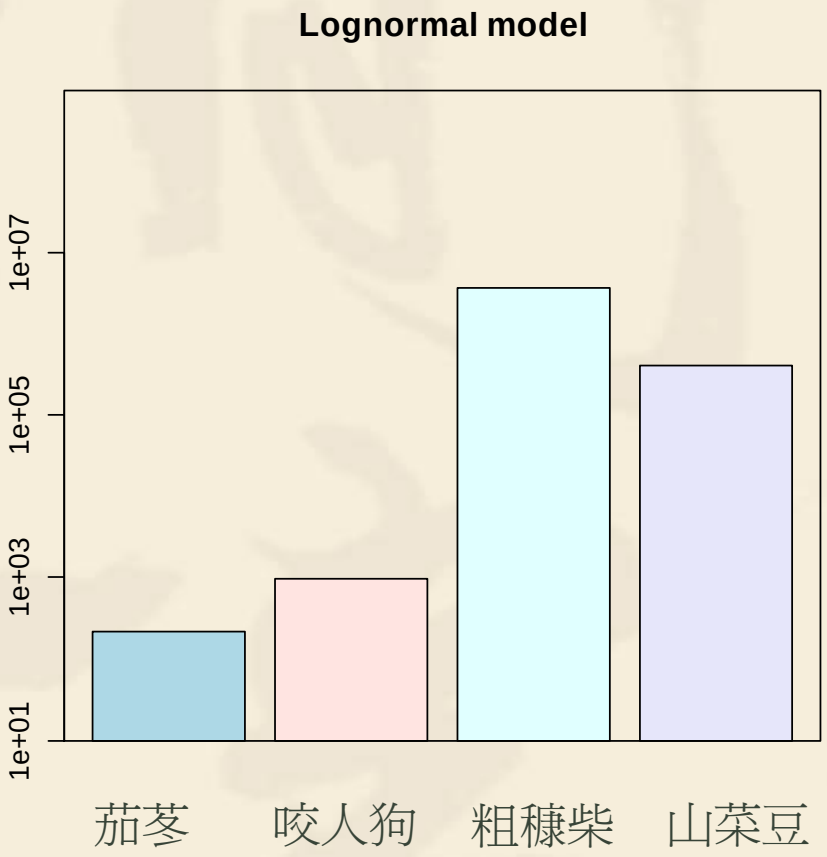
Model		*Radermachia sinica*	*Lagerstroemia subcostata*	*Fraxinus formosana*
Likelihood	Negative expontial	-810.16	-253.79	-105.33
	Lognormal	-804.33	-256.01	-104.81
	2Dt	-800.91	-255.22	-103.71
AIC	Negative expontial	1537.36	497.1	203.74
	Lognormal	1507.37	487.76	205.57
	2Dt	1494.97	491.81	214.38
P	Negative expontial	<0.001	0.99	0.23
	Lognormal	<0.001	0.99	0.38
	2Dt	<0.001	0.99	0.37

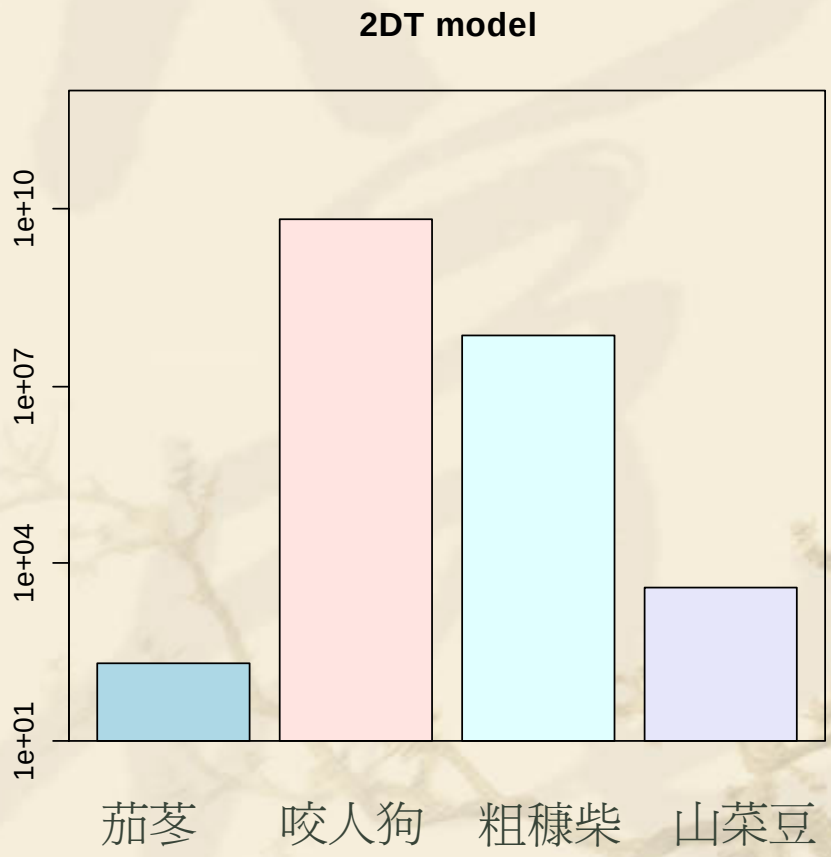
Best model

Species	Chinese name	AIC	Likelihood Ratio
Laportea pterostigma	咬人狗	2Dt	*
Bischofia javanica	茄苳	Lognormal	*
Macaranga tanarius	血桐	Negative expontial	NS
Pisonia umbellifera	皮孫木	Lognormal	NS
Mallotus phillipinensis	粗糠柴	Lognormal	*
Radermachia sinica	山菜豆	2Dt	*
Lagerstroemia subcostata	九芎	Lognormal	NS
Fraxinus formosana	白雞油	Negative expontial	NS


A
茄冬
種子密度 (數量/平方公尺)
0 2 4 6 8 10
0 50 100 150 200
距離(公尺)
B
咬人狗
種子密度 (數量/平方公尺)
0 10 20 30 40
0 50 100 150 200
距離(公尺)
C
粗糠柴
種子密度 (數量/平方公尺)
0 100 300 500
0 50 100 150 200
距離(公尺)
D
山菜豆
種子密度 (數量/平方公尺)
0 400 800 1200
0 50 100 150 200
距離(公尺)

Fecundity


Lognormal model
1e+01
1e+03
1e+05
1e+07
茄茎
咬人狗
粗穗柴
山菜豆


2DT model
1e+01
1e+04
1e+07
1e+10
茄茎
咬人狗
粗穗柴
山菜豆

Discussion

- **Seed dispersal functions: 2DT and Lognormal models**
- **Wind-dispersed species are dispersed farther**
- **High variability in fecundity**

Discussion

- Wind-dispersed species
- Field observations
  - Dioecious species
  - Seed dispersers
- Future work
  - Plot-wide estimation
  - Seedling census

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Plot census

TFRI, Tunghai University

Flab and field assistance

Students from KMU


Thank you for your attention