Inferences on dispersal and migration capacities: from local to landscape scales

Etienne E. Klein, Aurore Bontemps, Annabelle Amm, Christian Pichot, Sylvie Oddou-Muratorio Sylvie

Inferences on dispersal and migration capacities: from local to landscape scales

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Aurore Bontemps
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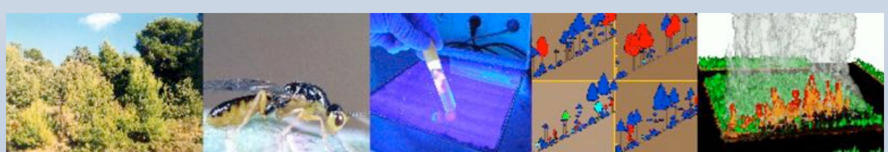
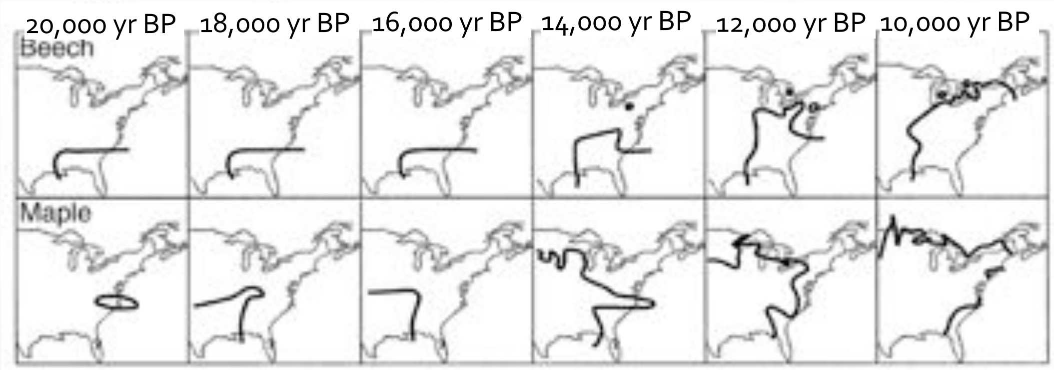
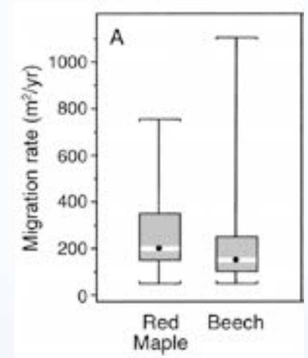
URFM, Écologie des Forêts Méditerranéennes, INRA Avignon
BioSP, Biostatistique et Processus Spatiaux, INRA Avignon

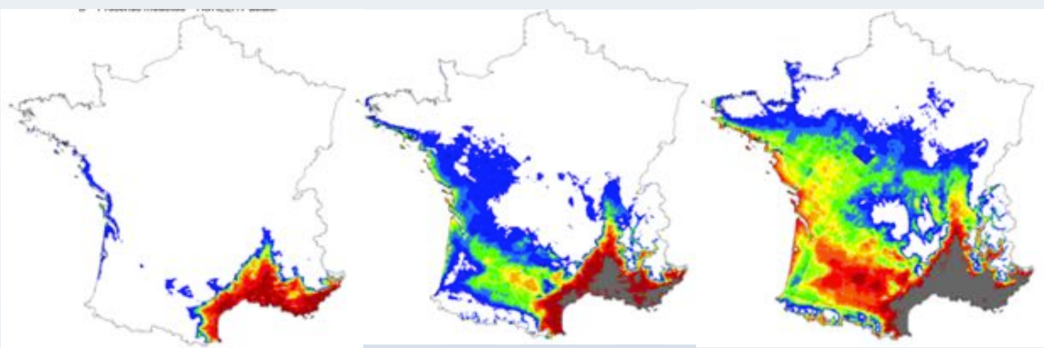


Prediction: a new challenge for dispersal ecology

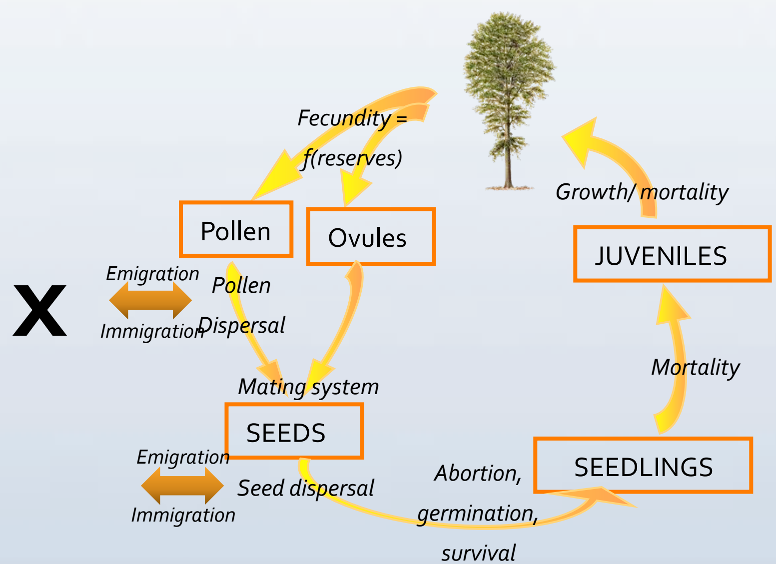




Skellam 1951; Davies 1981; Delcourt & Delcourt 1987, reported in McLachlan et al. 2005



Carbofor, 2004



Journal of Ecology 2003 91, 341–347

ESSAY REVIEW

Forecasting plant migration rates: managing uncertainty for risk assessment

S. I. HIGGINS, J. S. CLARK*, R. NATHAN†, T. HOVESTADT‡, F. SCHURR, J. M. V. FRAGOSO§, M. R. AGUIAR¶, E. RIBBENS** and S. LAVOREL††

THE YEAR IN ECOLOGY AND CONSERVATION BIOLOGY, 2009

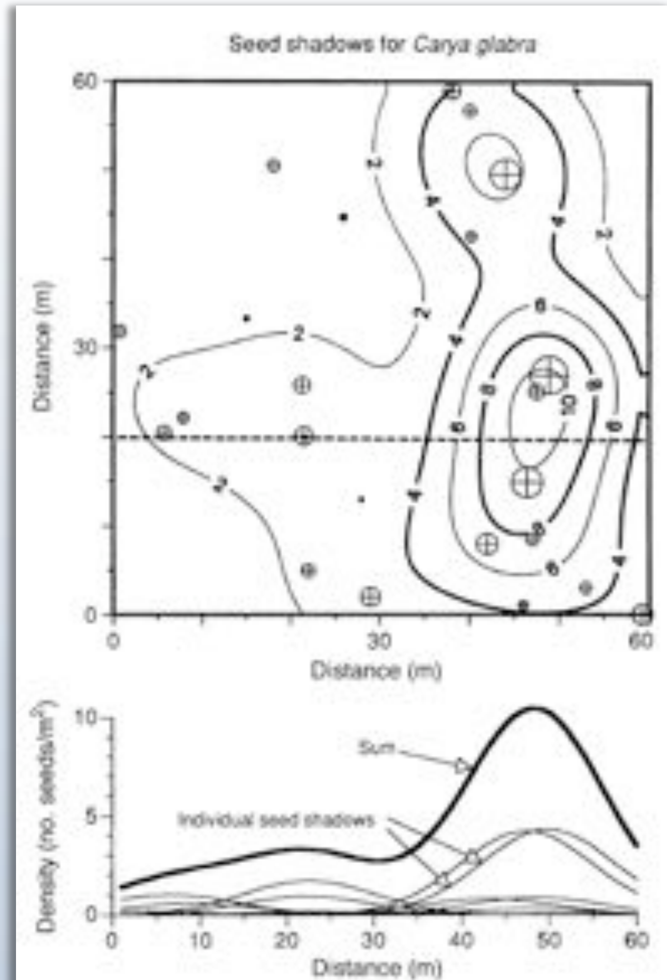
A Predictive Framework to Understand Forest Responses to Global Change

Sean M. McMahon,[a] Michael C. Dietze,[b] Michelle H. Hersh,[c] Emily V. Moran,[d] and James S. Clark[a,d,e]

First mechanistic component: the dispersal kernel

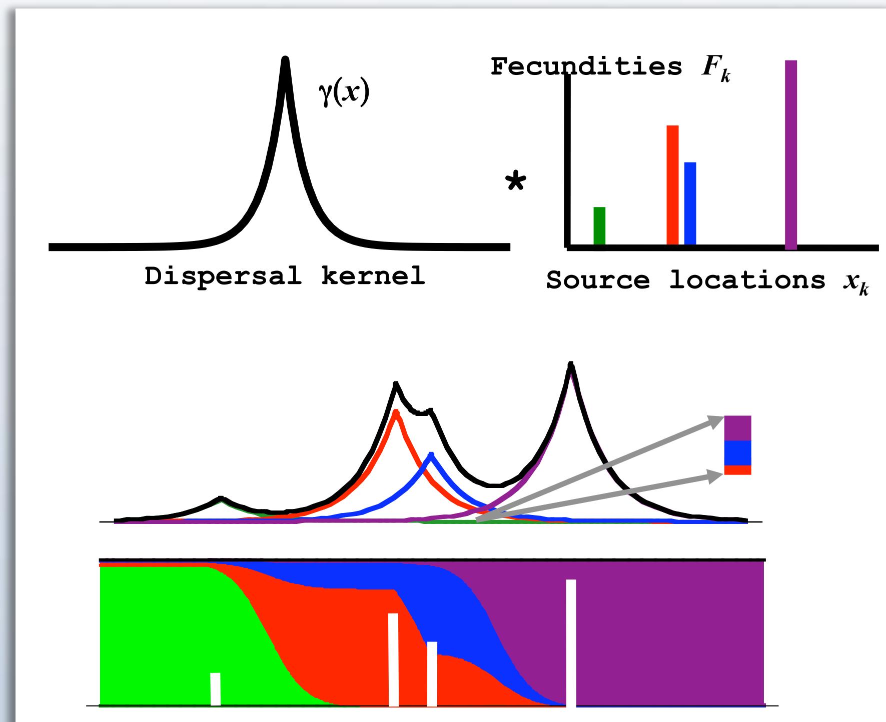
- Modelling the overlap of individual seed shadows

to characterize seed rain intensity …



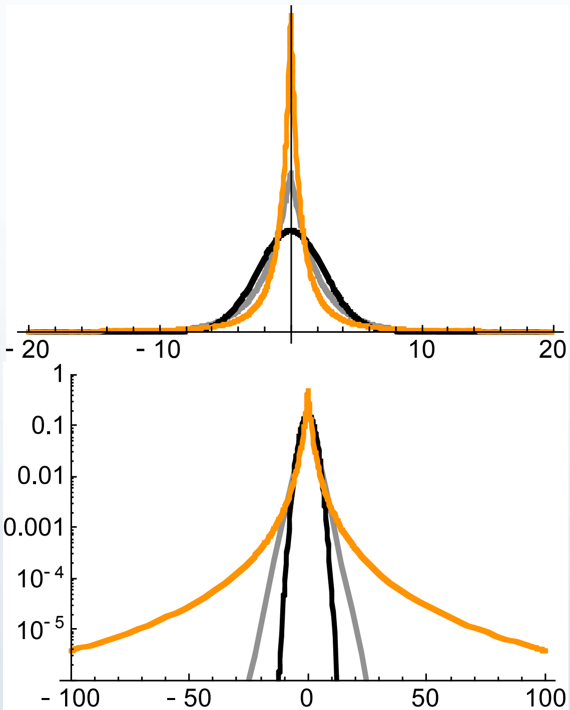
Clark et al. 1999

… and propagule pools diversity



Klein et al. 2008

1. One critical biological parameter for the rate of spread : the tail of the dispersal kernel



- Even if roughly similar at short distances, kernels that decrease differently at long distances provide markedly different rate of spread

Fat-tailed vs. thin-tailed kernels

Ecology, 77(7), 1996, pp. 2027–2042

DISPERSAL DATA AND THE SPREAD OF INVADING ORGANISMS[1]

Mark Kot
Department of Mathematics, University of Tennessee, Knoxville, Tennessee 37996-1300 USA

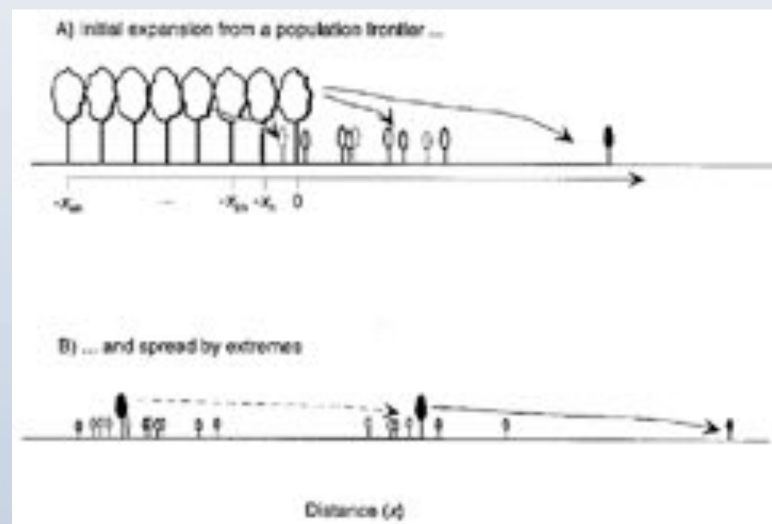
Mark A. Lewis
Department of Mathematics, University of Utah, Salt Lake City, Utah 84112 USA

P. van den Driessche
Department of Mathematics and Statistics, University of Victoria, Victoria, British Columbia, V8W 3P4 Canada

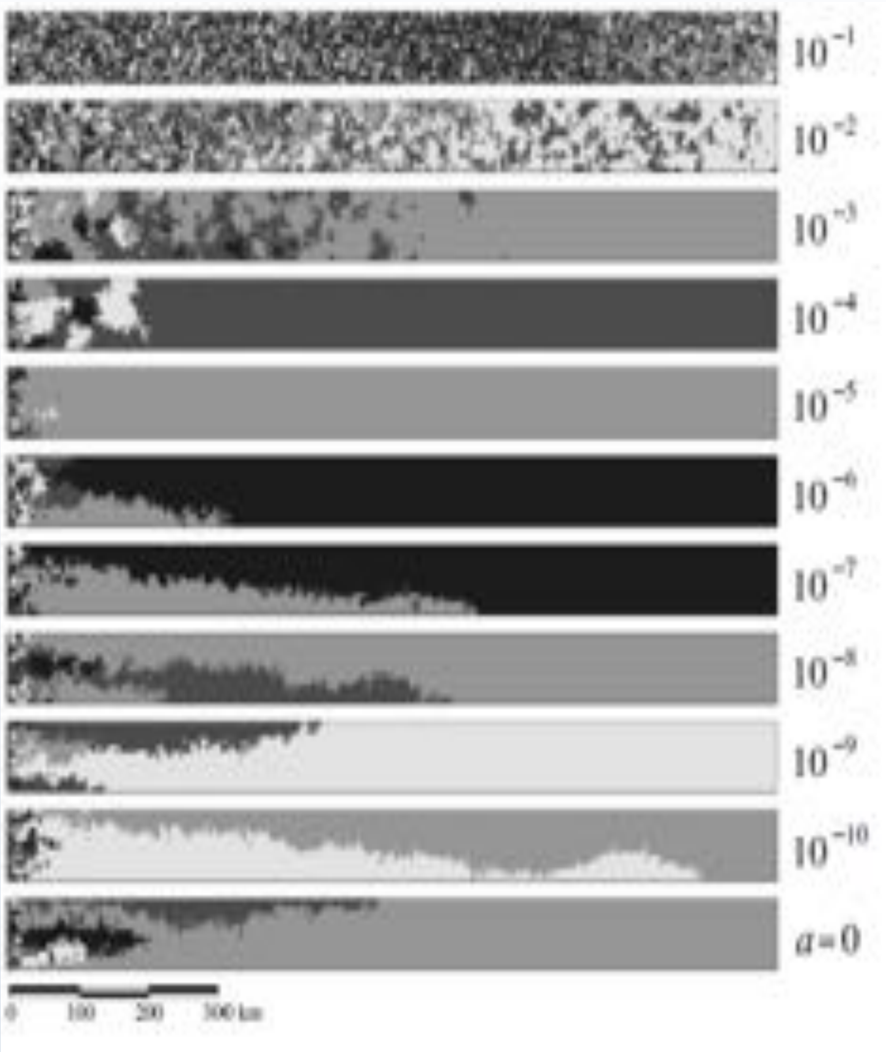
VOL. 157, NO. 5 THE AMERICAN NATURALIST MAY 2001

Invasion by Extremes: Population Spread with Variation in Dispersal and Reproduction

James S. Clark,[1,*] Mark Lewis,[2] and Lajos Horvath[3]



1. One critical biological parameter for genetic diversity:
LDD and the tail of the dispersal kernel

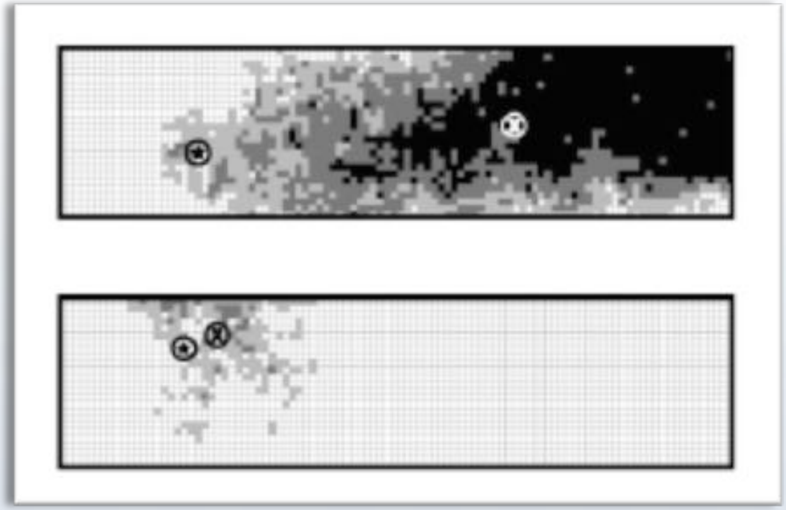


Bialozyt et al. 2006; two Gaussian components for short distance (1-a) and long-distance dispersal (a)

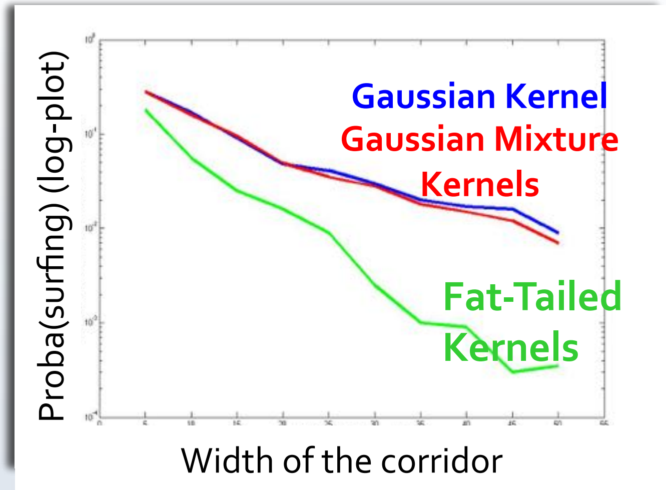
- Long-distance dispersal (LDD) events are responsible for **founder effects**
- Intermediate amounts of LDD result in the most critical loss of genetic diversity

1. One critical biological parameter for genetic diversity:
LDD and the tail of the dispersal kernel

- The shape of the kernel matters and not only amount of LDD
- Fat-tailed kernels hamper the surfing phenomenon on the colonisation front



Edmonds et al. 2004; Excoffier et al. 2009



Fayard et al. 2009

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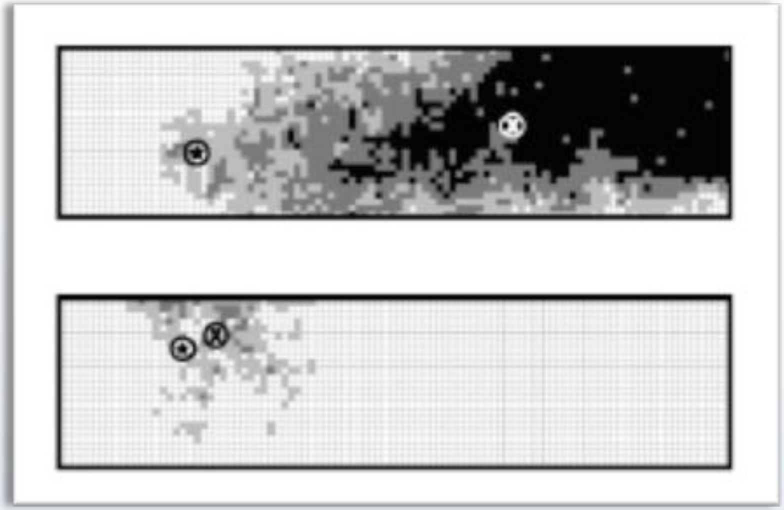
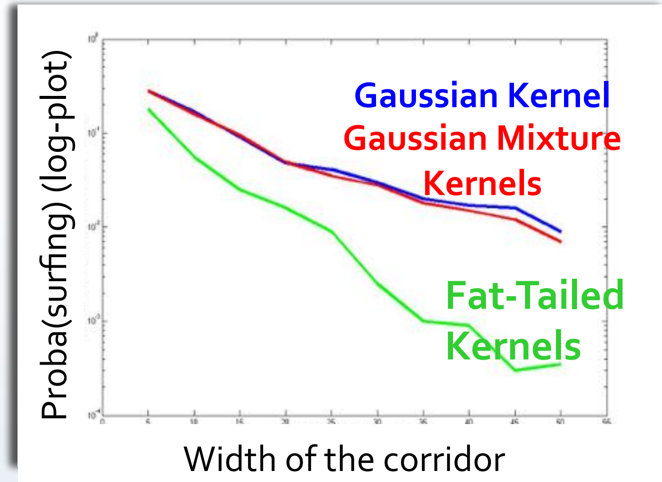
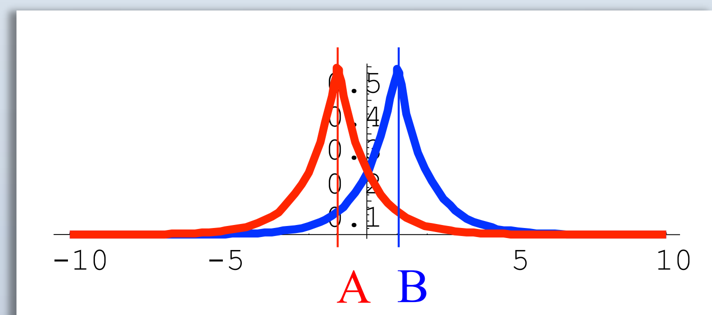


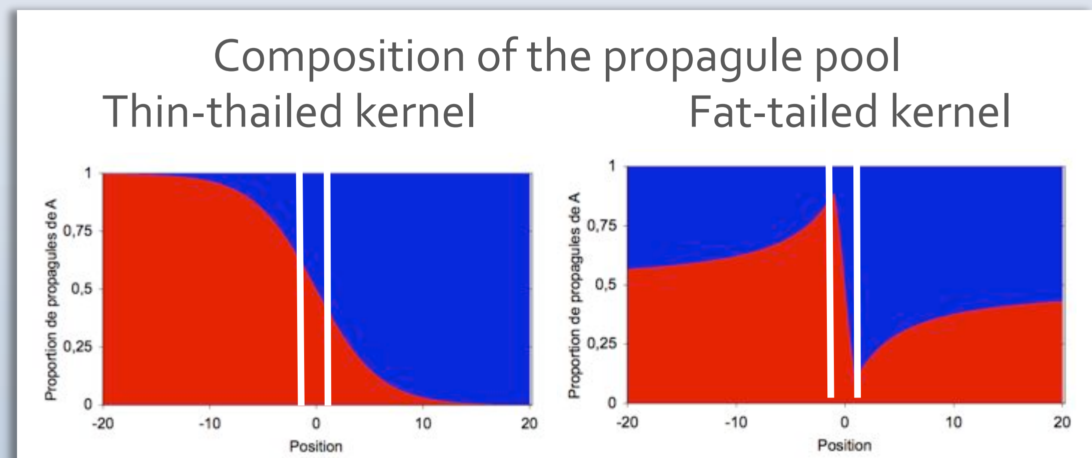
Edmonds et al. 2004; Excoffier et al. 2009



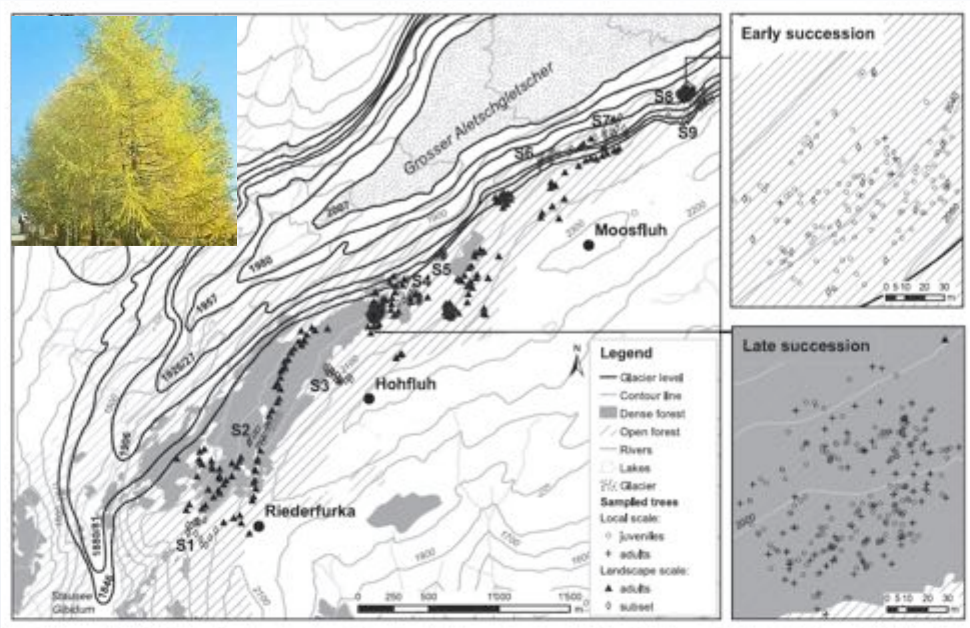
Fayard et al. 2009

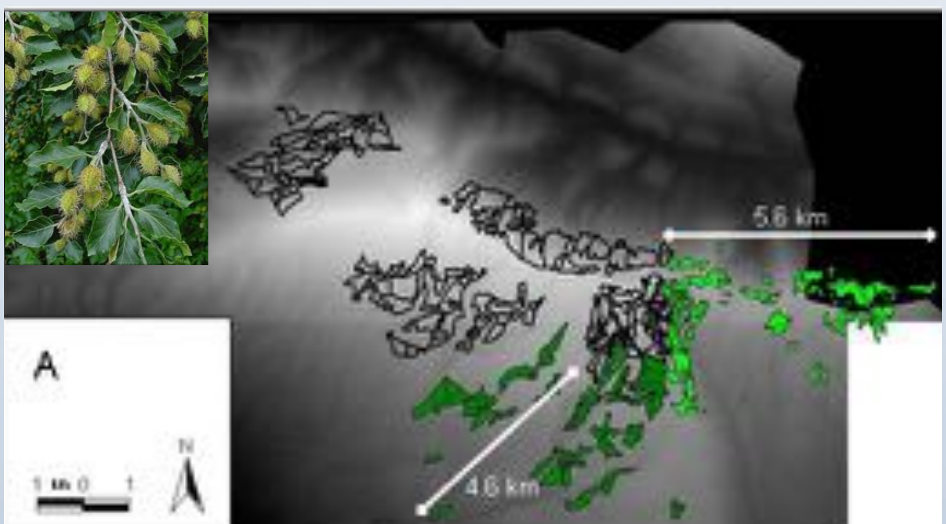
- One explanation: mixing of propagules counteracts the founder effects





1. One critical biological parameter for genetic diversity:
LDD and the tail of the dispersal kernel



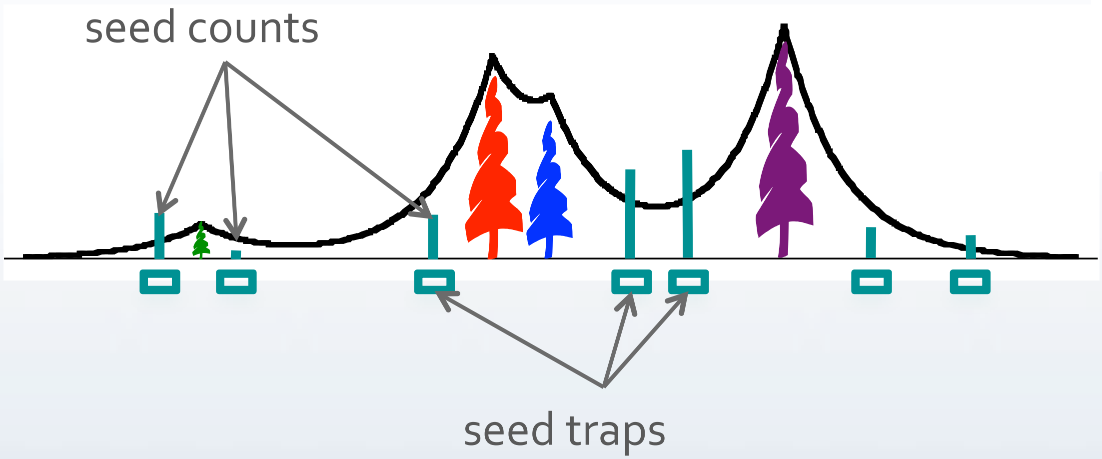


Pluess et al. 2011, Lander et al. submitted

- Gene mixing could explain the maintenance of genetic diversity:

  No reduction of genetic diversity on the leading-edge of populations in *Larix decidua* or *Fagus sylvatica* after ~150 years

2. Estimating dispersal kernels from sampled seeds: inverse modelling



Ecology, 75(6), 1994, pp. 1794–1806

SEEDLING RECRUITMENT IN FORESTS: CALIBRATING MODELS TO PREDICT PATTERNS OF TREE SEEDLING DISPERSION[1]

ERIC RIBBENS, JOHN A. SILANDER, JR., AND STEPHEN W. PACALA[2]
Ecology and Evolutionary Biology, University of Connecticut, Storrs, Connecticut 06269-3042 USA

- Uses counts of seeds in seed traps
- Relies on the exact positions of sources
- Finds the dispersal kernel (and the fecundity parameters) that best explain the seed counts

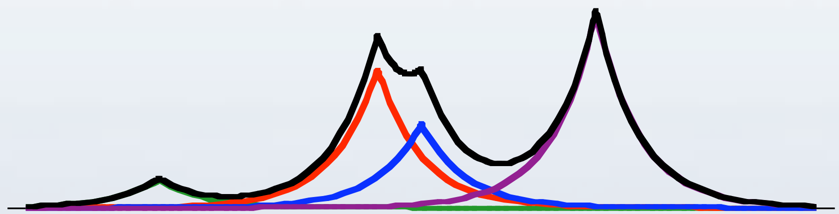
Statistics resolve the problem of seed shadows overlap and retrieve the "individual" dispersal kernel

2. Estimating dispersal kernels from established seedlings: inverse modelling

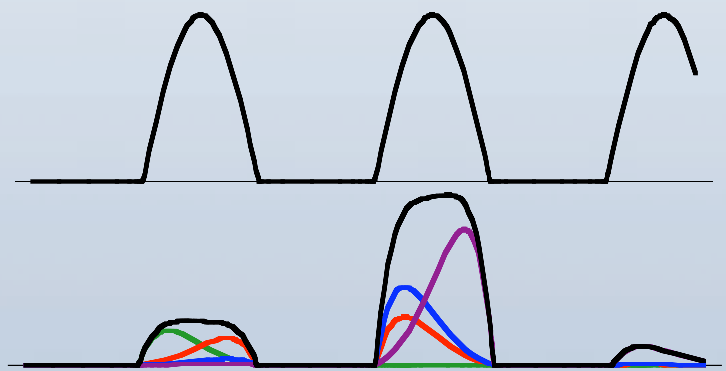
- Sampling established seedlings has several advantages…

  easier, all dispersal agents sampled representatively, cumulates several dispersal events

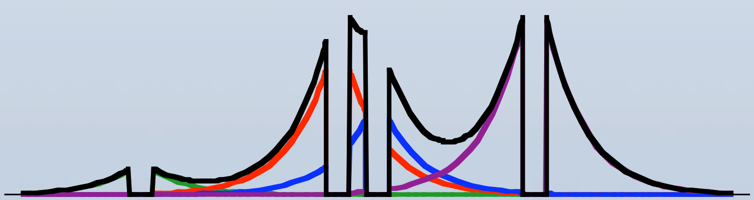
- … but one drawback



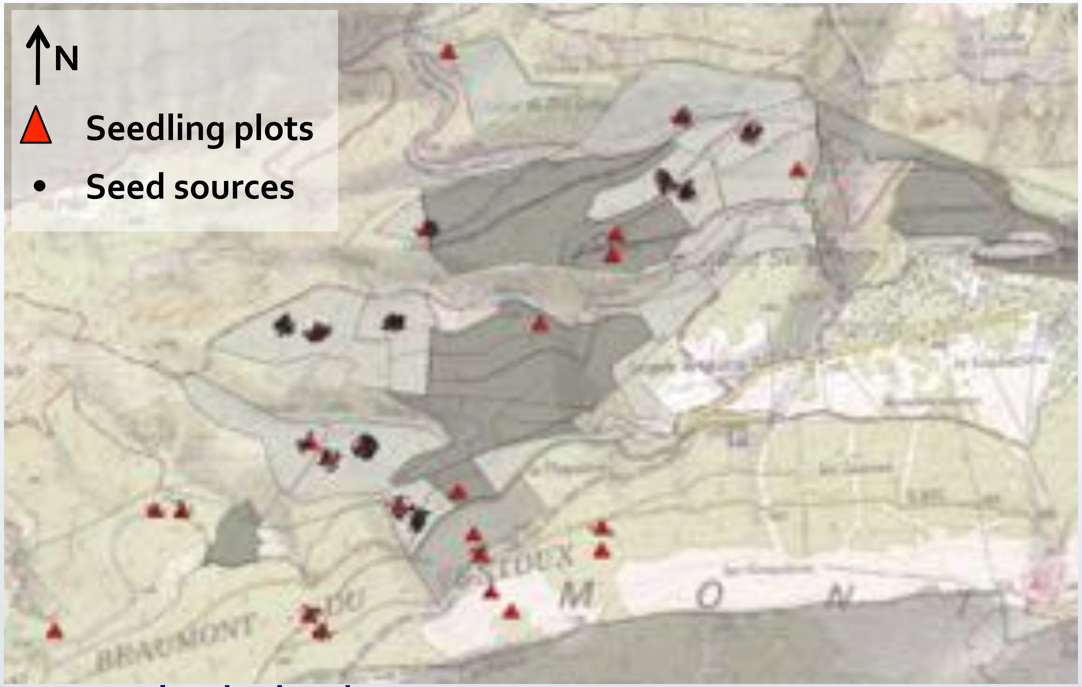
Germination and survival depending on the environment



Competition between adults and seedlings

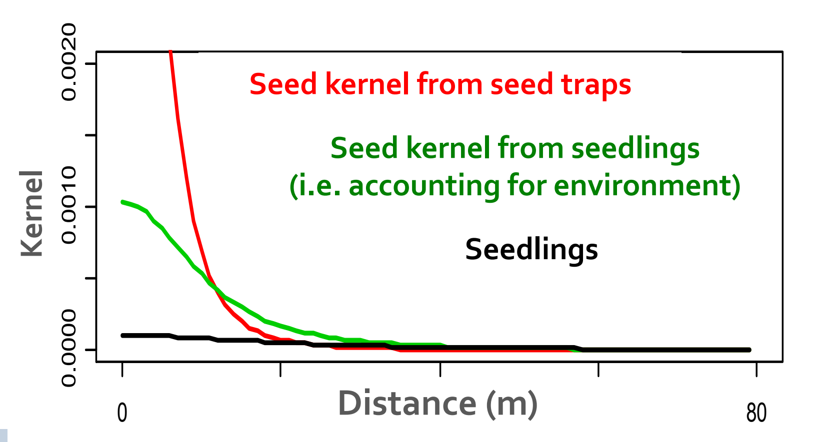


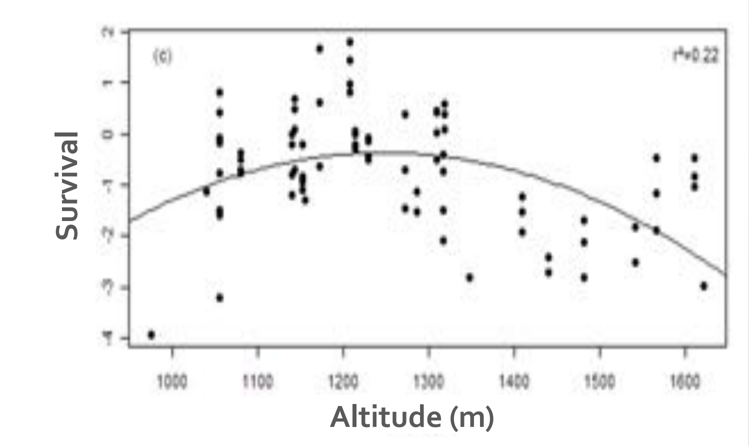
2. Estimating dispersal kernels from established seedlings: inverse modelling with environmental effects



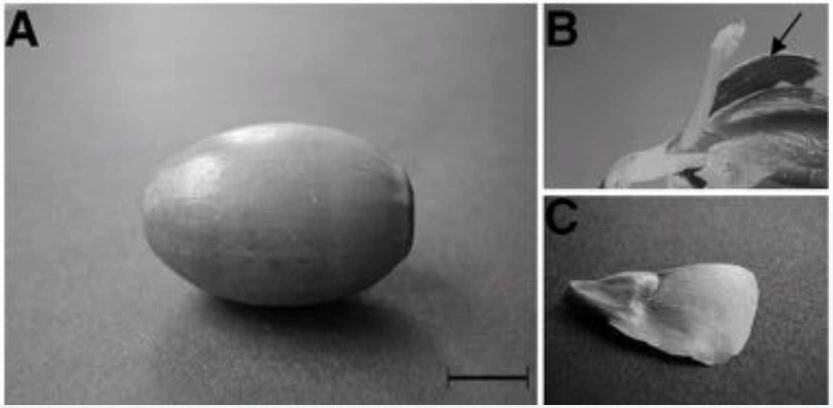
Amm et al. submitted

- From seedling counts…
- estimate the seed dispersal kernel jointly with…
- effects of environmental variables on germination and survival rates
- Wider scales investigated





2. Estimating dispersal kernels from sampled seeds: genetical markers to retrieve dispersal events

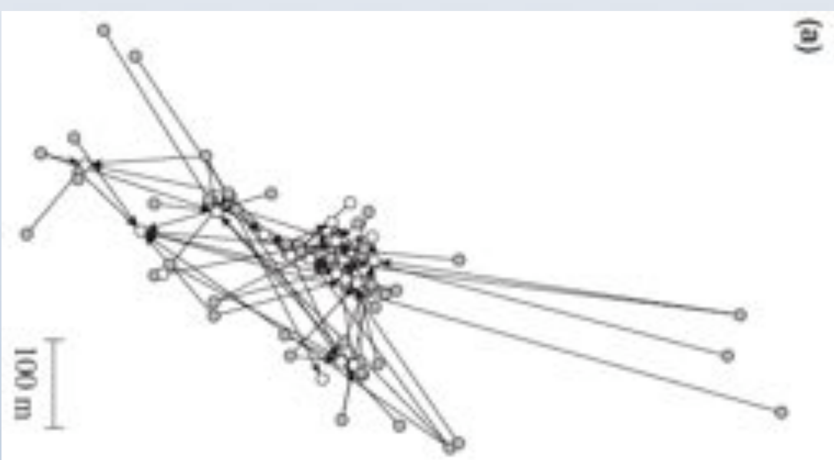


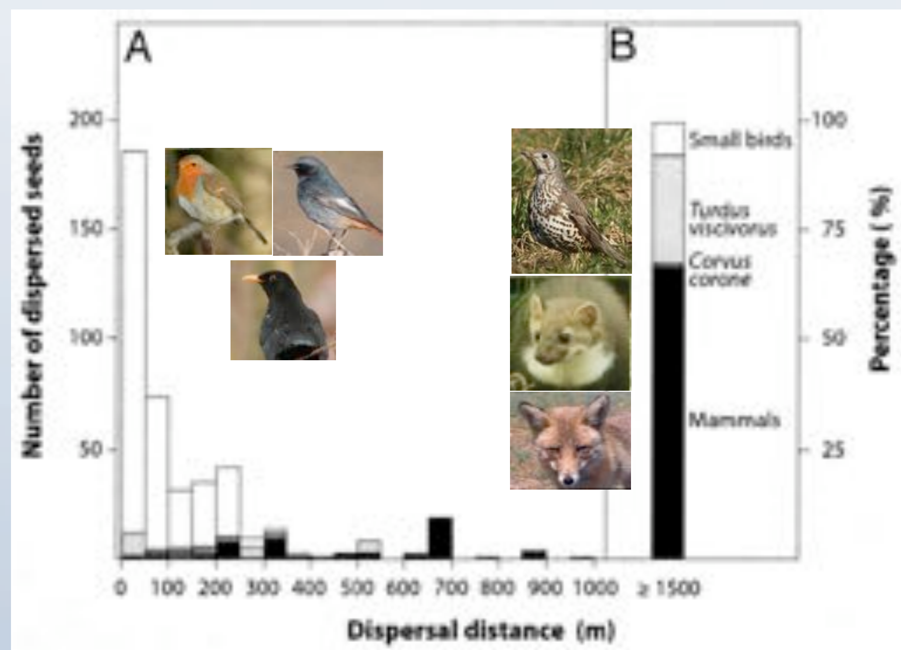
Ziegenhagen et al. 2003

- Maternal tissues from sampled seeds can be genotyped
- Mother plants of the sampled seeds can be retrieved from molecular markers if adults are exhaustively genotyped in the stand…

Differential contribution of frugivores to complex seed dispersal patterns

P. Jordano*†, C. García*, J. A. Godoy*‡, and J. L. García-Castaño*§





Jordano et al. 2007

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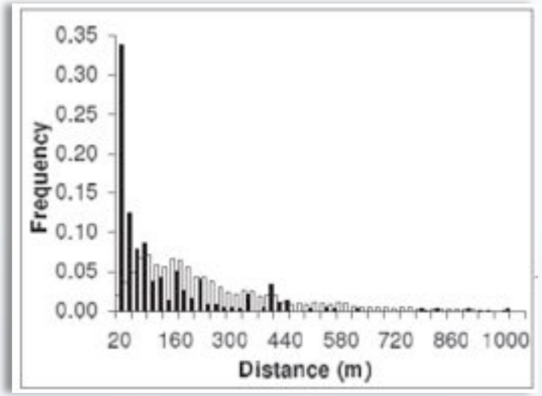
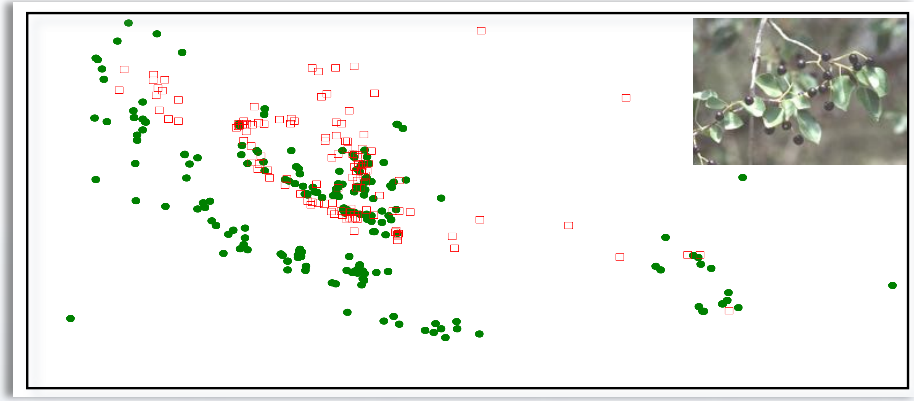
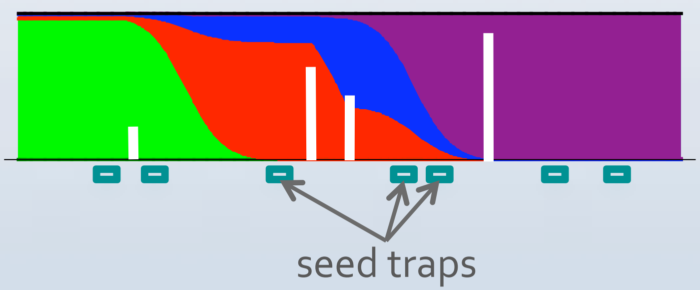




Garcia et al. 2007

- Necessity to account for the relative positions of sources and traps (cf. inverse modelling)



- Finds the dispersal kernel (and the fecundity parameters) that best explain the mixing of origins
- Statistical analysis of the seed pool composition enables to retrieve properly the kernel (mean dispersal distance = 278m vs. 110m)

Molecular Ecology (2007) 16, 5098–5109 doi: 10.1111/j.136

Estimation of the seed dispersal kernel from exact identification of source plants

JUAN J. ROBLEDO-ARNUNCIO* and CRISTINA GARCÍA†

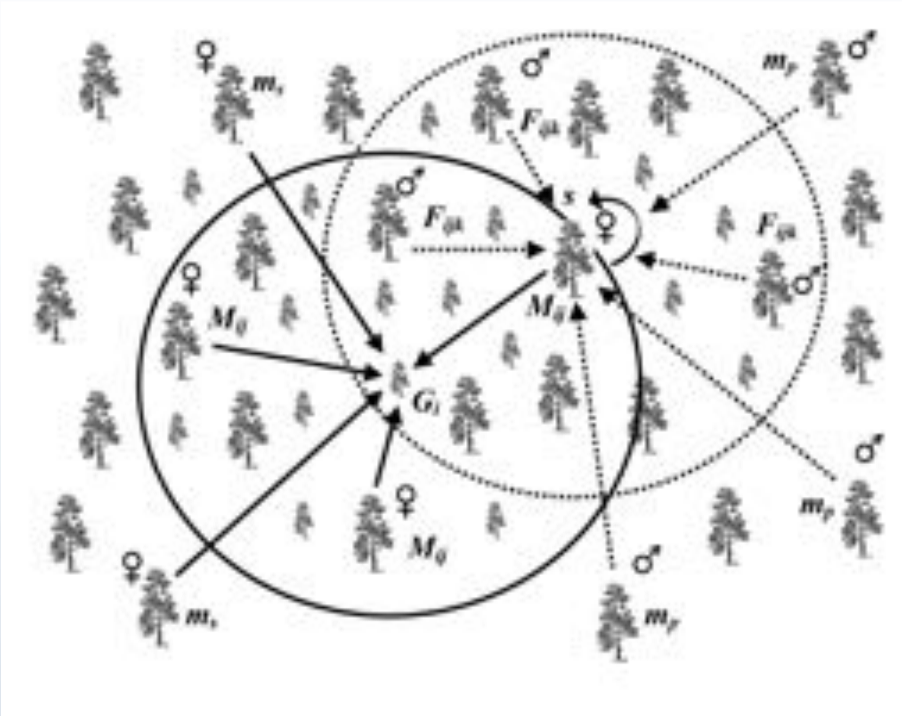
Journal of Ecology 2008, **96**, 642–652 doi: 10.1111/j.1365-2745.2008.01400.x

DISPERSAL SPECIAL FEATURE

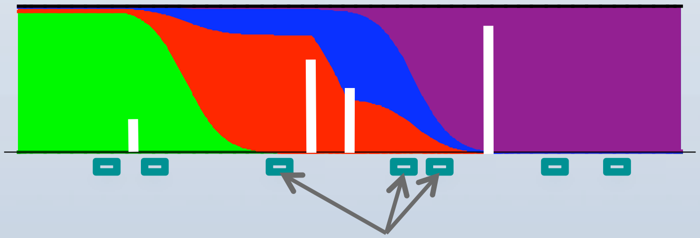
Measuring long-distance seed dispersal in complex natural environments: an evaluation and integration of classical and genetic methods

F. Andy Jones[1,2*] and Helen C. Muller-Landau[1,2]

2. Estimating dispersal kernels from established seedlings:
Seedling neighbourhood models



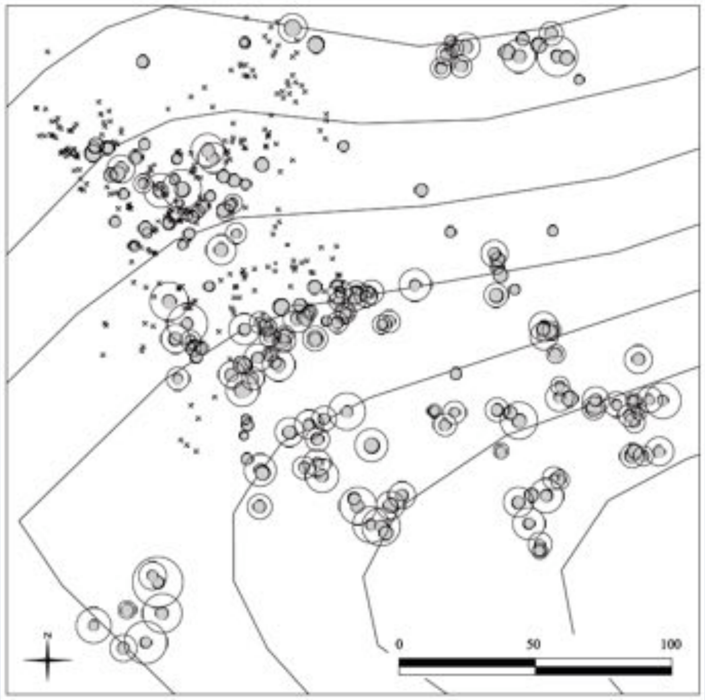
Burczyk et al. 2006



- Full probability approach
- Account for all plausible parents,
  even if parentage is not fully resolved
- Only relies on the seed and pollen pool compositions,
  not intensities

2. Estimating dispersal kernels from established seedlings:

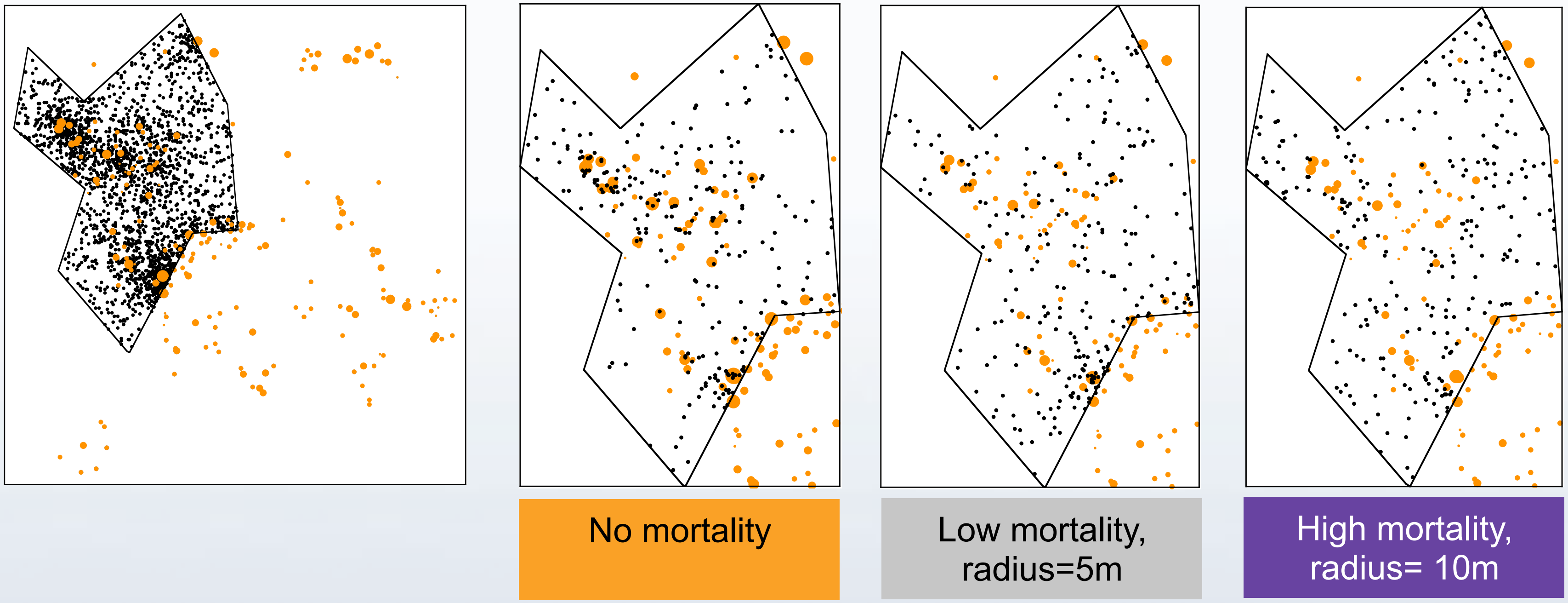
Seedling neighbourhood models



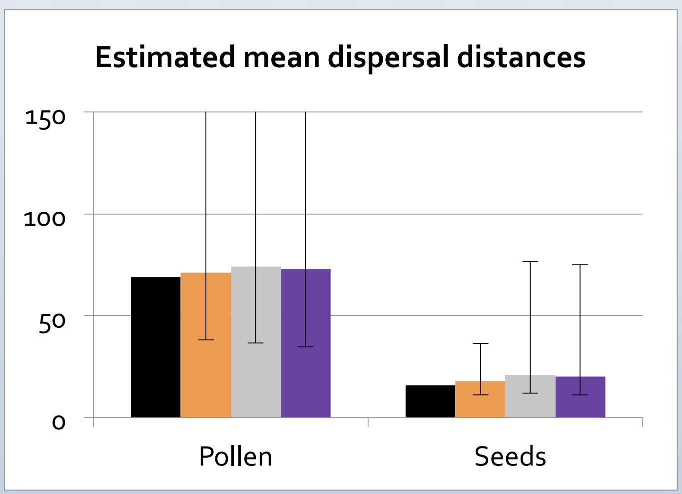
- 257 seedlings
- 10 microsatellites markers
- 7.3 single parents and 22.5 pairs of parents genetically compatible per seedling (avg.)

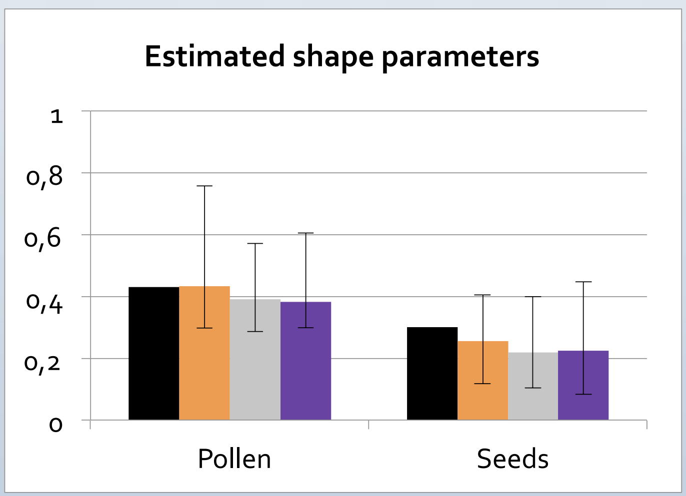
	Pollen dispersal			Seed dispersal			
	Mean distance δ_P	Shape b_P	Migration rate, m_P		Mean distance δ_S	Shape b_S	Migration rate m_S
Different dispersal in two cohorts of seedlings	68,22	0,43	0,59	Young seedlings	11,76	0,89	0,13
				Old seedlings	21,16	0,2	0,34

2. Estimating dispersal kernels from established seedlings:
Seedling neighbourhood models



- 200 simulations to check the accuracy of the method
- Estimations are insensitive to the density-dependent mortality





3. Estimating dispersal at larger scales:
Population assignment for meso-scale dispersal rates

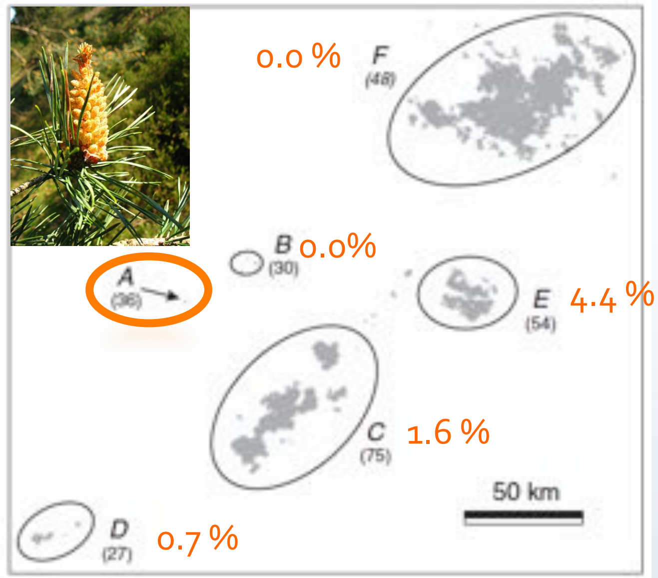
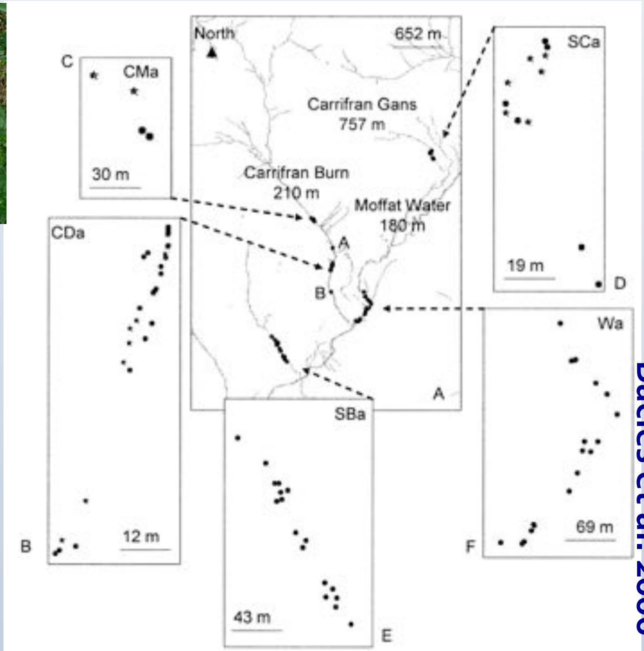


Fig. 1 Scots pine (*Pinus sylvestris*): natural distribution and spatial location of the six sampled populations in the Spanish Northern Meseta. Population codes are indicated by capital letters (A–F). Numbers in parentheses indicate the size of adult tree samples.

Robledo-Arnuncio 2011

- Exhaustive inventory of source populations
- Genetically differentiated source populations
- Reasonable amount of immigrant propagules in the recipient site



Bacles et al. 2006

Is dispersal kernel still a pertinent concept in an heterogeneous environment ?

Some conclusions

- LDD and the shape of the kernel tail are critical for both spread rate and structure of diversity
- Genetic marker greatly improved our capacities to characterize dispersal kernels at the local scale through parentage assignment
- Landscape scale estimations of dispersal kernels from microsatellites are more challenging and require non-typical study-sites
- Landscape elements might modify dispersal process

Mechanistic models for dispersal patterns are an alternative to phenomenological kernels inferred from data

Merci de votre attention