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The effect of landscape heterogeneity and anthropogenic land-uses on pollination patterns for wild cherry trees in north-eastern France

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Fragmentation, land-use change, and pollination patterns of wild cherry; straight line, least cost path and circuit analyses

Tonya Lander, Etienne Klein, Sylvie Oddou-Muratorio



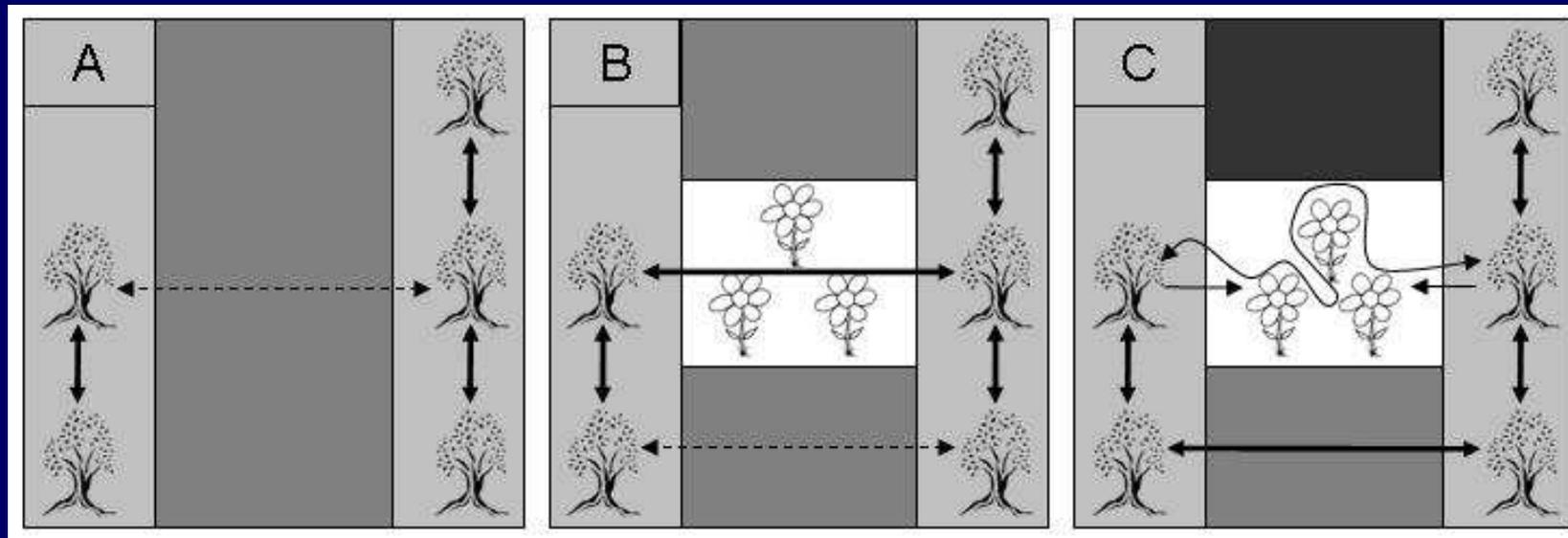
Fragmentation

- 25% of terrestrial biomes are under cultivation
- 50-66% have been changed and fragmented

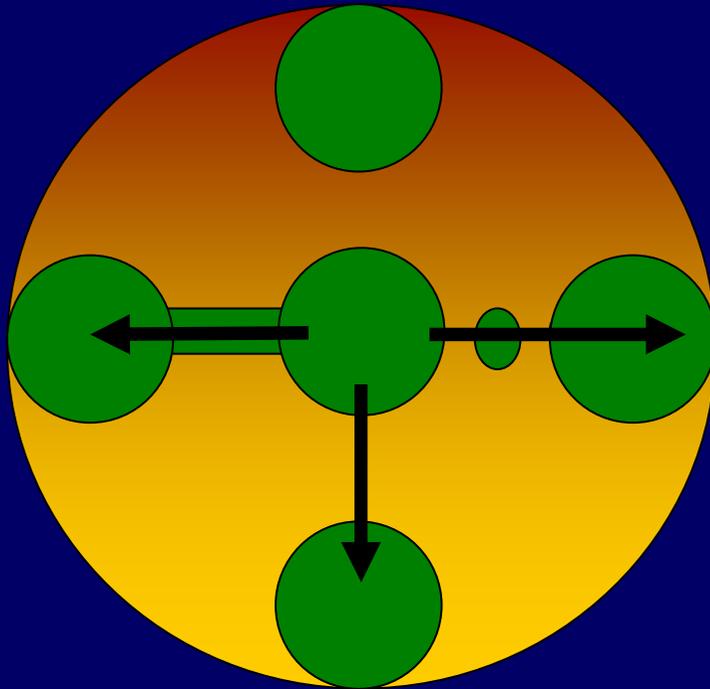
Millennium Ecosystem Assessment <http://www.maweb.org/>



Movement in fragmented landscapes: Island Biogeography, Corridors, and the Circe Principle



Movement in fragmented landscapes: Habitat Models and Resource Models



Movement from habitat to habitat:

- Corridors
- Stepping stones
- Areas of low resistance

Habitat Models:

The question:

Is the study species present in, absence from, or able to travel between patches of native habitat?

Movement in fragmented landscapes: Habitat Models and Resource Models

Probability of movement

High

Low

Resources

High



Low



Resource Models:

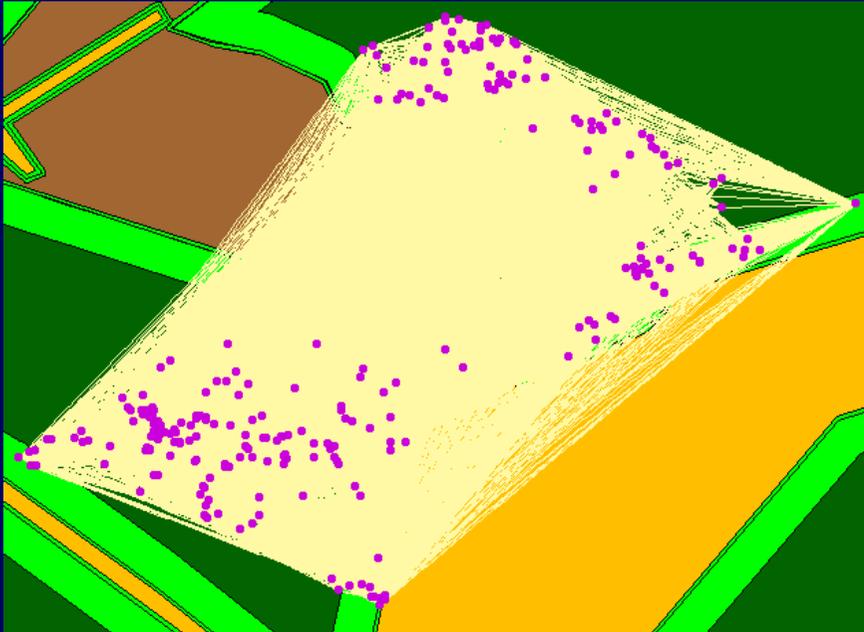
The questions:

What is the quantity and accessibility of resources in the landscape?

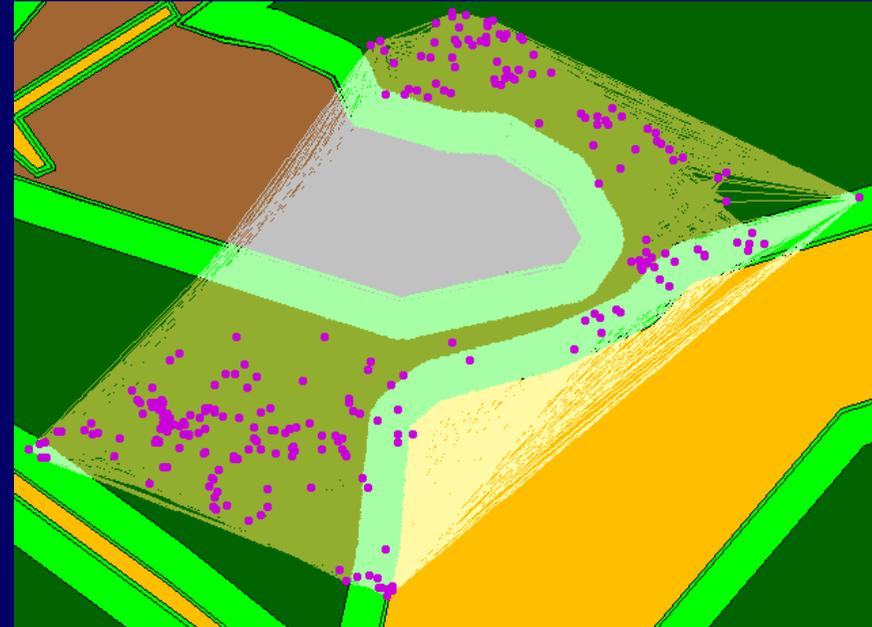
How does the species respond?

Movement in fragmented landscapes: Movement paths

Straight line paths

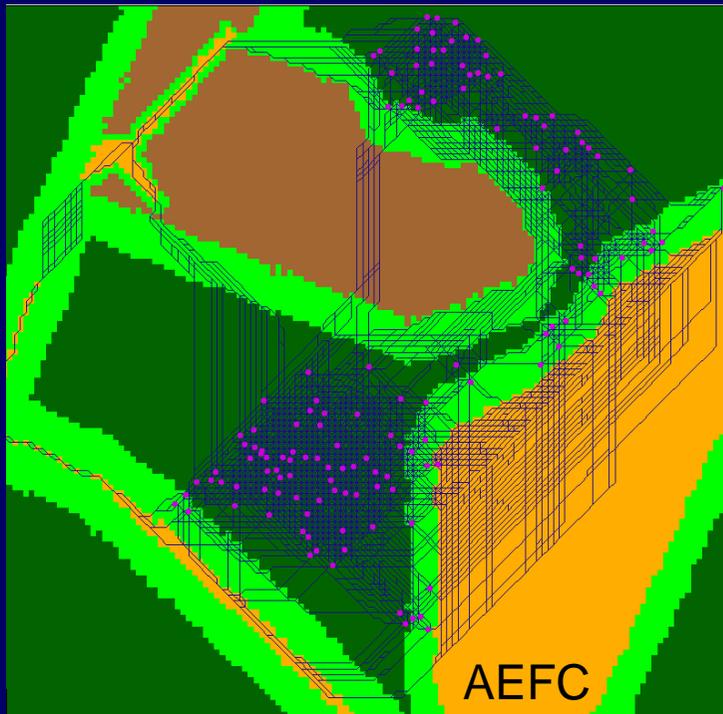


Straight lines weighted by land-use

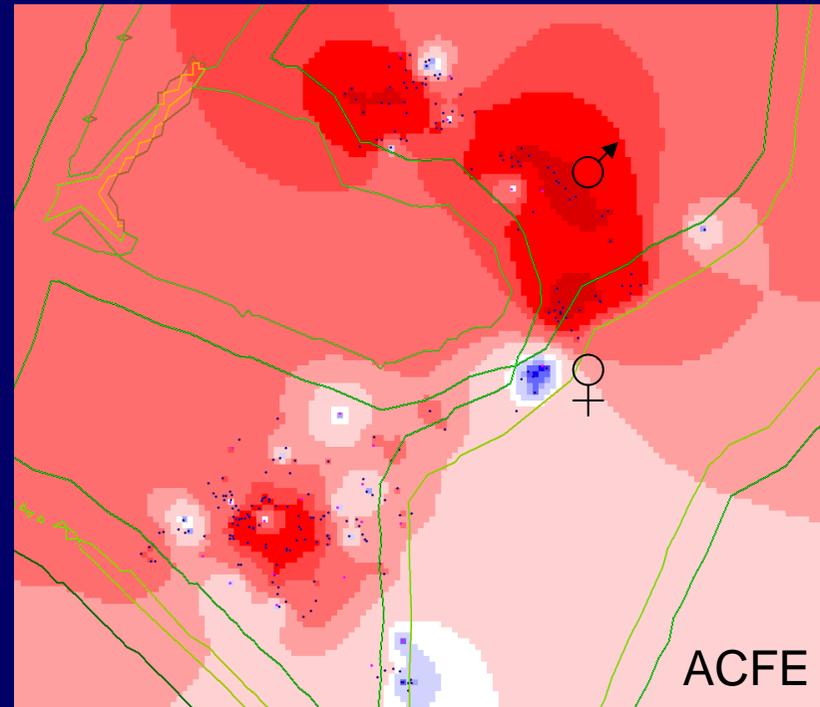


Movement in fragmented landscapes: Movement paths

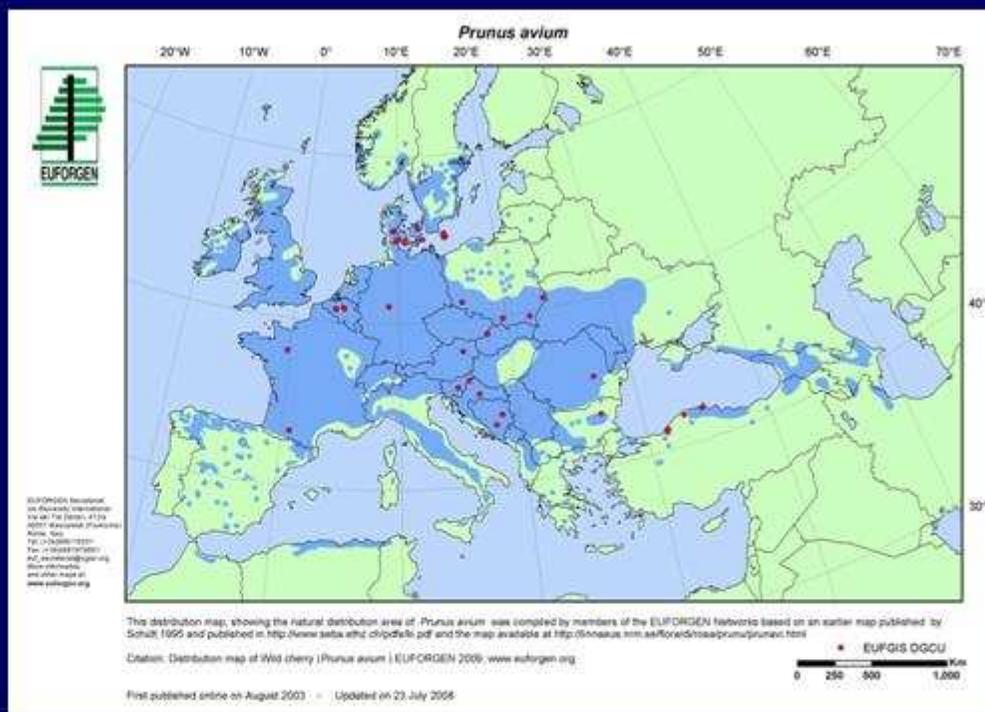
Least Cost Paths



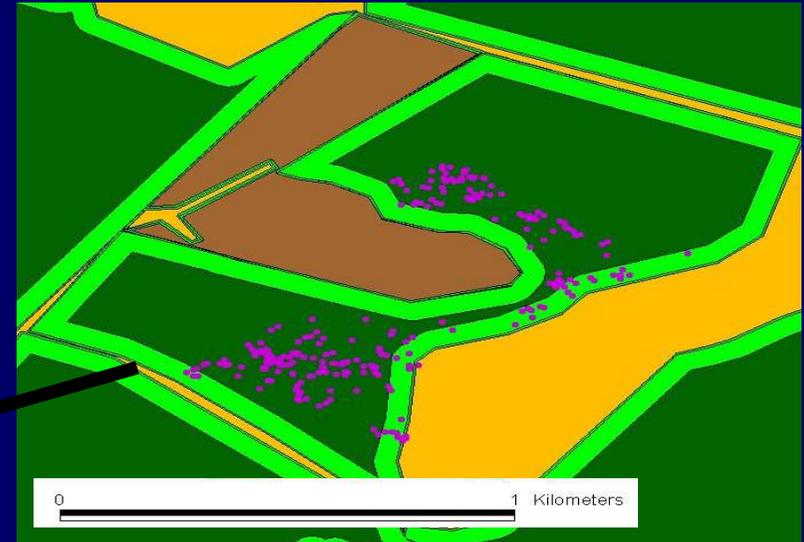
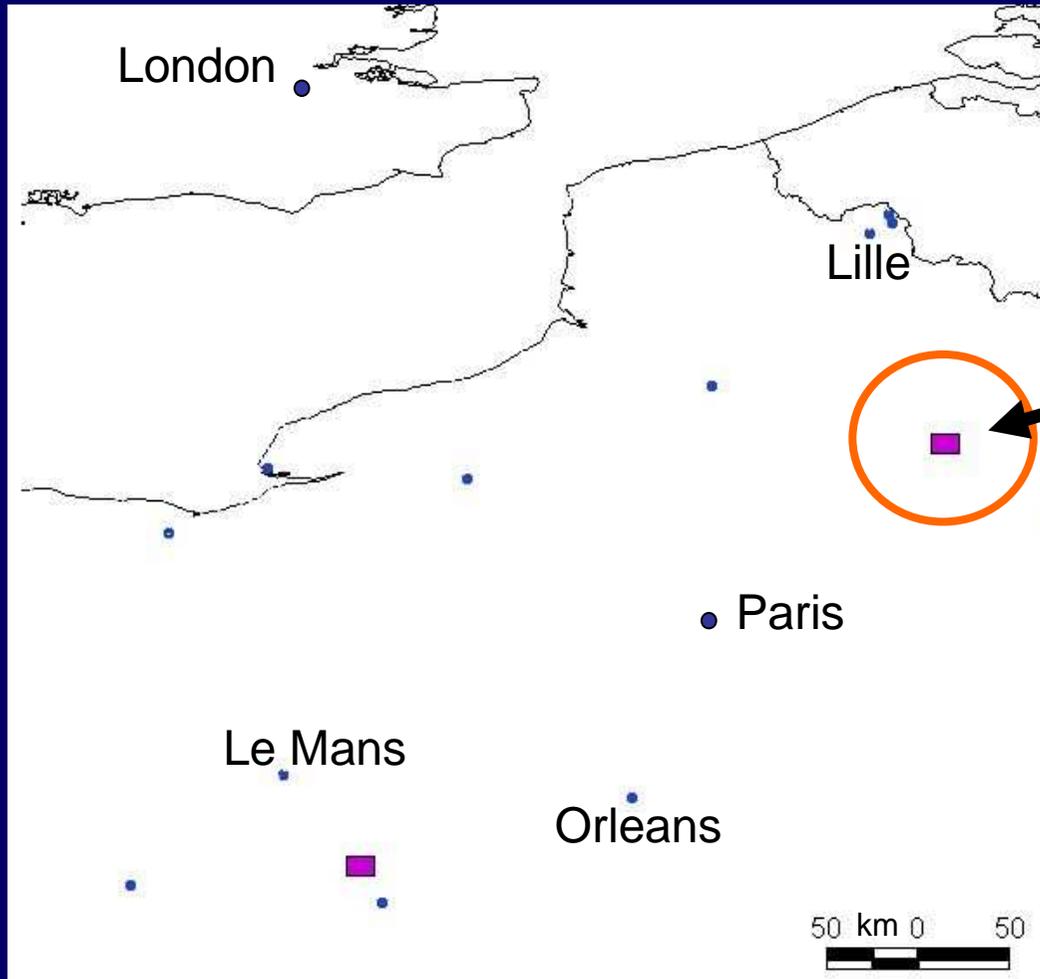
Circuit model



Wild cherry, *Prunus avium*



Study site: Saint Gobain, semi-natural



22ha

Sampled in 2002 and 2003

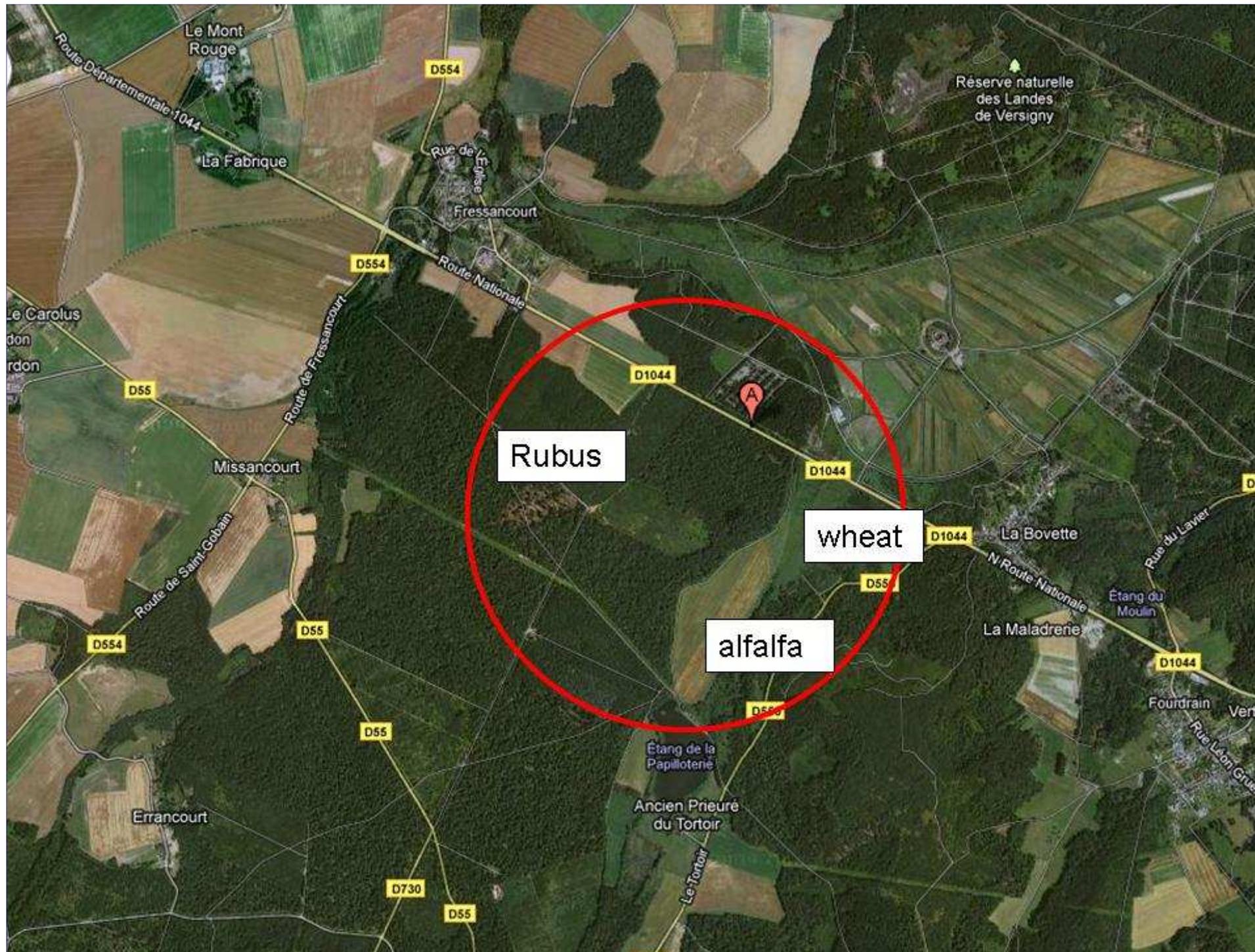
249 adult trees

2002: 937 seeds (24 mother trees)

2003: 794 seeds (26 mother trees)

5929/6449 tree pairs in 2002/2003

7 SSRs, 1 self-incompatibility locus



Native forest resource availability



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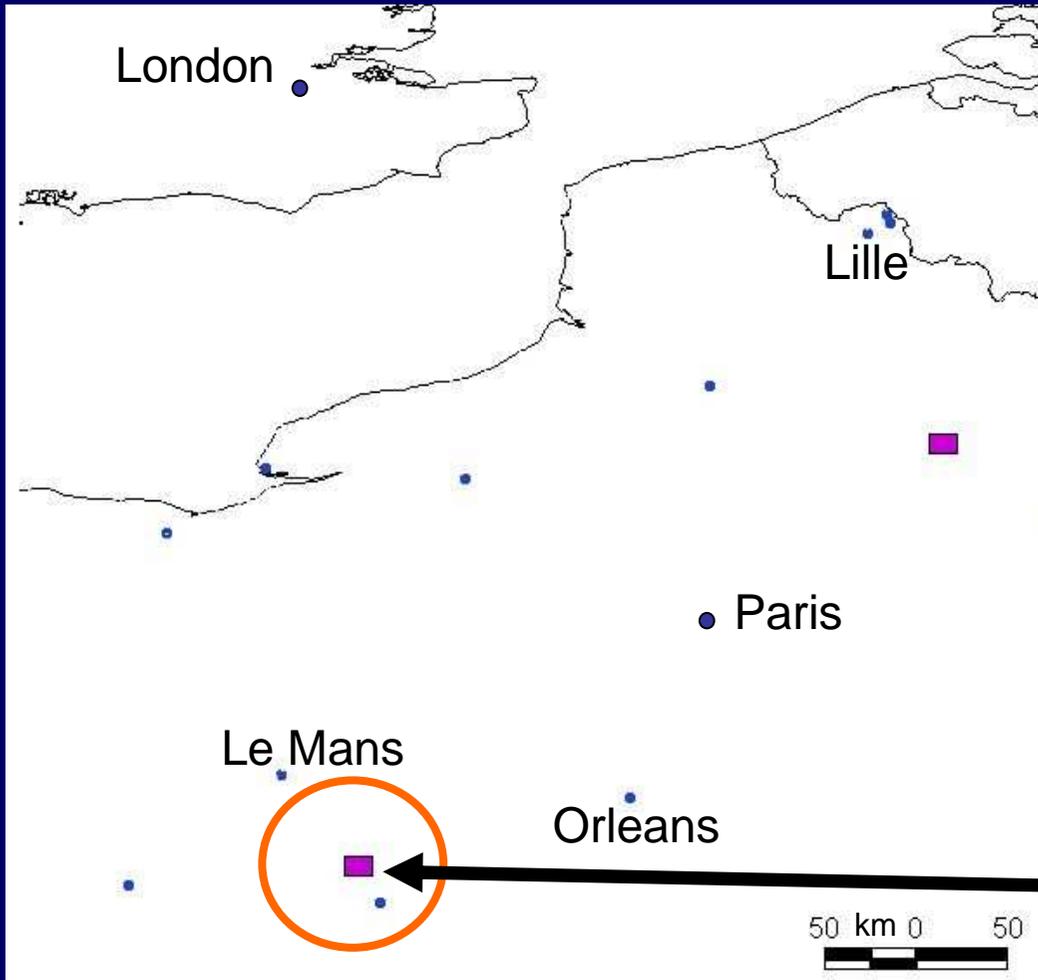
Henri Rousseau, *The Dream*, 1910.



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Study site: Neuillé, fragmented



0.9ha

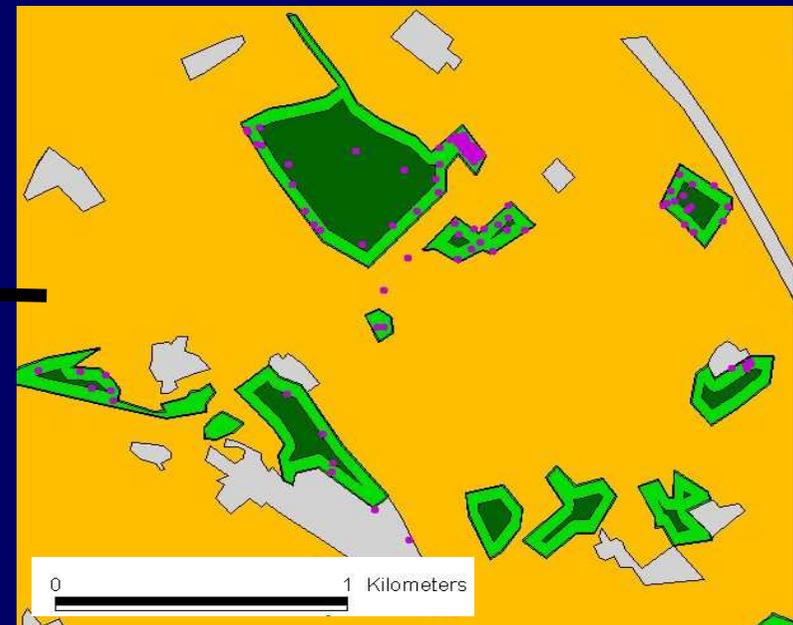
Sampled 2003

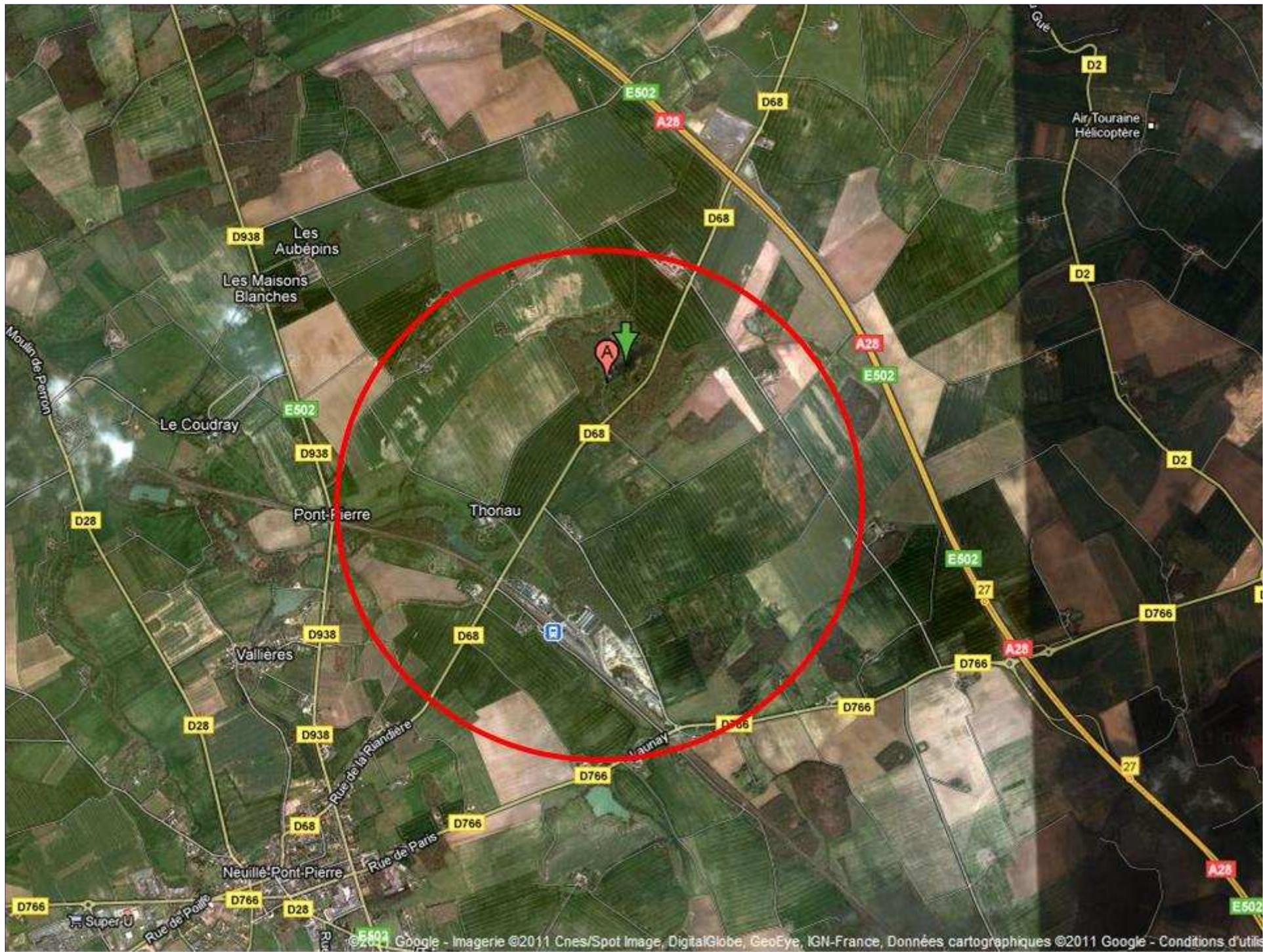
179 adult trees

631 seeds (31 mother trees)

21965 possible tree pairs

7 SSRs, 1 self-incompatibility locus





Resource availability in fragmented landscapes

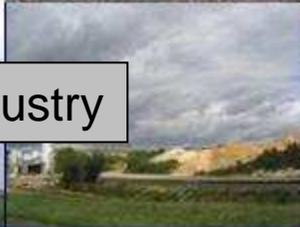
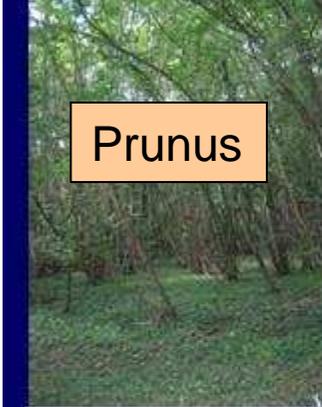
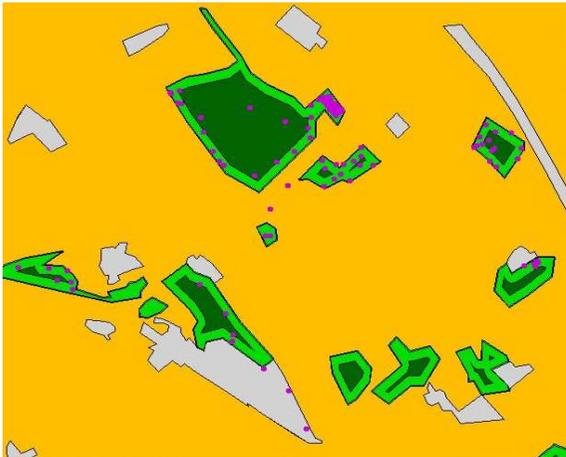


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Prunus

alfalfa

wheat

wheat

black currant

canola

Prunus

black currant

alfalfa

sunflower

industry

flax

Prunus

wheat

corn



Analysis

Mother tree	Father tree	Forest (m)	Agriculture (m)	Forest edge (m)	Cut forest (m)	LCP acfe	LCP cafe	LCP feac	Circuit acfe	Circuit cafe	Circuit feac
SG_143p	SG_100	120.8765	0	0	0	118.8835	118.8835	118.8835	1.947757	1.963738	0.675302
SG_143p	SG_101	104.8727	0	0	0	100.2715	100.2715	100.2715	1.884877	1.894547	0.643982
SG_143p	SG_11	354.7085	0	95.0139	189.4034	687.3066	699.6174	855.3125	2.668137	2.675052	1.18811
SG_143p	SG_12	358.8936	0	94.8247	189.3432	690.2083	690.2083	852.4108	2.668562	2.679762	1.185658
SG_143p	SG_213	143.9699	1.5445	36.6866	0	192.2101	192.2101	192.2101	1.713215	2.017712	1.188523

Spatially Explicit Mating Model (SEMM)

Paternity analysis (fractional assignment)

Ability to explain the pollination pattern discovered through paternity analysis:

1. Unweighted linear distance (m)
2. Linear distance subdivided into land-use types, weight of land-uses optimized
3. Distance (m) along the Least Cost Path
4. Pair-wise resistance

Results

Straight line weighted by land-use:

F = forest

E = forest edge

A = agriculture

U = urban

	Model with no forest edge	Model with forest edge
Fragmented: Neuillé	$F < U < A$	$U < F < E < A$
Unfragmented: Saint Gobain 2002	$A < F < C$	$A < C < F < E$
Saint Gobain 2003	$F < A < C$	$F < E < A < C$

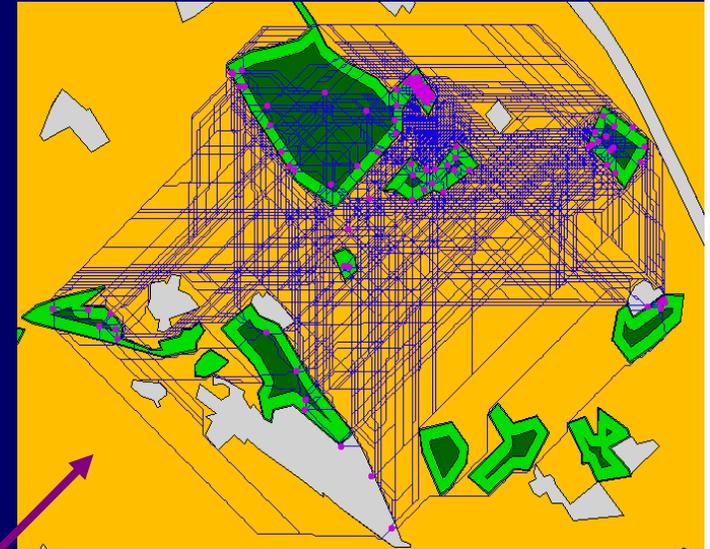
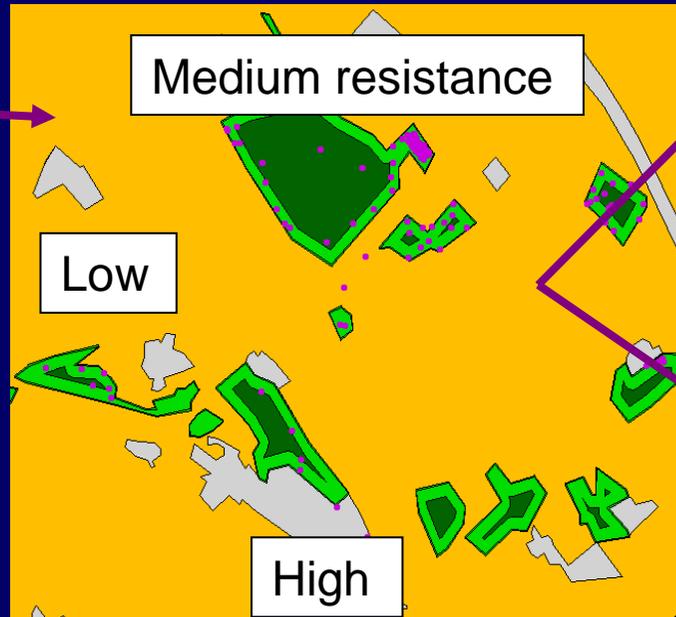
Habitat Model applies

Resource Model applies

Analysis

Least Cost Paths and Pair-wise resistance calculated in
 5 resistance landscapes for Neuillé (fragmented)
 8 for Saint Gobain (unfragmented)

Neuillé	Saint Gobain
AEFU	AGFE
AFEU	AEFC
FEA	AFEC
FUEA	CAFE
UFEA	EFAC
	FACE
	FAEC
	FEAC



Results

Model	Site	AIC
Straight line exponential power, no forest edge	N	-43283.0
Straight line exponential power with forest edge	N	-43294.6
LCP, circuit, exponential power with forest edge	N	-43304.6
Straight line exponential, no forest edge	N	-43334.2
Straight line exponential power, no forest edge	SG02	-23751.2
Straight line exponential power with forest edge	SG02	-23766.2
LCP, circuit, exponential power with forest edge	SG02	-23768.2
Straight line exponential, no forest edge	SG02	-23846.2
Straight line exponential power with forest edge	SG03	-20752.6
Straight line exponential power, no forest edge	SG03	-20756.2
LCP, circuit, exponential power with forest edge	SG03	-20756.4
Straight line exponential, no forest edge	SG03	-20807.0

At both sites:



Exponential power pollen dispersal kernel



Weighted straight lines out-perform unweighted lines: Landuse type matters!



Straight lines (weighted or not) out-perform LCP and Circuit Models

Results



Least Cost Paths

Capacity to choose the LCP depends on complete landscape knowledge

LCP may not be the best route for feeding, breeding or resting



Circuit models

Resistance surface optimization

Conclusions



Forest patches in agricultural landscapes are not the same as oases in the desert

But not all forest patches provide a wealth of resources



Both secondary forest and agricultural areas may provide resources

But all agriculture and secondary forests do not provide the same resources



Annual changes in crops and management may impact pollinator behaviour more than fragmentation



Use of bee hives may change pollination patterns from year to year



Straight lines out-perform least cost path and resistance surfaces

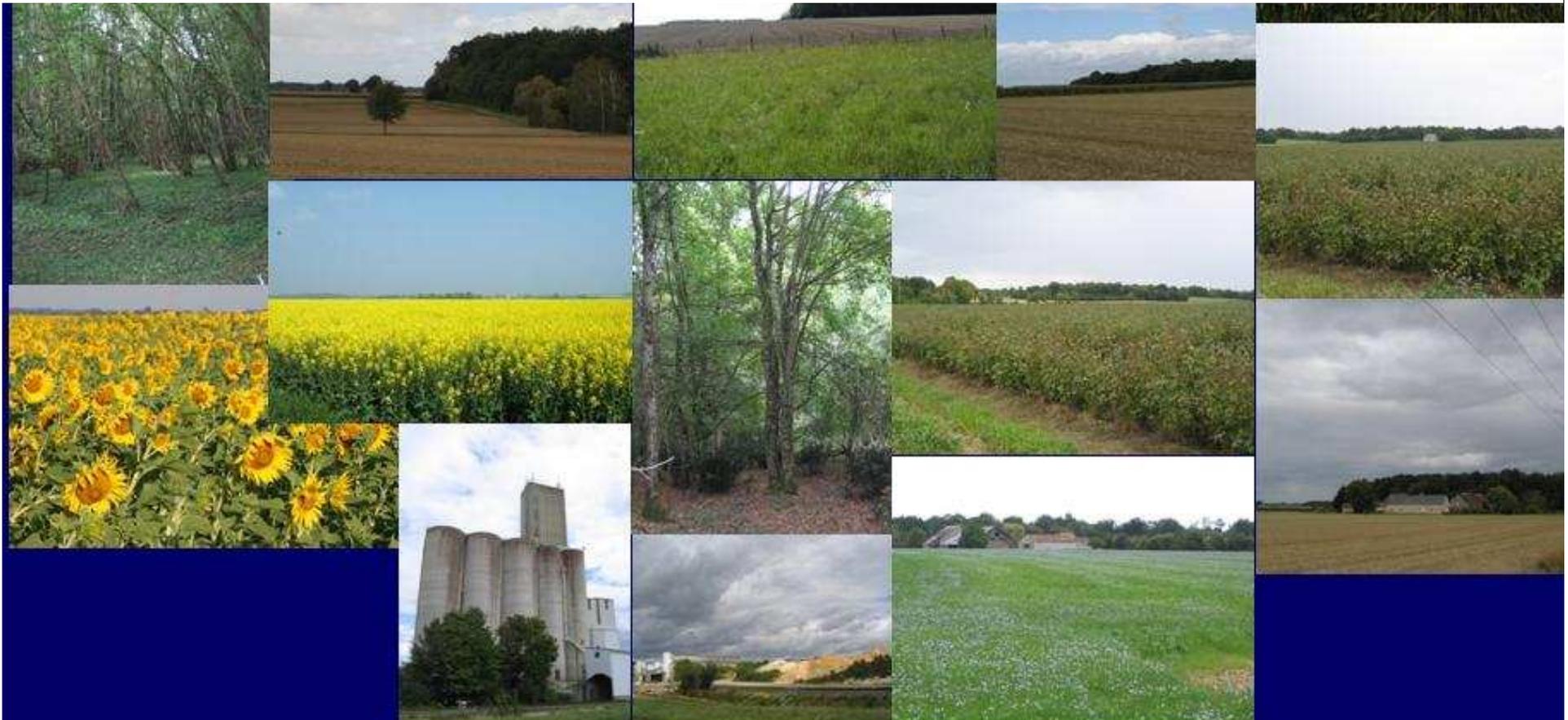


Habitat Models and Resource Models may both apply –
depending on the density of resources in the landscape?

Conclusions

Pollination does not occur in a binary landscape of
habitat and non-habitat

Land-use matters!



Thank you

Ecologie des Forêts
Méditerranéennes



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