

Assessing the extinction risk of the spontaneous flora in urban tree bases using yearly floristic inventories

Rencontres CiSStats-RESSTE 2026,

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Apolline Louvet

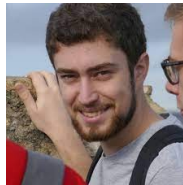
Unité BioSP, Département SPE, INRAE Avignon

Dormancy in urban tree bases

Joint work with



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(CESCO, MNHN)



Clément Mantoux
(INRIA Paris)

Based on previous works with Amandine Véber (MAP5, Univ. Paris Cité), Jean-Baptiste Mihoub (CESCO, MNHN) and Alexandre Robert (CESCO, MNHN).

What are urban tree bases ?



Why studying plant dynamics in urban tree bases?

Relevance in ecology:

- Potential ecological corridors between larger urban green spaces.
- Highly fragmented environment.
- Very frequent extinction events.

Ex: *Population wiped out once a year by gardeners.*

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(?) What is dormancy ?

What is dormancy ?

Dormancy: reversible state of reduced metabolic activity

Ex: *Seeds formed by plants*

⊕ Can protect from adverse conditions

Ex: *Weeding does not affect seeds in soil*

Seed bank: Stock of viable dormant seeds, e.g. in the soil

- Transient seed bank: A few months, e.g. during winter ✗
- "Actual" seed bank: ≥ 1 complete generation ✓

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Relevance for researchers interested in dormancy:

- Weeds considered as part of this study produce seeds.
- Frequent extinction events \implies Going dormant might be a good strategy to ensure survival.

Research questions

- ① **Are urban tree bases used as ecological corridors ?**

Identification taking into account effect of dormancy

- ② **Is dormancy important ?**

- ③ **Are other traits important ?**

Seven traits tested

The Paris 12 dataset

- > 1300 tree bases in 14 streets in Paris
- **Floristic inventories** carried out annually from 2009 to 2018
 - All years except 2013: All species inventoried
 - 2013: Only ~ 10 species inventoried

⇒ **Presence/absence data**

1 pair (species, portion of street)

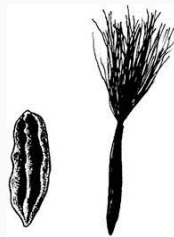
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1 metapopulation



What is known?

1. [Mau10]: Spontaneous flora in urban tree bases contains few invasive species.
⇒ *Invasions not facilitated by urban tree bases.*
2. [CCRC08]: Evidence of fast evolution/adaptation against long-range dispersal of seeds, for *Crepis sancta*.



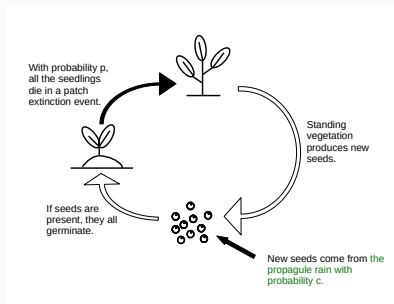
3. [DPC11, OSMB⁺19]: Some species seem to use tree bases as ecological corridors.

⚠ These studies neglect the presence of a seed bank, and the results of [OSMB⁺19] seem to suggest that a seed bank is actually present.

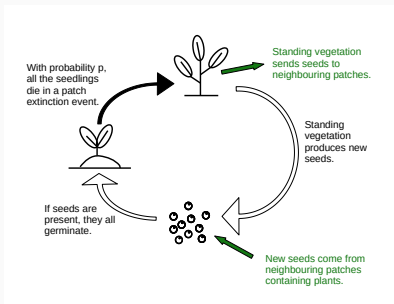
How to identify ecological corridors? The SPOM approach

SPOMs = Stochastic Patch Occupancy Models

Describe the temporal occupancy dynamics in a metapopulation.



(a) Propagule Rain Model [Got91]



(b) Levins model [Lev69]

[DPC11, OSMB⁺19]:

PRM = no ecological corridor

Levins model = (potential) ecological corridors

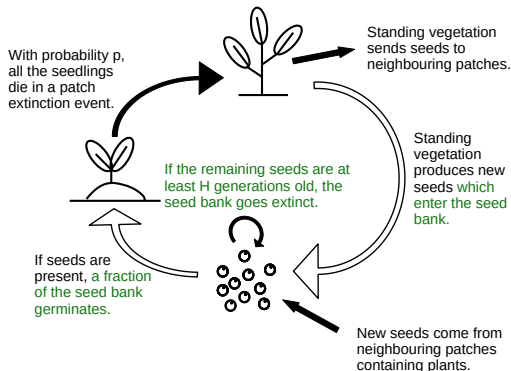


- 1) False identification of PRMs when the presence of a seed bank is neglected
- 2) For the Levins model, only some parameter sets correspond to "usable" ecological corridors: the ones associated to a small extinction risk at the metapopulation scale

The *Best Occupancy Achievable* (BOA) process

BOA process: Simplified Levins model with a seed bank component.

Introduced in [Lou22] as the large population limit of a (meta)population genetics process with intra-patch dynamics given by a Wright-Fisher model with a seed bank component and recurrent patch extinction events.



Parameter inference in the BOA process

- Presence/absence of plants: observed
- Presence/absence of seeds: hidden, but influences the observed state

⇒ **Hidden Markov model**

In [LMM23], we introduce a Bayesian framework for parameter inference under a BOA process using yearly occupancy data for plants.

⇒ Package available online: <https://github.com/cmantoux/boa-process>

Identification of ecological corridors

Idea:

Ecological corridor
 \iff
The BOA process survives forever
with non-zero probability

?: Survival probability of the BOA process given estimates of model parameters?

- Brute-force approach: Do a lot of simulations.
- Percolation approach: Introduce a *metric of the extinction risk* based on a result from percolation theory.

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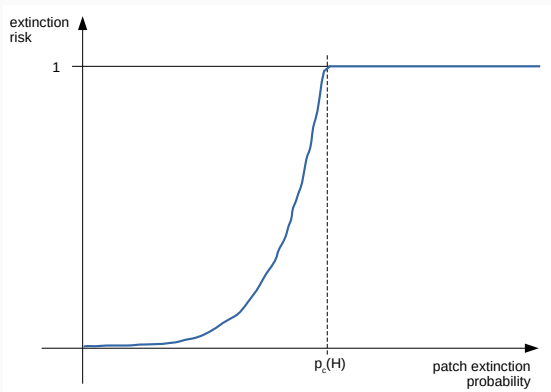
- Brute-force approach: Do a lot of simulations.
- **Percolation approach**: Introduce a *metric of the extinction risk* based on a result from percolation theory.

Assessing the extinction risk

Theorem [Lou22]

For all $H \geq 0$, there exists $p_c(H) \in (0,1)$ such that:

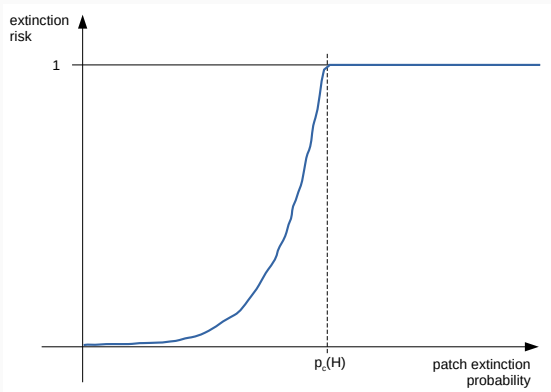
- If $p > p_c(H)$, the BOA process goes extinct in finite time a.s.
- If $p < p_c(H)$, the BOA process survives with a non-zero probability that increases with $|p - p_c(H)|$



Metric of the extinction risk - The MaxGER metric

Issues:

- 1) **Qualitative result:** No explicit expression for the extinction probability at the metapopulation scale
- 2) **Threshold effect:** Need to account for the uncertainty on the estimates of p and H



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Solution: The MaxGER metric

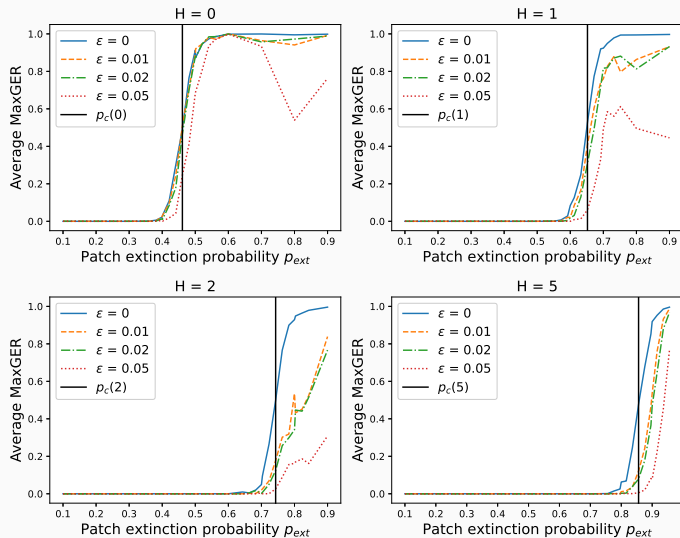
⇒ The MaxGER metric is defined as

$$\text{MaxGER} := \mathbb{P}_{\text{post}}(p > p_c(H) \mid H = H_{\text{inf}}),$$

where

$$H_{\text{inf}} := \min \{ \hat{H} \geq 0 : \mathbb{P}_{\text{post}}(H \leq \hat{H}) \geq 0.05 \}.$$

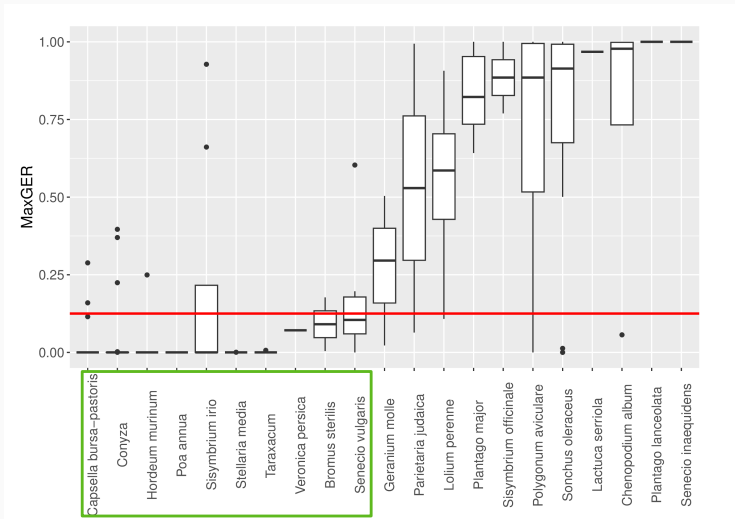
Metric of the extinction risk - The MaxGER metric



$\epsilon \approx$ error rate when recording data/deviation from model

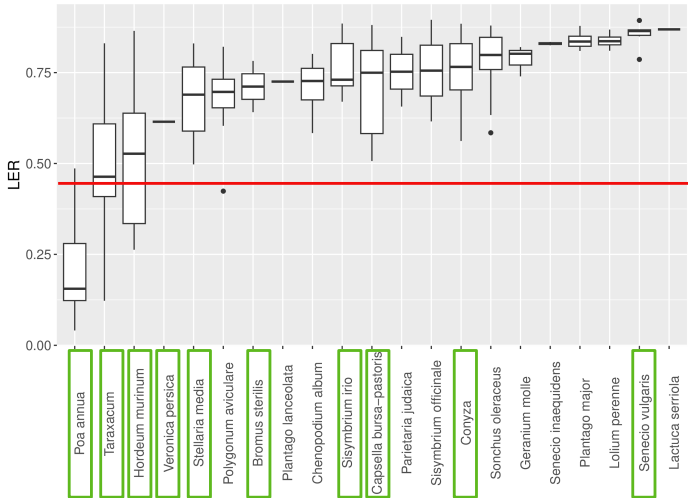
Results

- ① Some species **are able** to use tree bases as ecological corridors



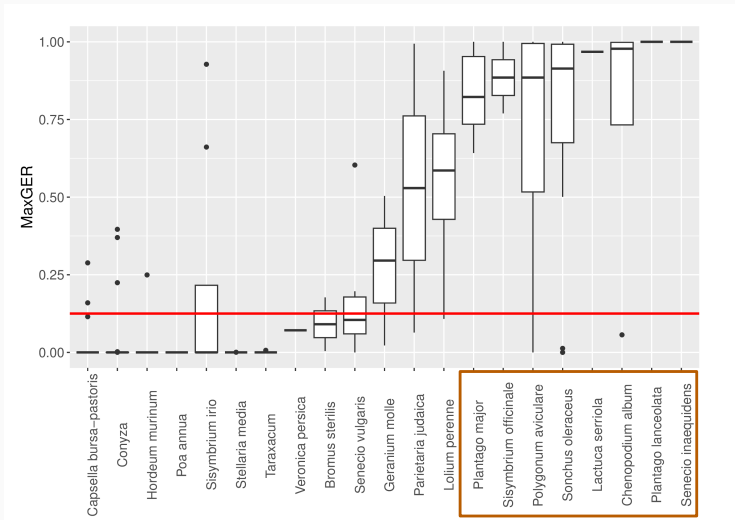
Results

② Dormancy is **important** for survival in tree bases



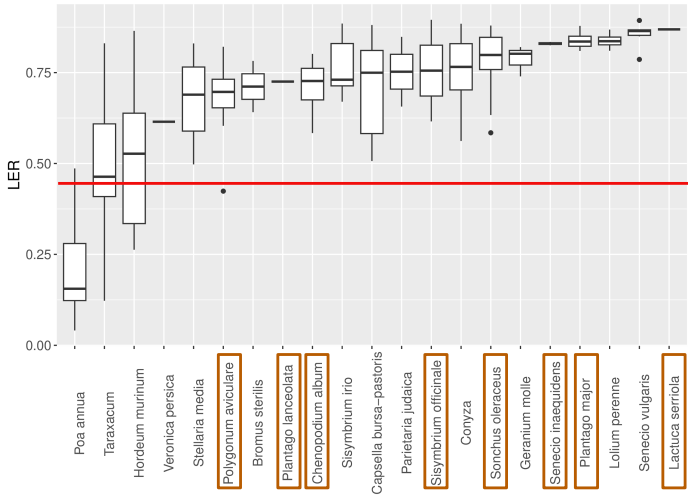
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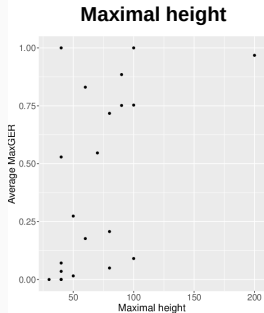


Influence of other biological traits

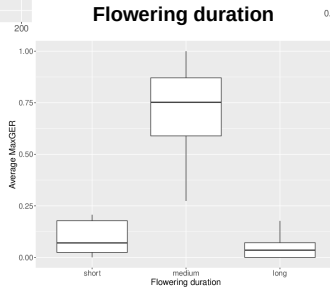
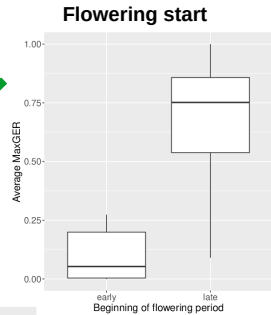
| Plant trait | Values taken |
|-------------------------------|---|
| Dispersal mechanism | Anemochorous (by wind) Barochorous (by gravity) Epizoochorous (by animals, without ingestion) Autochorous (by the plant) |
| Flowering duration | Short (≤ 3 months) Medium (≥ 4 and ≤ 6 months) Long (≥ 7 months) |
| Seed mass | Quantitative variable (in grams) |
| Heat preference | Sensitive (Ellenberg value ≤ 6) Resistance (Ellenberg value ≥ 7) |
| Pollination vector | Insect Wind Selfed |
| Maximal height | Quantitative variable (in centimeters) |
| Beginning of flowering period | Early (in April or earlier) Late (in May or later) |

Results

③ Three other correlations identified



Effect of gardeners



???

① Are urban tree bases used as ecological corridors ?

⇒ Yes (for some species)

② Is dormancy important ?

⇒ Even more than expected

③ Are other traits important ?

⇒ Yes (three traits identified)

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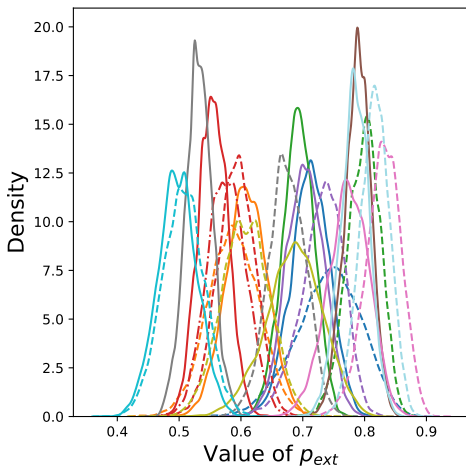
③ Are other traits important ?

⇒ Yes (three traits identified)

⚠ Is the model valid ?

Validity of the model

Ex: Posterior distributions of patch extinction probabilities for *Stellaria media*. The colour indicates the street.



Validity of the model

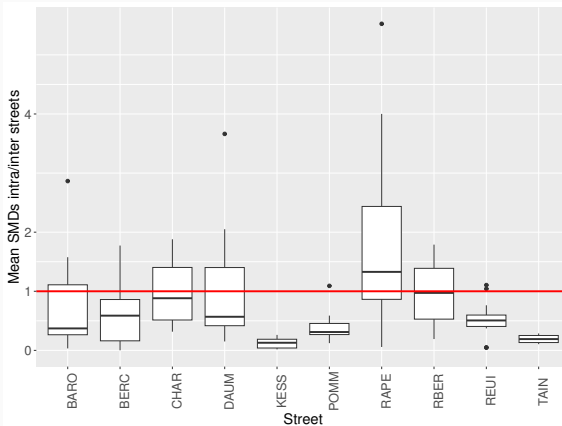
⇒ Comparison of posterior patch extinction probabilities between portions:

→ of the same street

→ of different streets

SMD < 1: probabilities closer for portions of a same street

SMD > 1: probabilities closer for portions of different streets



Conclusion and perspectives

- Patch extinction probabilities are overall very high, and survival is generally not possible without a seed bank.

? *Evolution of dormancy in urban tree bases?*

- We identified ten plant species that use urban tree bases as ecological corridors, and nine plant species that cannot.
- We identified three other biological traits correlated to the extinction risk at the metapopulation scale.

? *Application of our inference method to other biological systems?*

Thank you for your attention !





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