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Assessment of management strategies of sharka epidemics by modeling complemented with experiments

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Assessing sharka management strategies through experiments and modeling

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Sharka management strategy in France

Since the 1990's

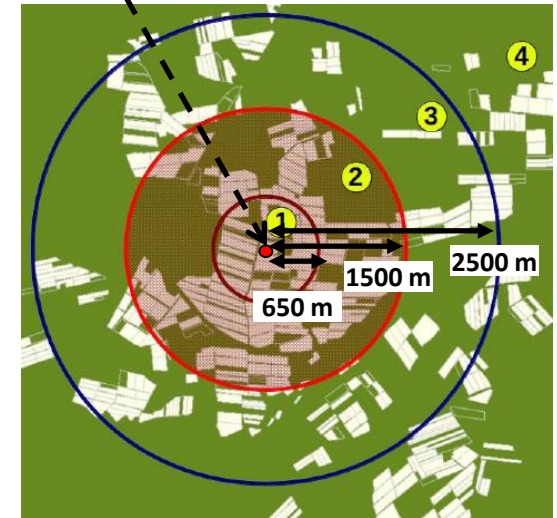
- Frequent visual inspections of the orchards
- Removal of the symptomatic trees (or whole orchards)
- Protection of the nurseries

Law published in 2011

- Definition of 4 areas around each infected tree



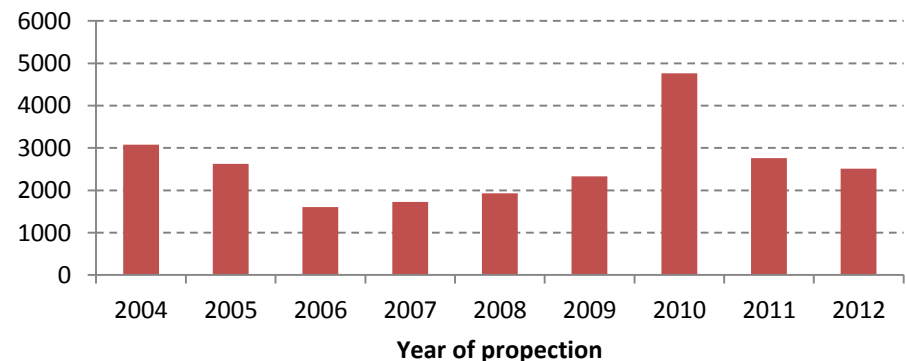
Infected tree



Disappointing outcome:

- Costly strategy
- Still many trees infected each year

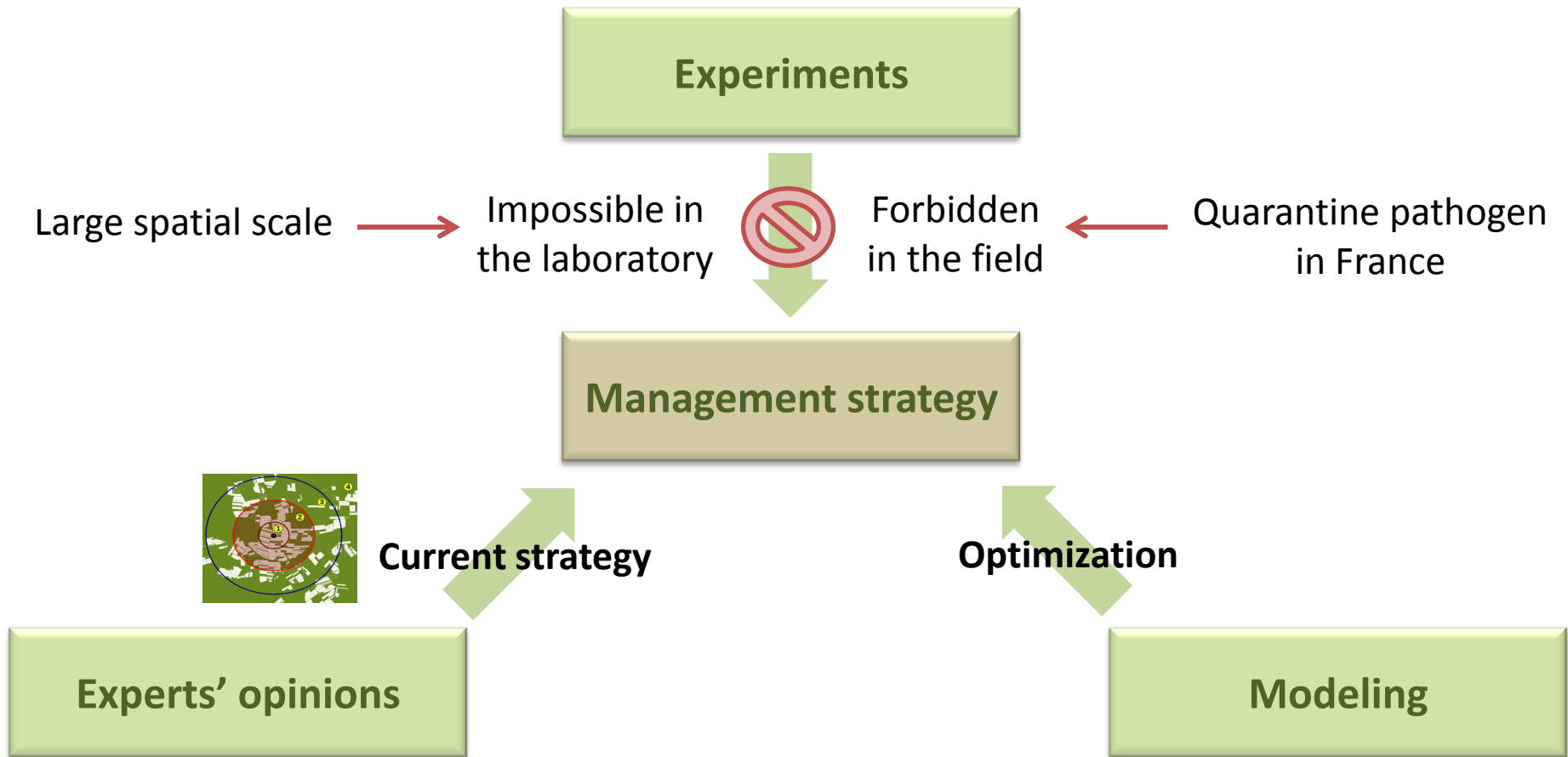
Symptomatic trees detected in Gard (South of France)



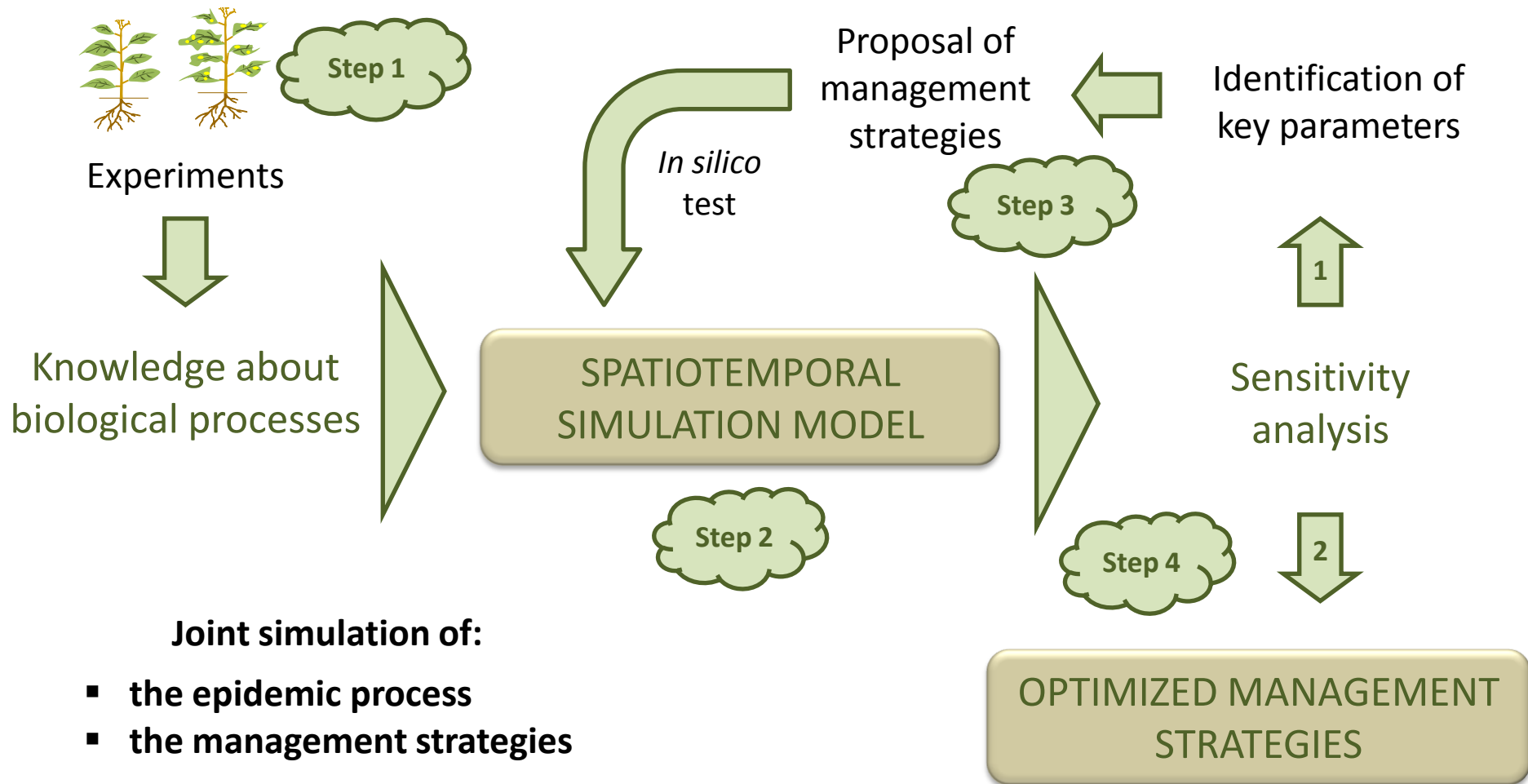
Data from J.Y. Couderc

How to optimize management strategies?

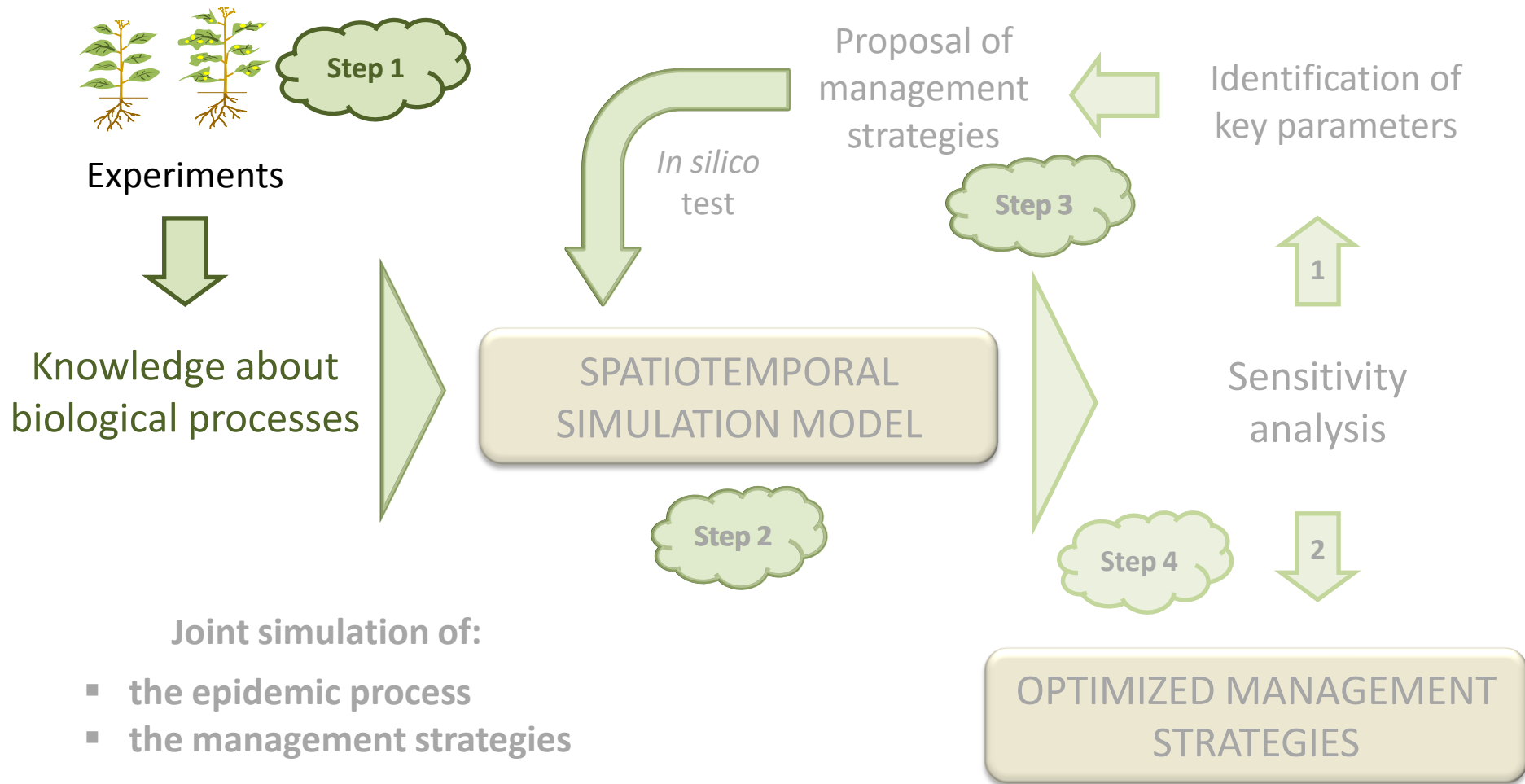
Complex interactions between biological and human processes



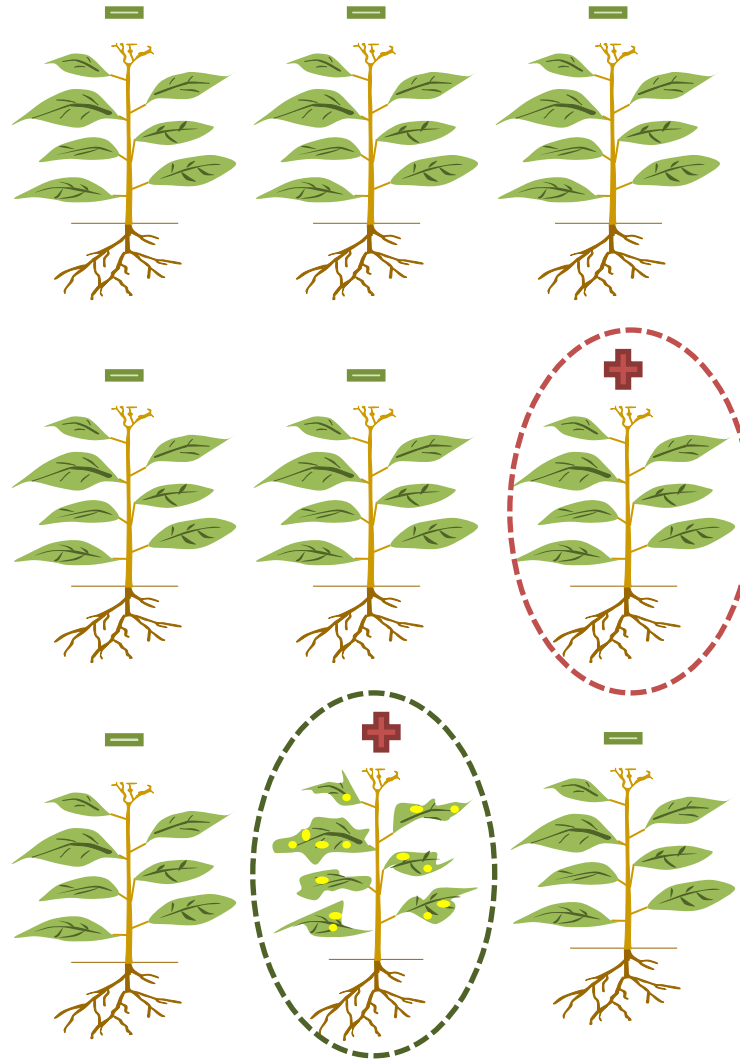
Research project



Research project



Consequences of symptom-based detection



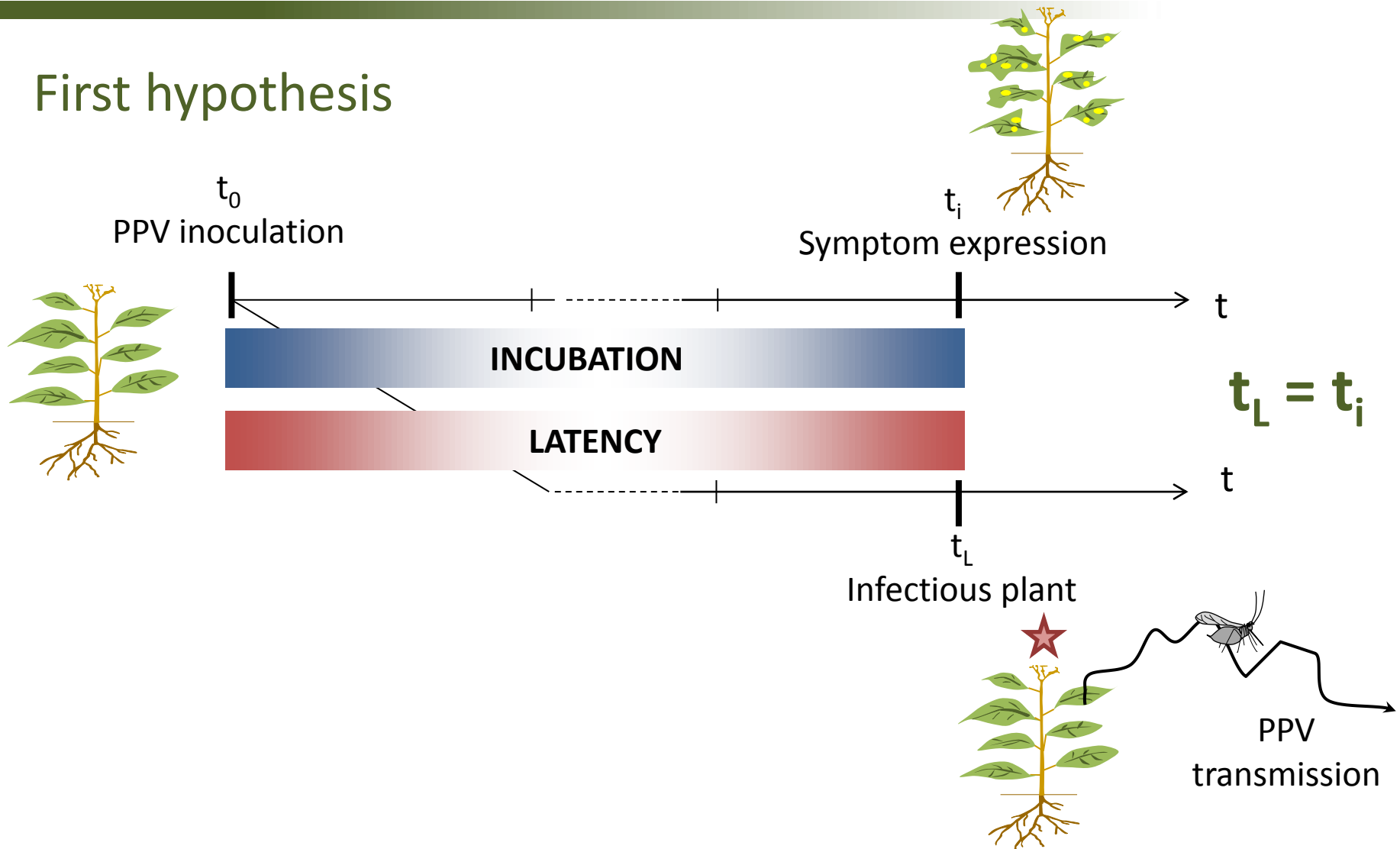
Infected trees without symptoms cannot be detected

Visual inspections allow the detection of symptomatic trees

+ Infected
- Healthy

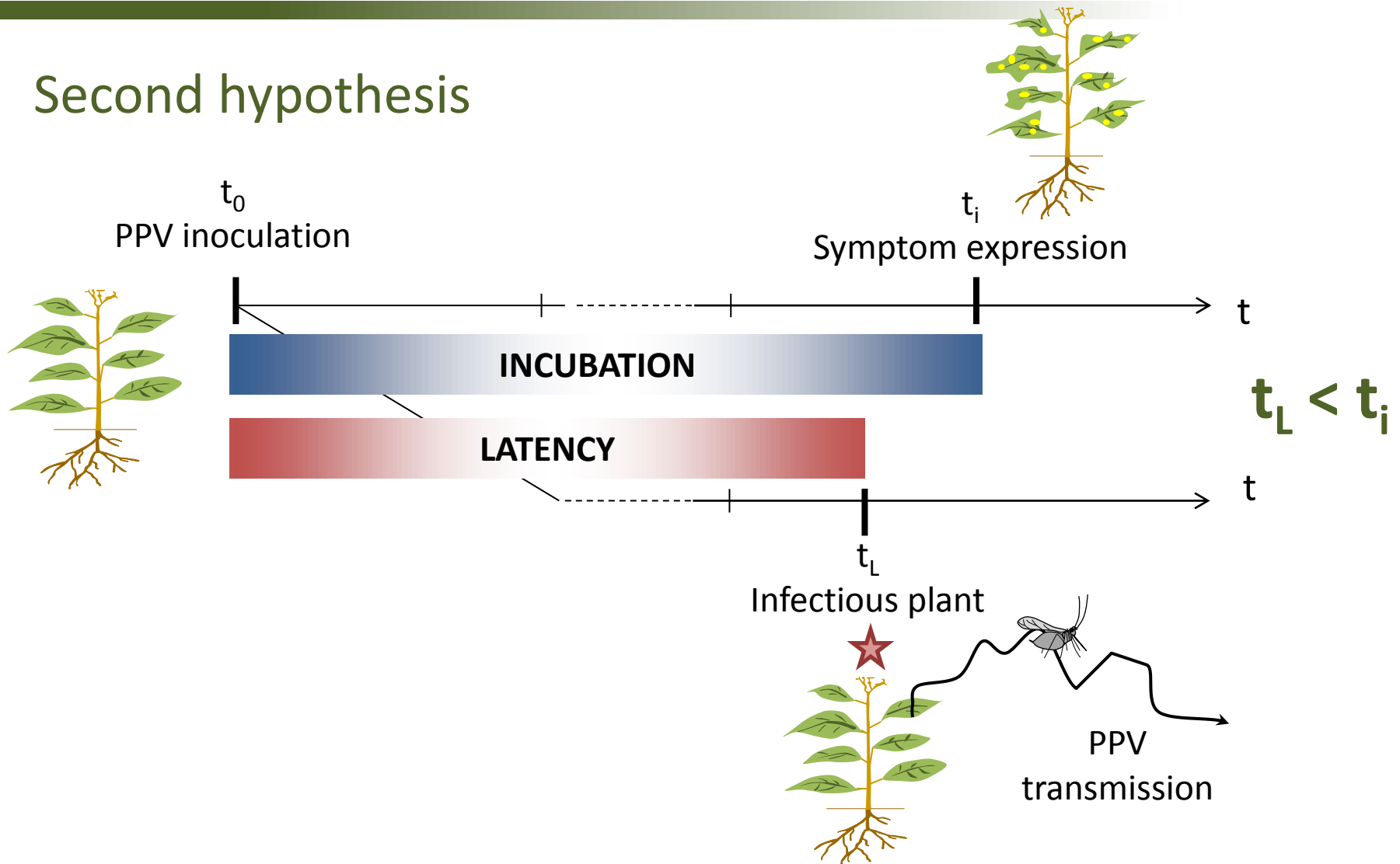
Latency vs. Incubation

First hypothesis



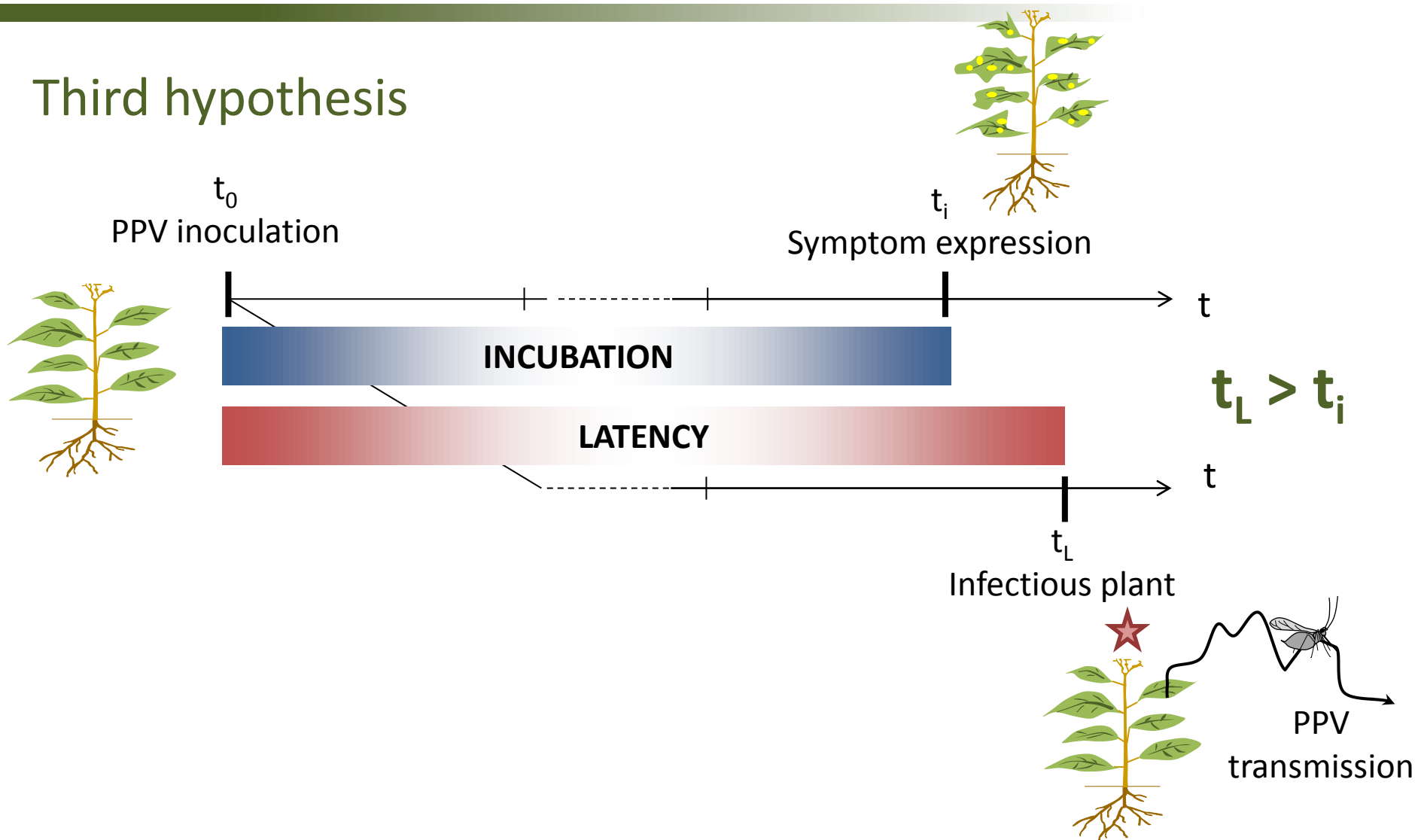
Latency vs. Incubation

Second hypothesis

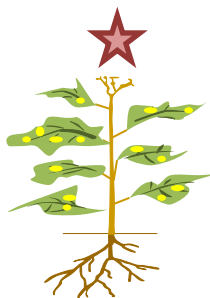


Latency vs. Incubation

Third hypothesis



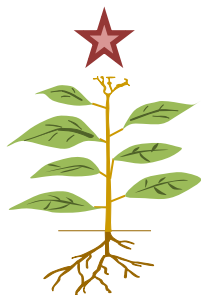
Consequences of these scenarios



Infectious with symptoms

Exemples in literature

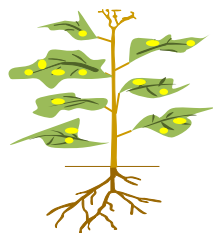
Influenza virus
Hepatitis B virus



Infectious without symptom

Virus source trees not detected by visual inspections
→ Need to apply alternative methods

Rabies virus
Hepatitis A virus

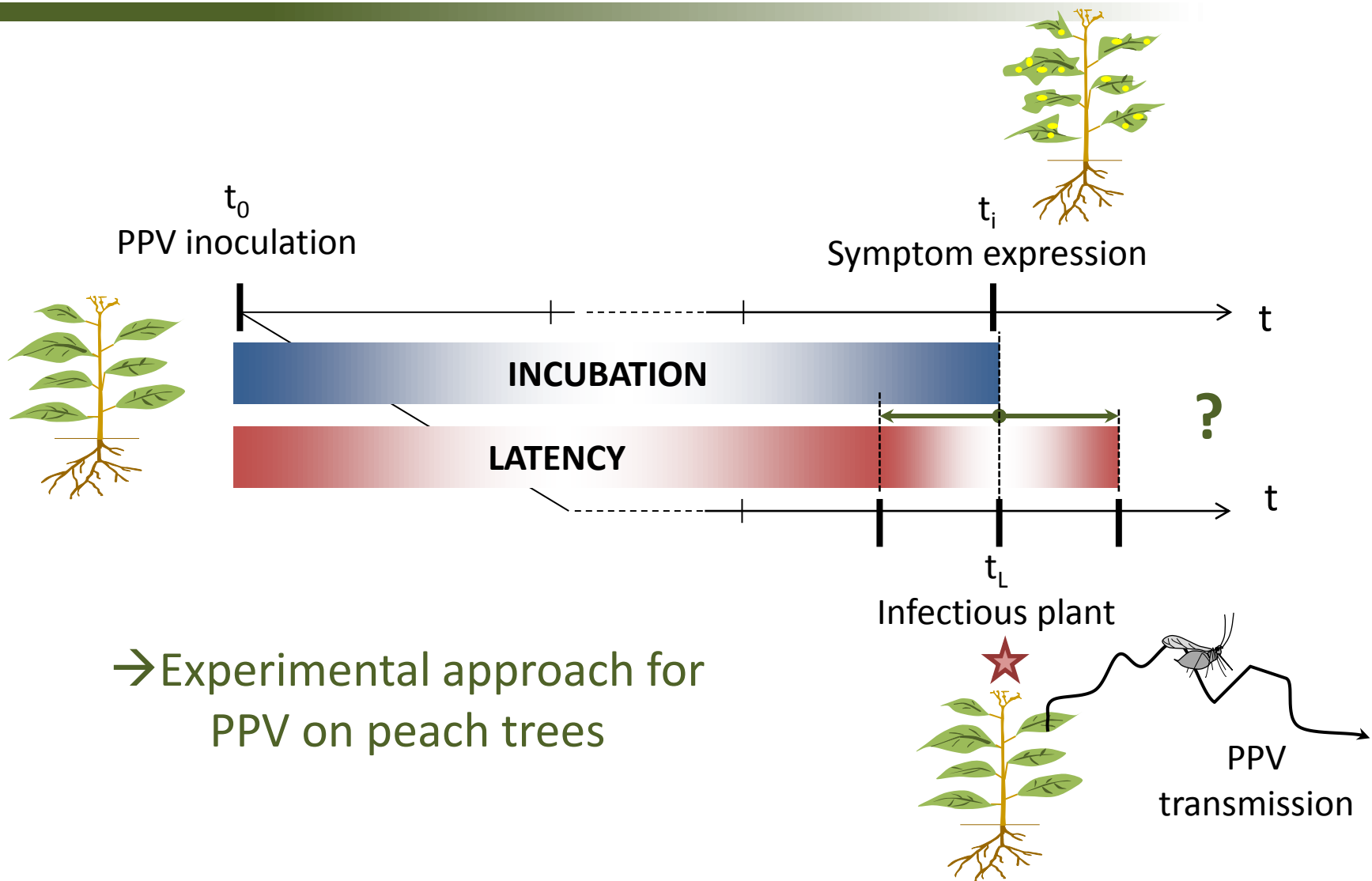


Symptomatic but not infectious

Visual detection possible before the spreading of the disease
→ Visual inspections efficient

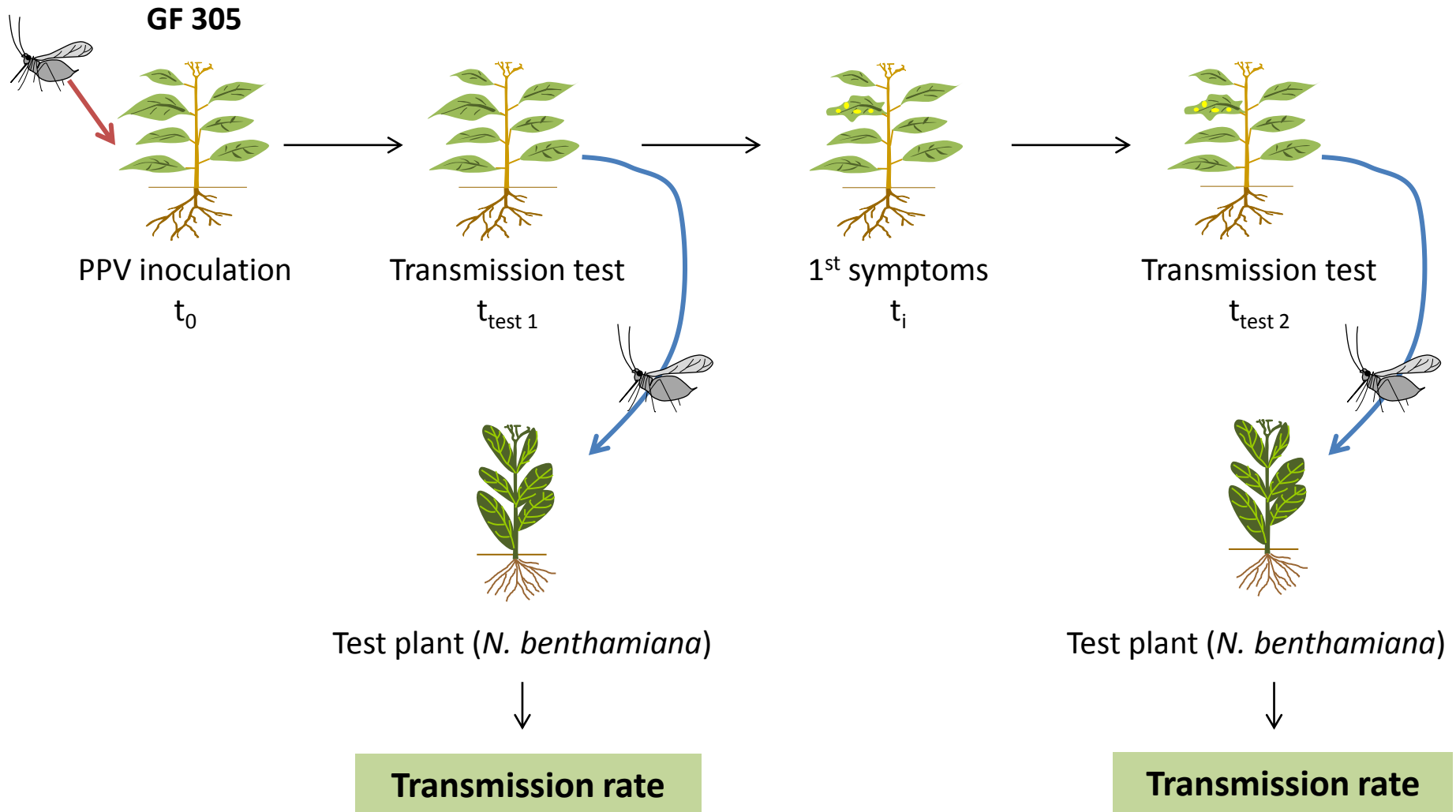
Mycosphaerella fijiensis
Septoria nodorum

Goal: assessment of the potential asynchronism

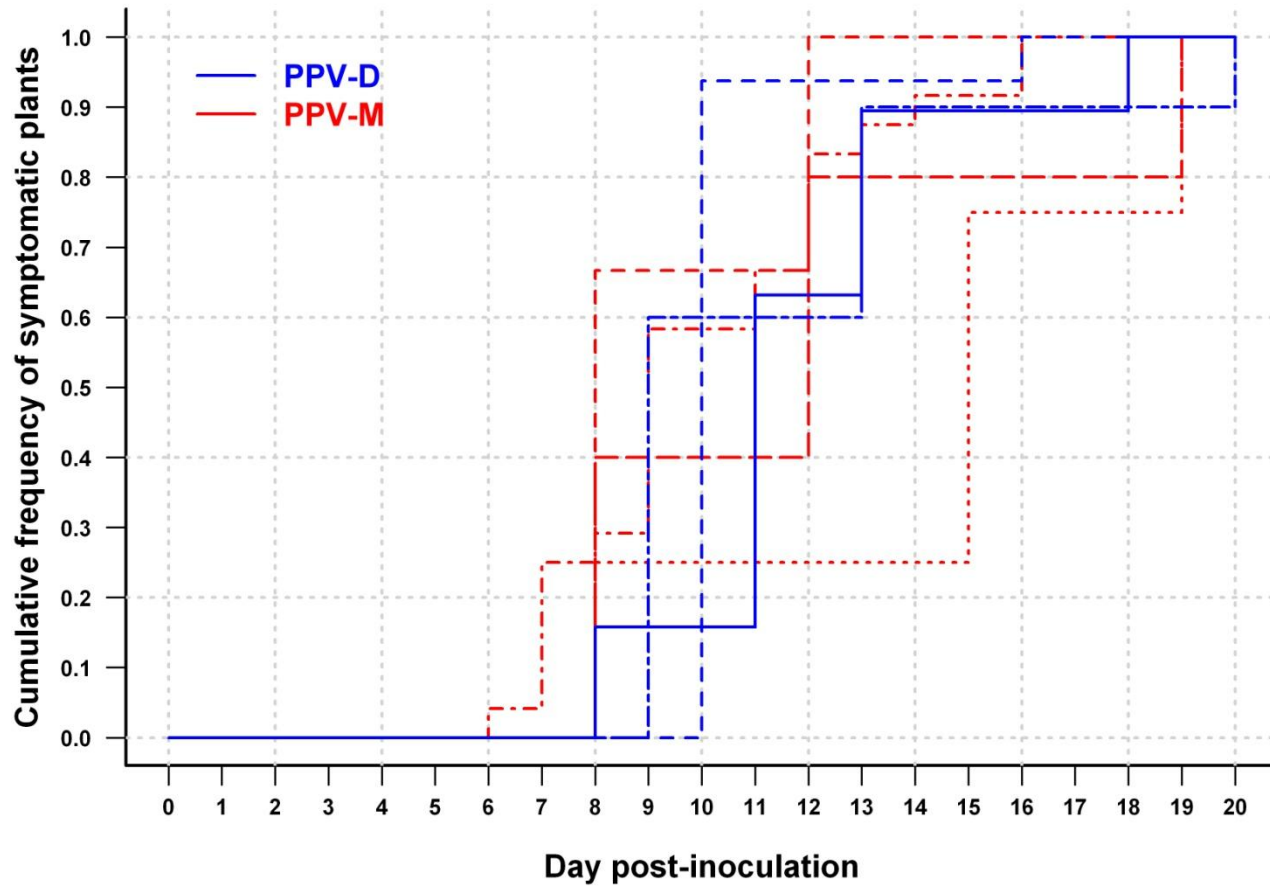


→ Experimental approach for PPV on peach trees

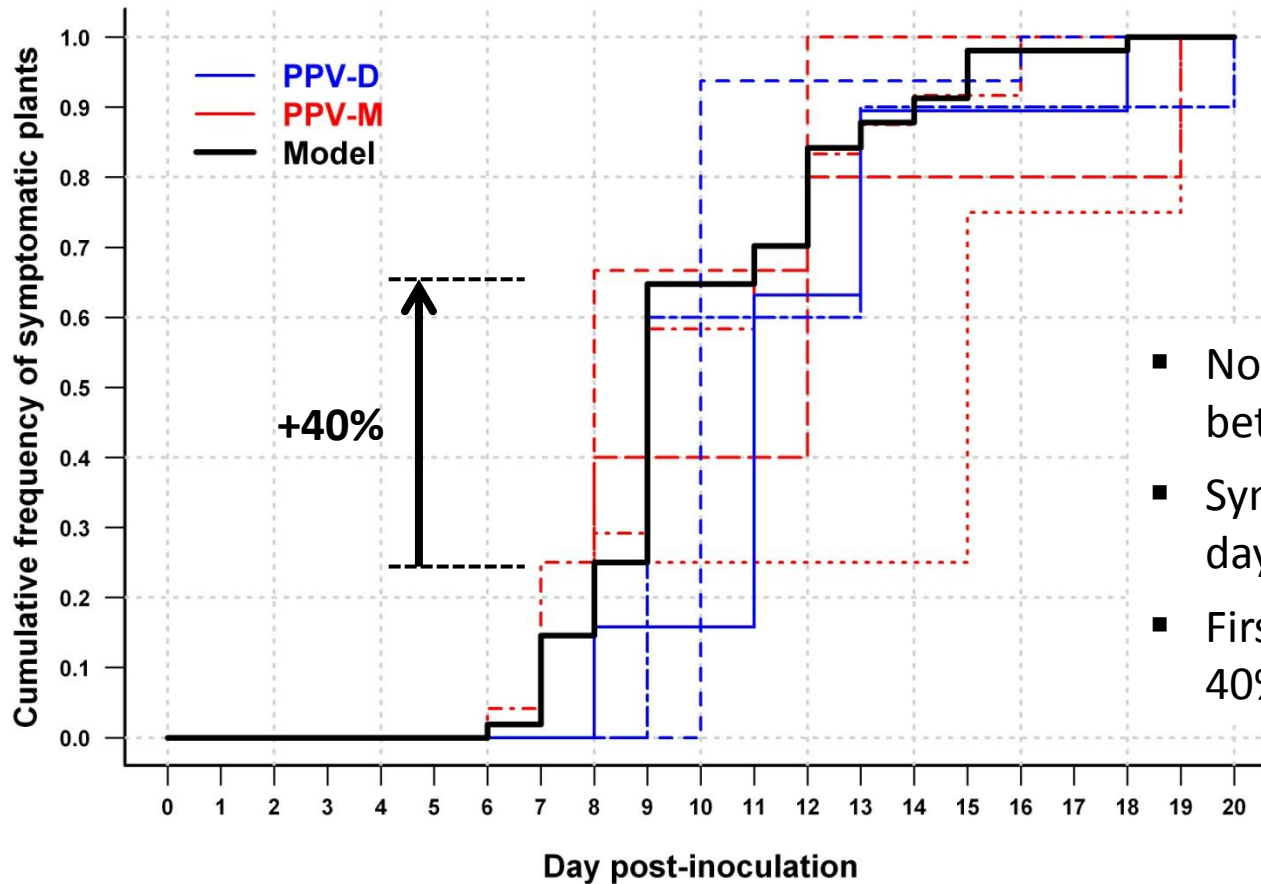
Experimental approach



Analysis of inter-plant variation of t_i



Analysis of inter-plant variation of t_i



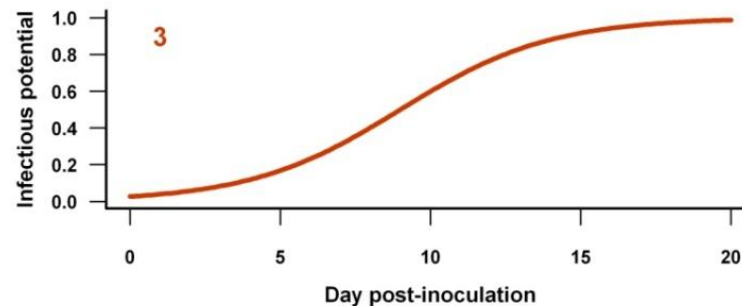
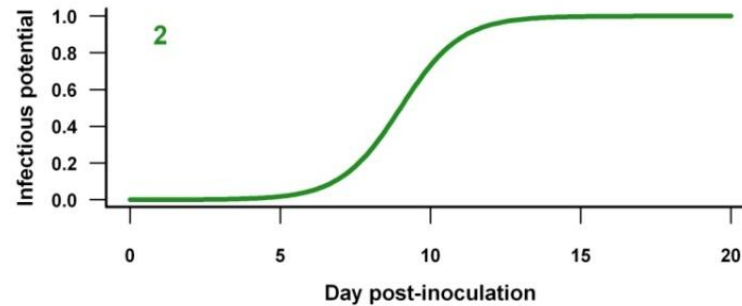
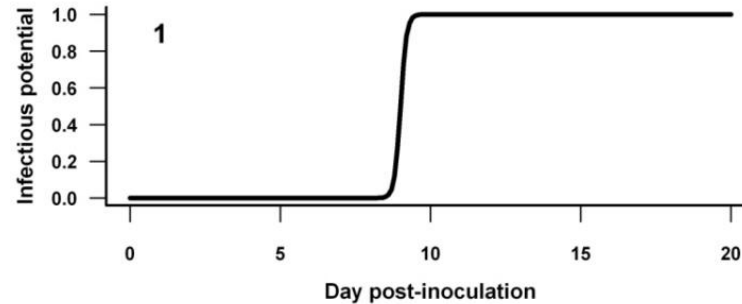
- No significant difference between strains ($p = 0.70$)
- Symptom expression between days 6 and 18
- First symptoms on day 9 for 40% of the plants

Simulation of inter-plant variation of t_L

Low variation in the latency duration

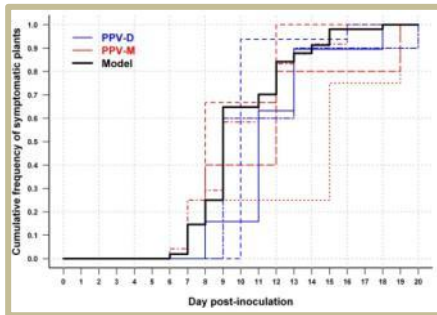


High variation in the latency duration

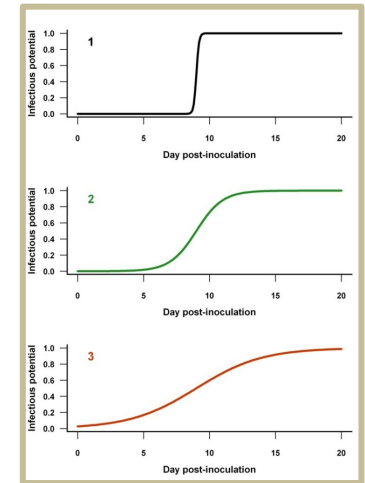


Validation of the protocol by modeling

3 scenarios for the synchronization



Empirical distribution to simulate the incubation period

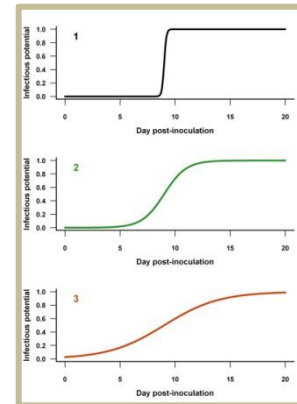


3 theoretical distributions to simulate the latency period

1. Simulation of the number of infected test plants
2. Model fitting & assessment of the mismatch between latency and incubation
3. Assessment of the adequacy between simulated and estimated mismatches



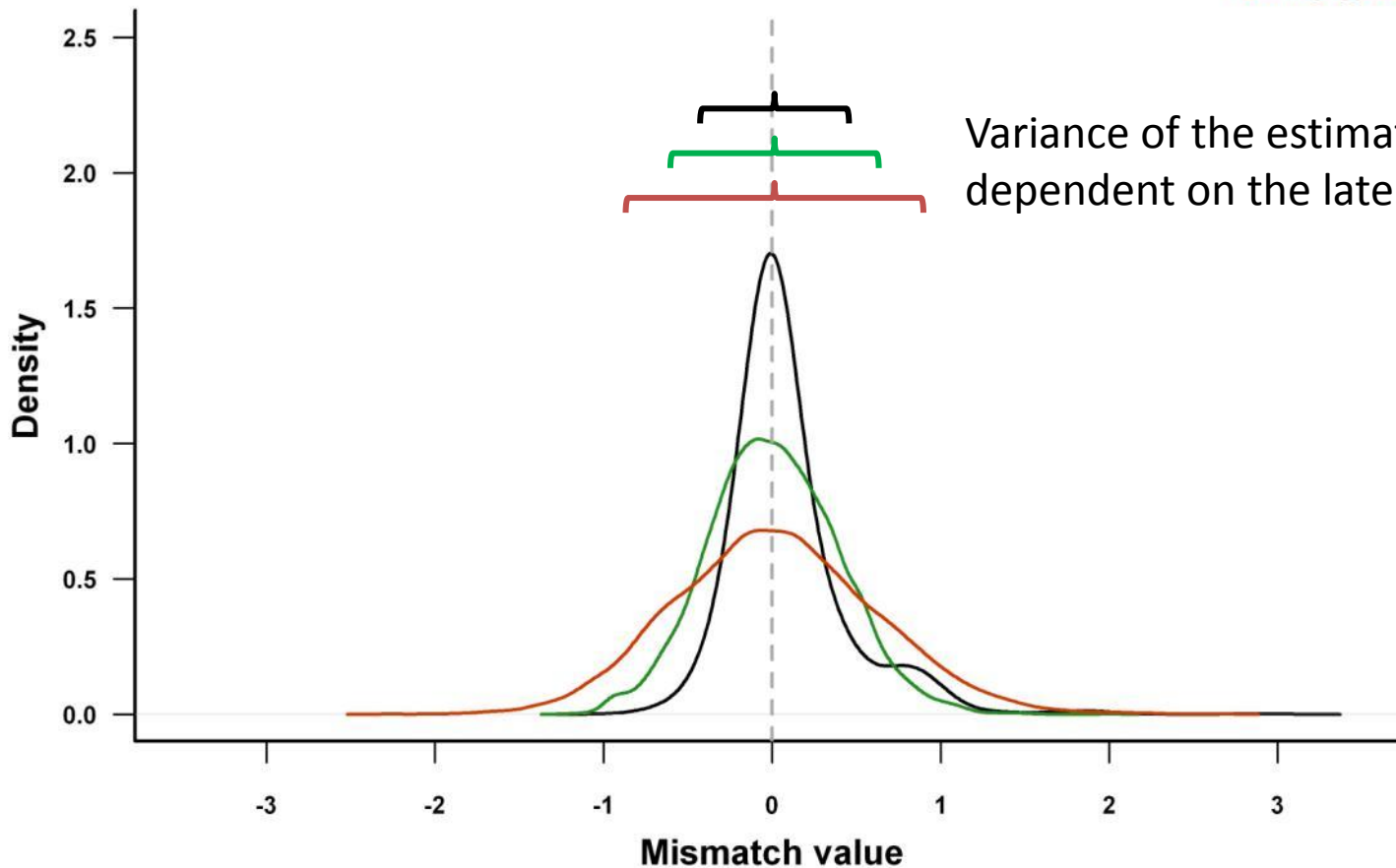
Assessment of the mismatch



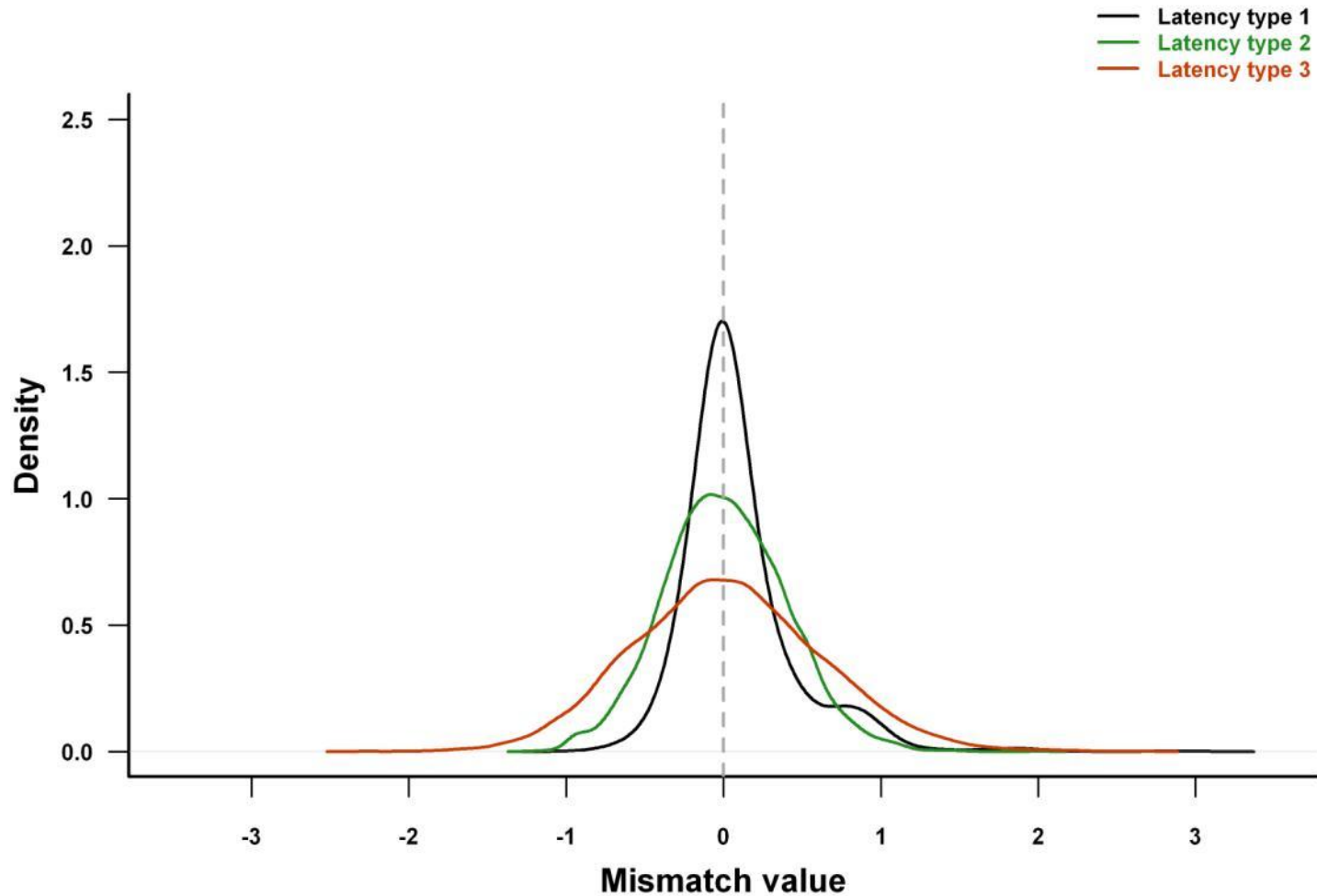
Symptom expression

— Latency type 1
— Latency type 2
— Latency type 3

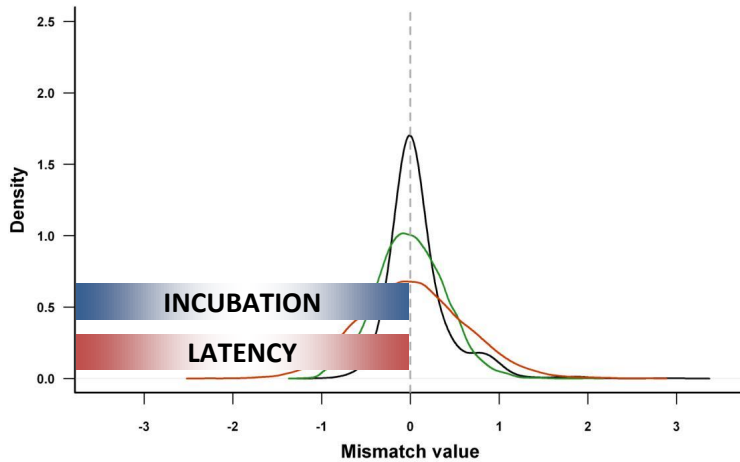
Variance of the estimated mismatch dependent on the latency scenario



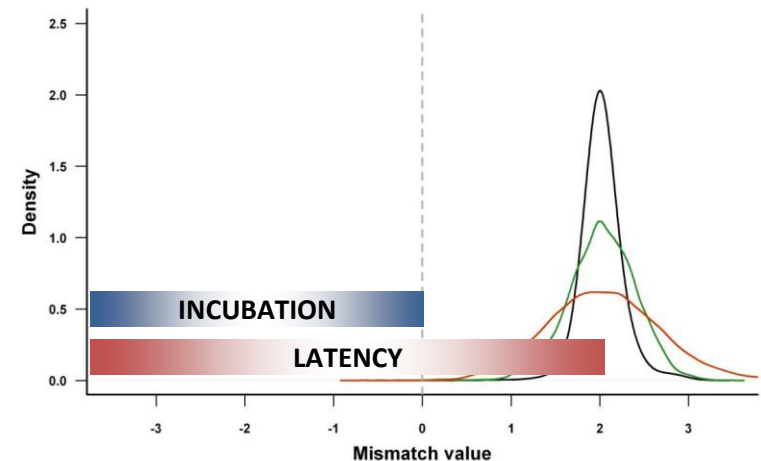
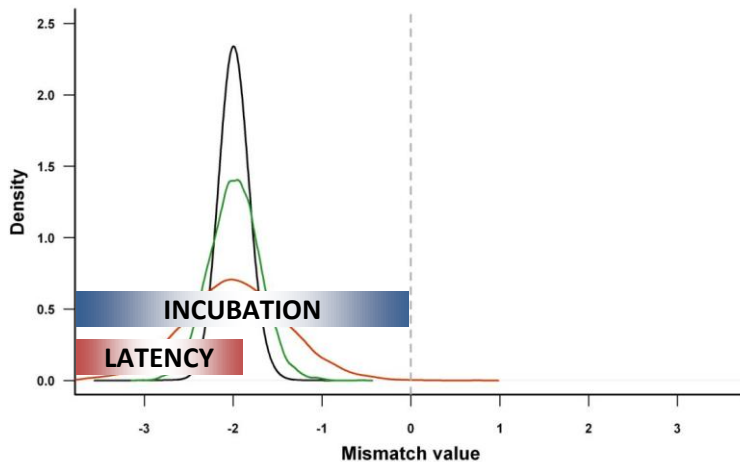
Assessment of the mismatch



Adequacy between simulated and estimated mismatches



Mismatch between latency and incubation assessed with a precision of 1 day



Conclusions

- Model-based experimental design: a useful approach for assessing several scenarios and designing experiments
- We adopt this approach to acquire new data on latency and incubation periods for PPV
- Knowledge acquired through this experiment will be used to improve:
 - The spatiotemporal model of propagation
 - The proposed management strategies

Thank you
for your
attention

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