Modelling framework to coordinate disease control decisions: example of PRRS

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CONTEXT

Non notifiable diseases in livestock populations

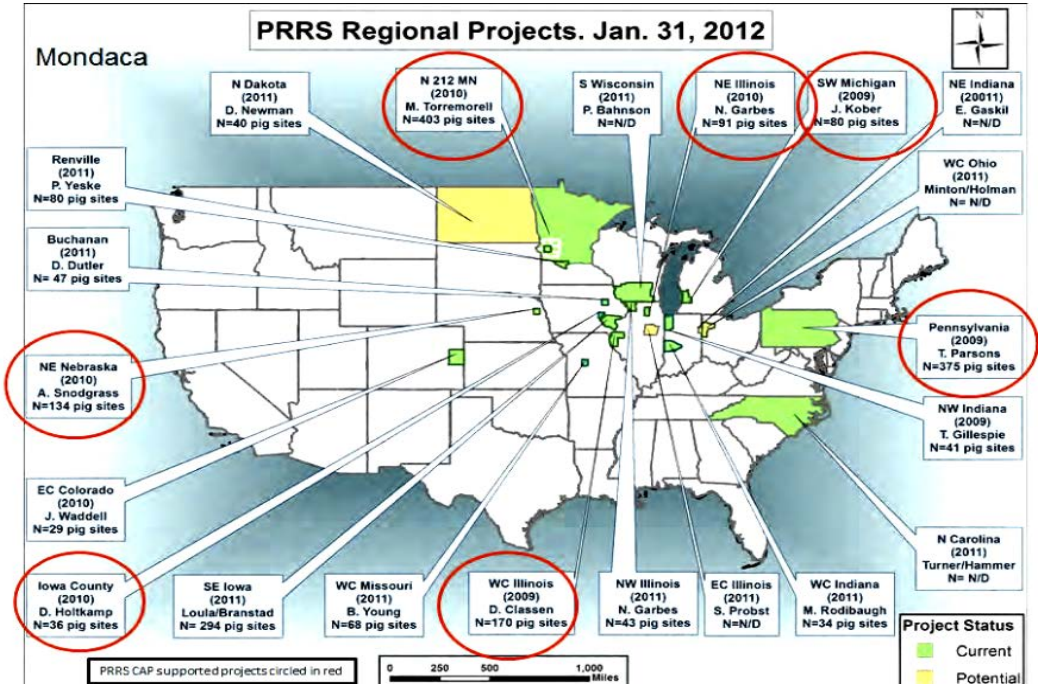
- Control measures at farmers' initiative
- Transmissible infectious disease => impact of decisions on the prevalence in an area
- Groups/associations of farmers : try to coordinate individual decisions
  - To achieve a global objective
  - Through advices or financial incentives

Tool helpful to coordinate individual decisions at group levels

PRRS (Porcine Reproductive and Respiratory Syndrome)

- Viral disease of pigs
- Endemic in many pig producing areas
- Responsible for significant economic losses in pig industry *4.67€/hog (Holtkamp 2013)*
- Infection of herds : purchase of infected animals, airborne transmission (manure)
- Persistent within a contaminated herd
- Control measures : vaccines, biosecurity, control of animal movements

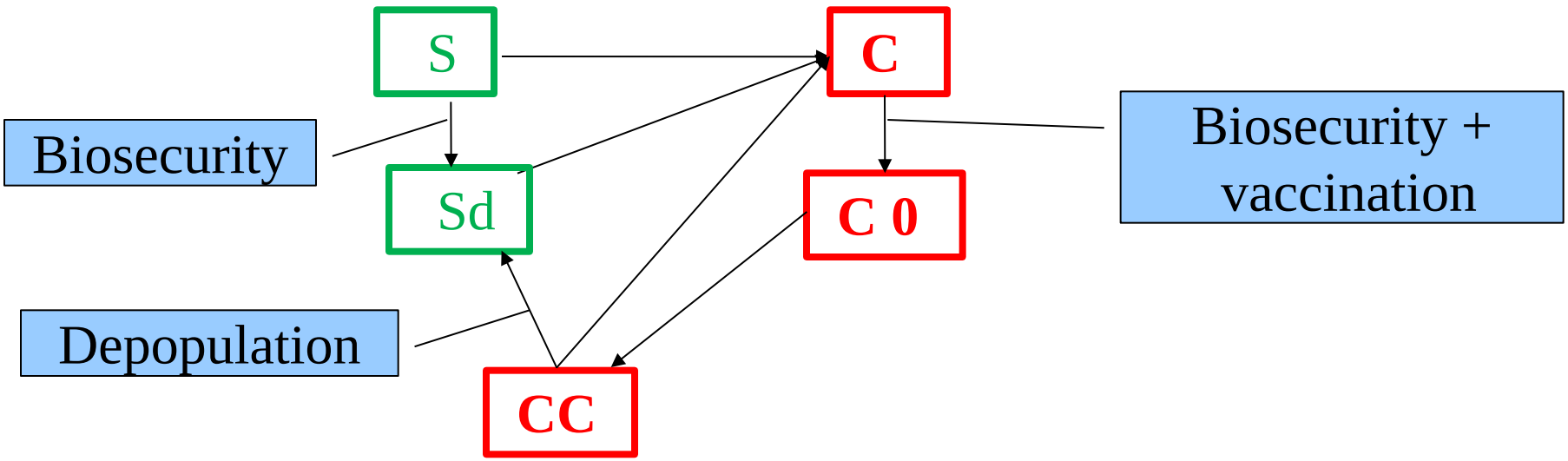
CONTEXT



Objective: proposing a strategy at the group level to limit the total cost of the PRRS within a group of farms

AT FARM LEVEL

Herd PRRS statuses and individual actions



Herds:

S ⇔ Susceptible

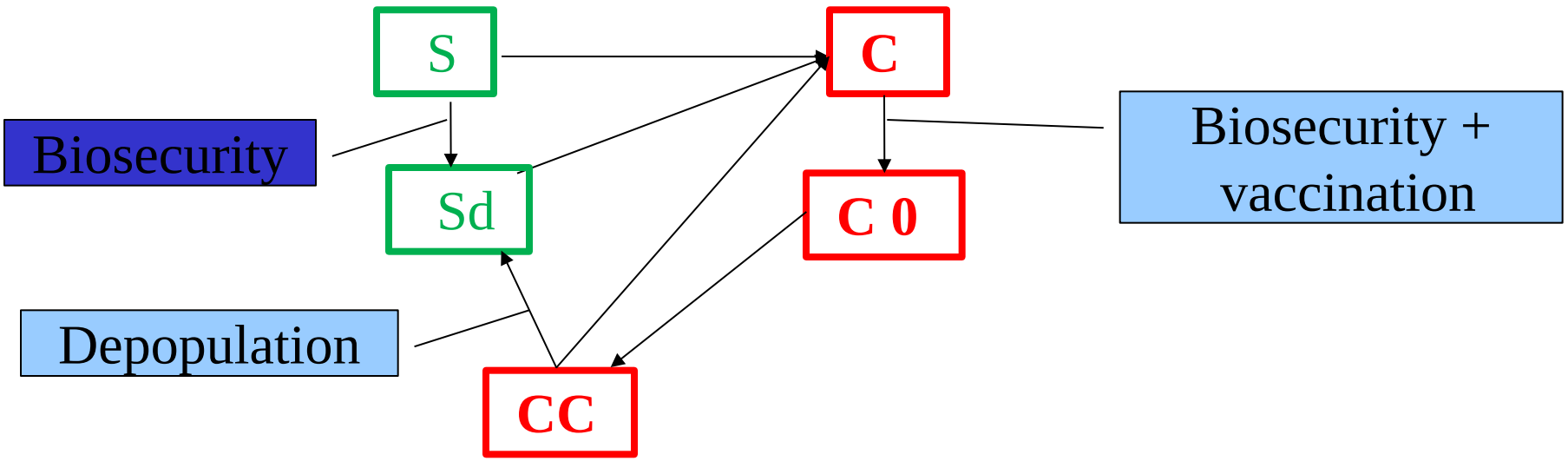
Sd⇔ Susceptible with biosecurity

C ⇔ Contaminated without any control

C0⇔ Contaminated with recent control action

CC⇔Controlled contaminated

Strategy a



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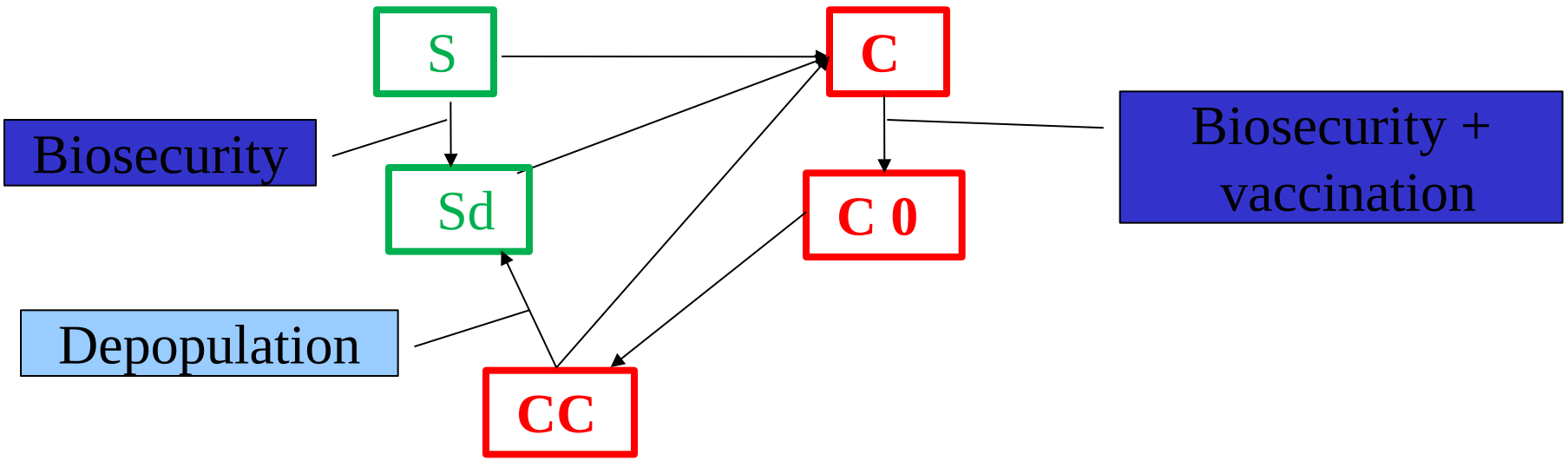
Strategy b



Herds:

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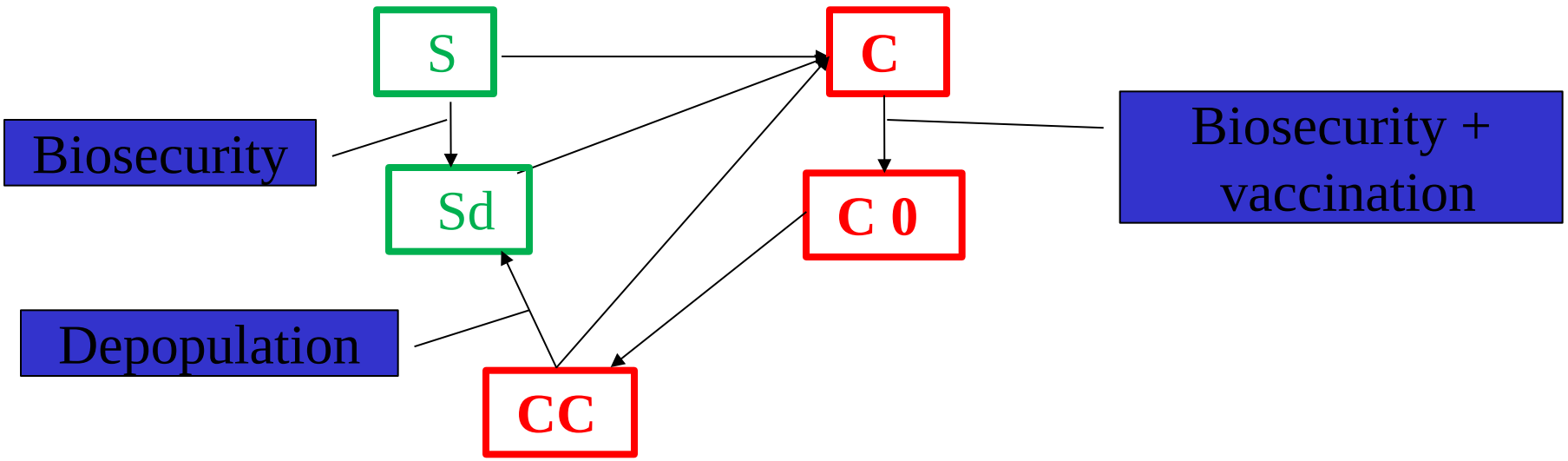
Strategy c



Herds:

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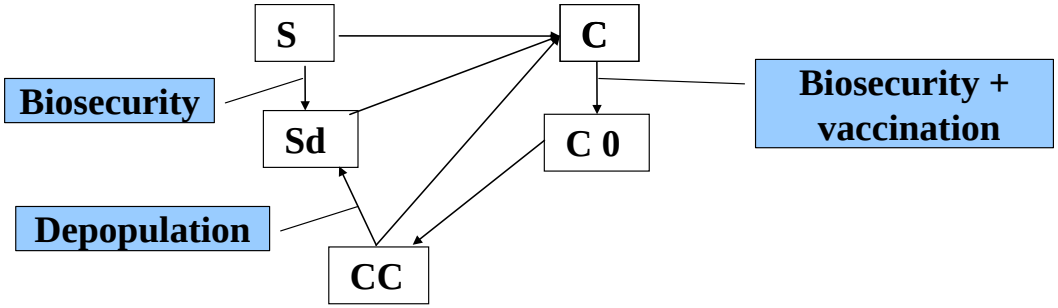
AT GROUP LEVEL

Objective: Minimising the total costs

- Cost of the disease
- Cost of actions



Deadline: None

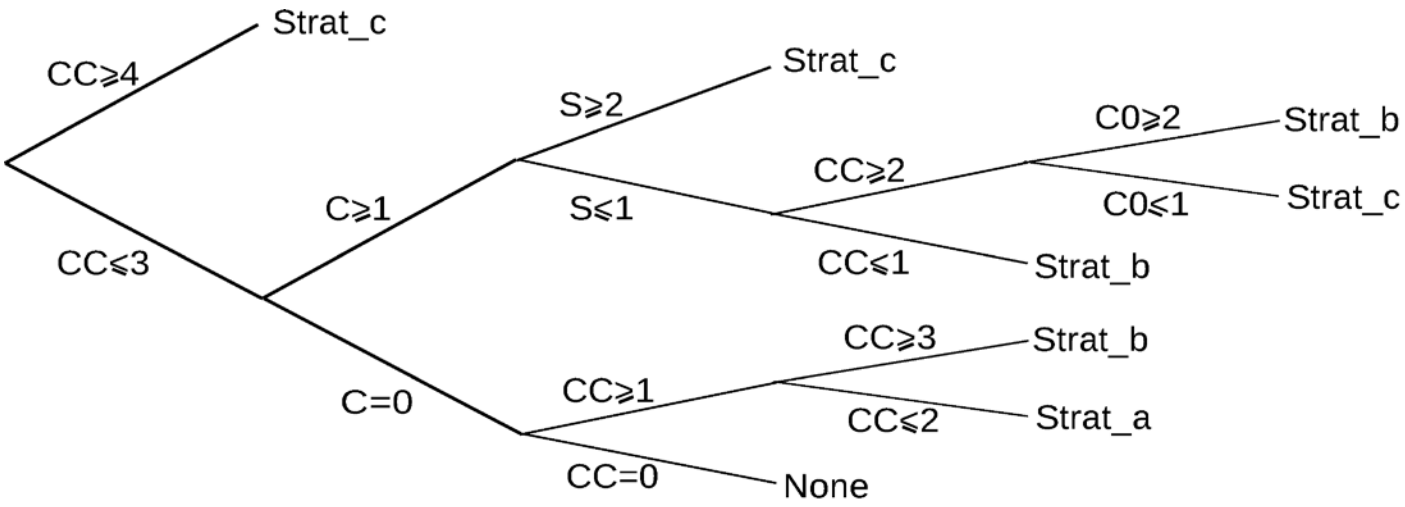
=> Optimisation to propose rules to decide which strategy to retain at each time step to achieve the objective (Markov Decision Model)

RESULTS

Scenario

- Group of 50 herds (40% S+Sd, 40% CC)
- Simulation over 50 years (time-step of 6 mo)

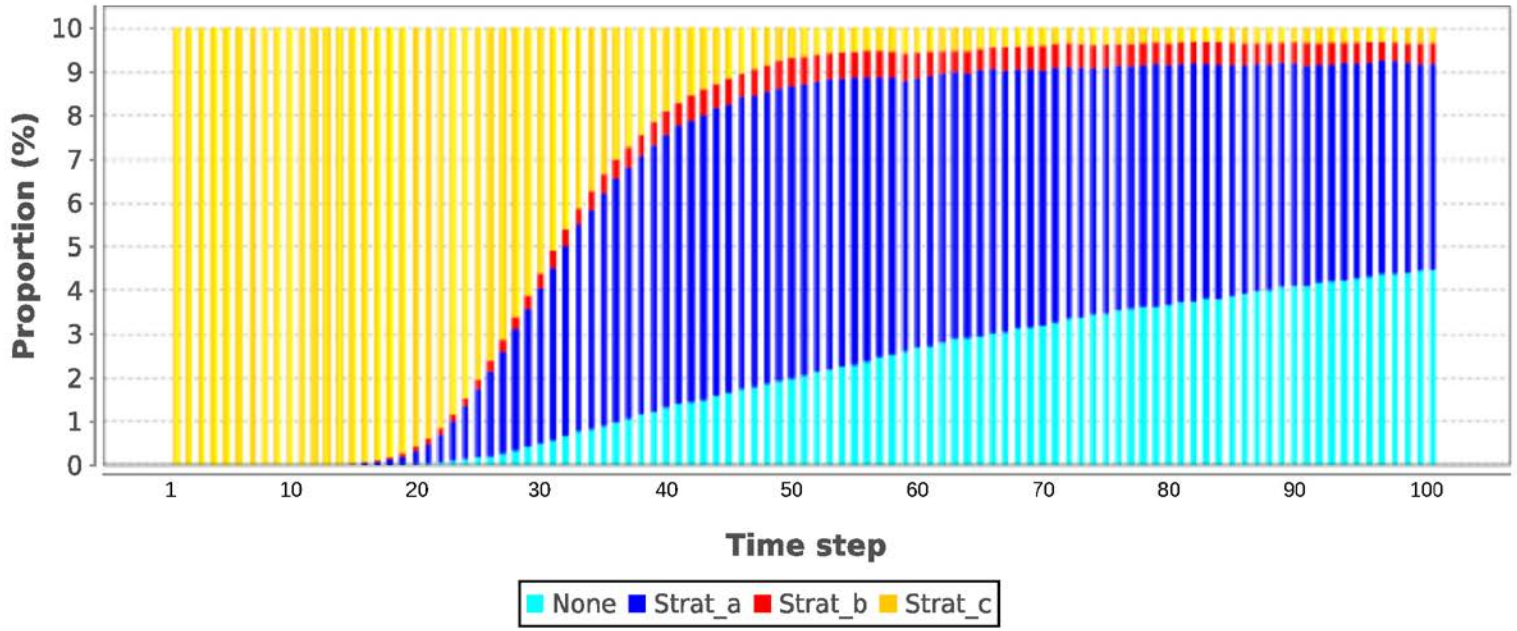
Rules depending on the epidemiological situation at the group level



RESULTS

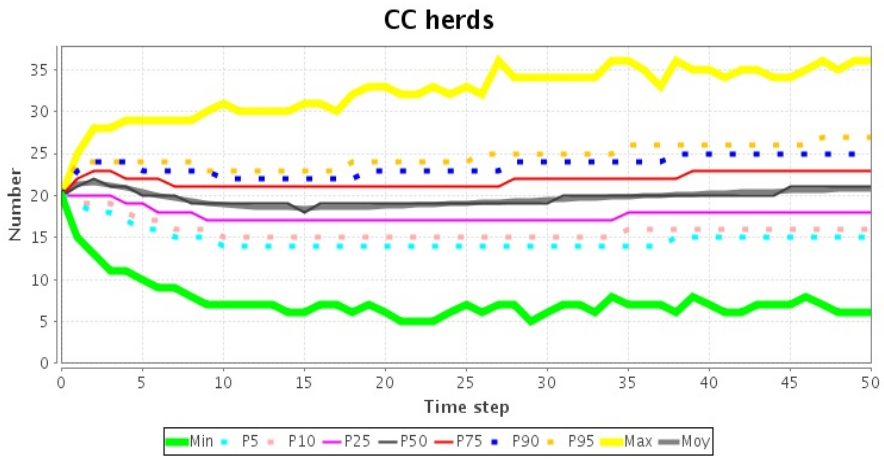
Use of each strategy over time when following rules – Time 0:

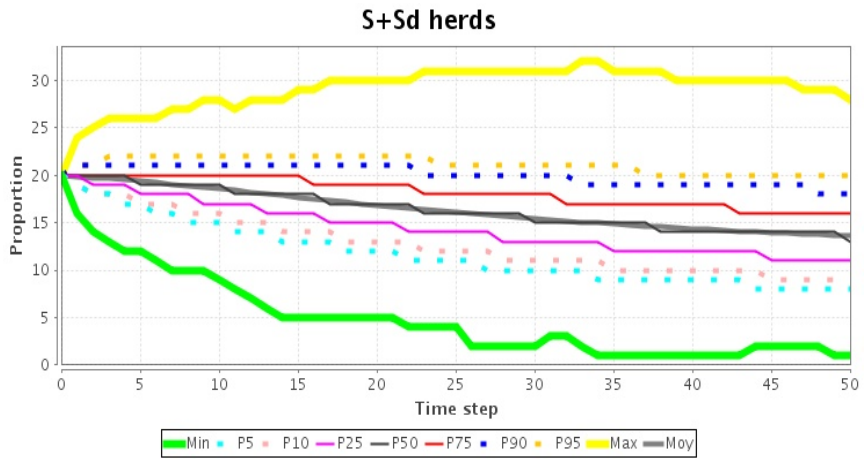
S	Sd	C	C0	CC
5	15	5	5	20



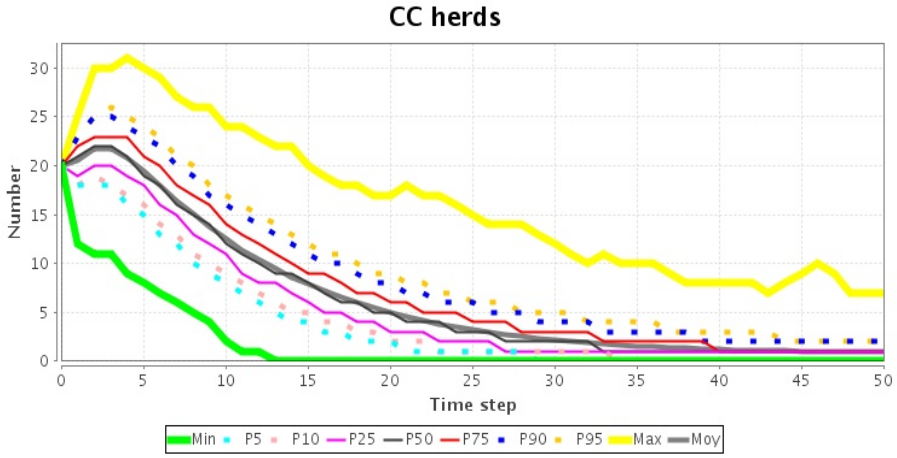
Epidemiological impact

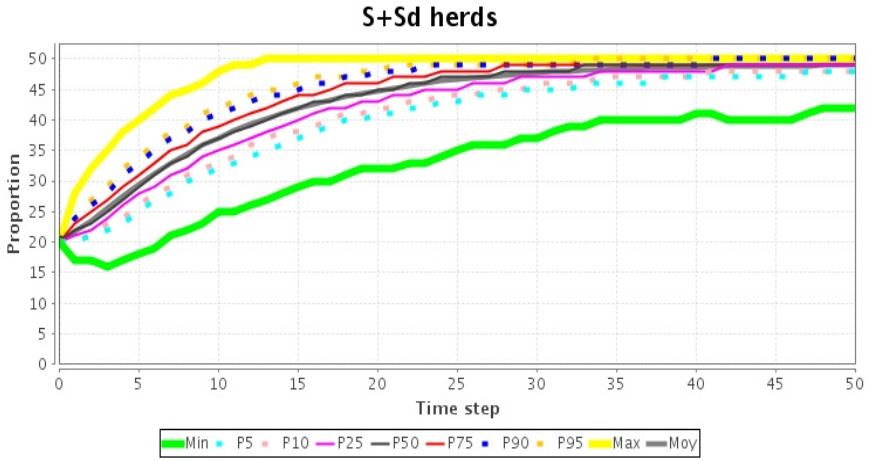
Do nothing





Follow the Rules





Data/Compliance

- Parameters based on literature and expert knowledge
- Heterogeneity of farmers regarding risk attitude
  - Previously infected => compliance >>
- Estimation
  - Based on previous collective management
  - Evaluation with game-theory experiments (Chapman et al., 2012) on a set of representative farmers

DISCUSSION - PERSPECTIVES

Approach

- **Adaptive** coordination
  - Combination of strategies
  - Adaptation to the current epidemiological situation

- Perspectives
  - Multi-objective (minimal cost and prevalence target at a given time step)

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