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Modelling animal movement patterns for disease impact assessment – rationale and implications of the FLI/DTU EuFMD-FAR project

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eofmd
european commission for the control of foot-and-mouth disease

FMD

- Risk of introduction
- Different control options
- Decisions must be taken:
  Recommendations?

=> Simulation models

Different prevention and control strategies

- Culling
- Vaccination
- Stand still
- Movement restrictions

Reduced social acceptance of massive culling of animals

FMD – simulation models

-Davis Animal Disease Simulation (DADS) model – University of California, Davis

-North American Animal Disease Spread Model (NAADSM) – Center of Epidemiology and Animal Health and United States Department of Agriculture

-InterSpreadPlus (ISP) model – Massey University, New Zealand

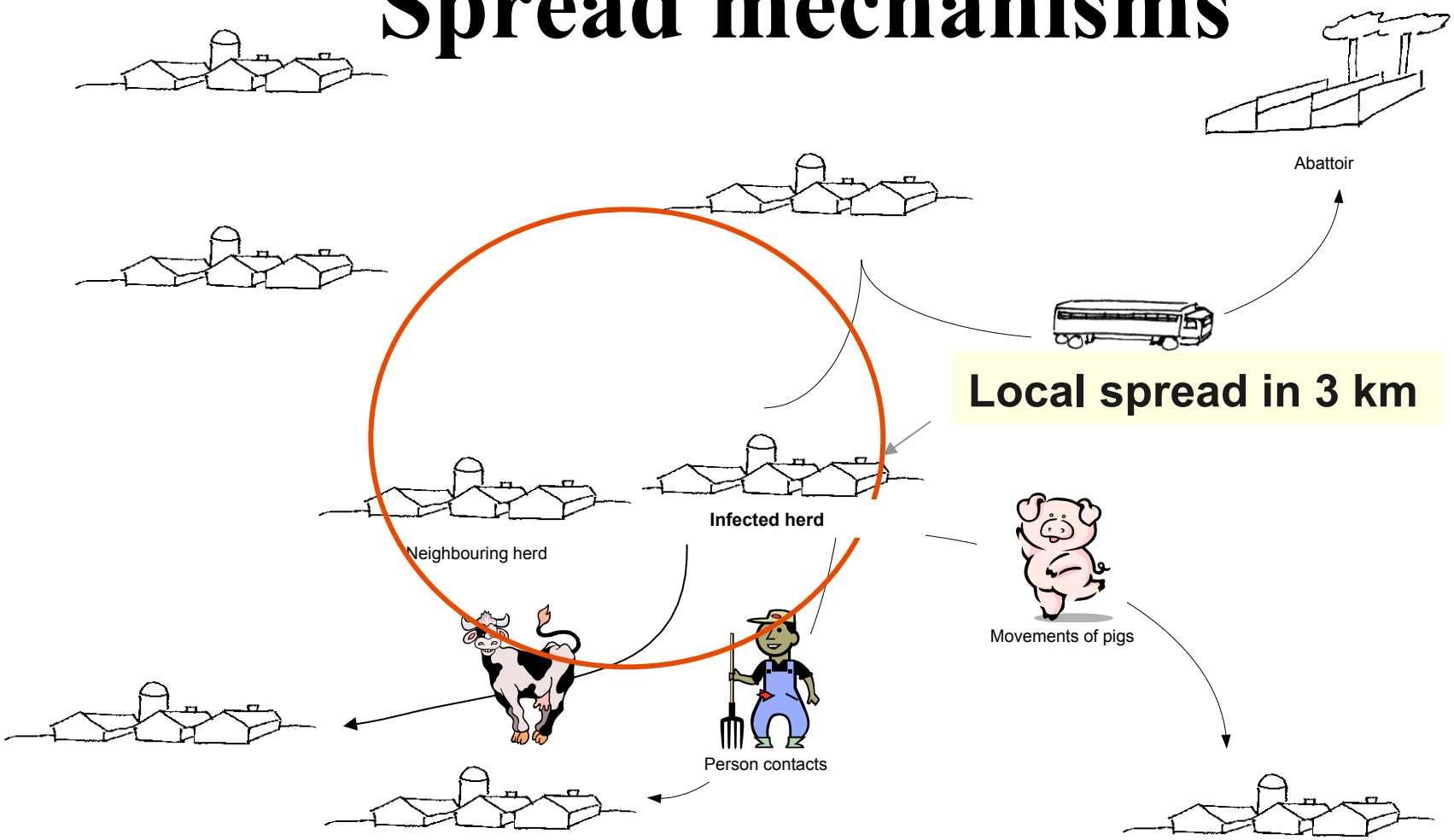
FMD simulation model

- DADS selected (Bates et al., 2003; Halasa et al., 2014)
- Simulation of transmission
  - intra- and inter-herd
- Spatial, stochastic, state-transition model
- Deterministic on animal-level
- Time steps of 1 day

Bates et al., 2003, Am J Vet Res 64: 195-204

Halasa et al., 2014, PLOS ONE. 9 (3): e92521

Spread mechanisms



Animal Movements

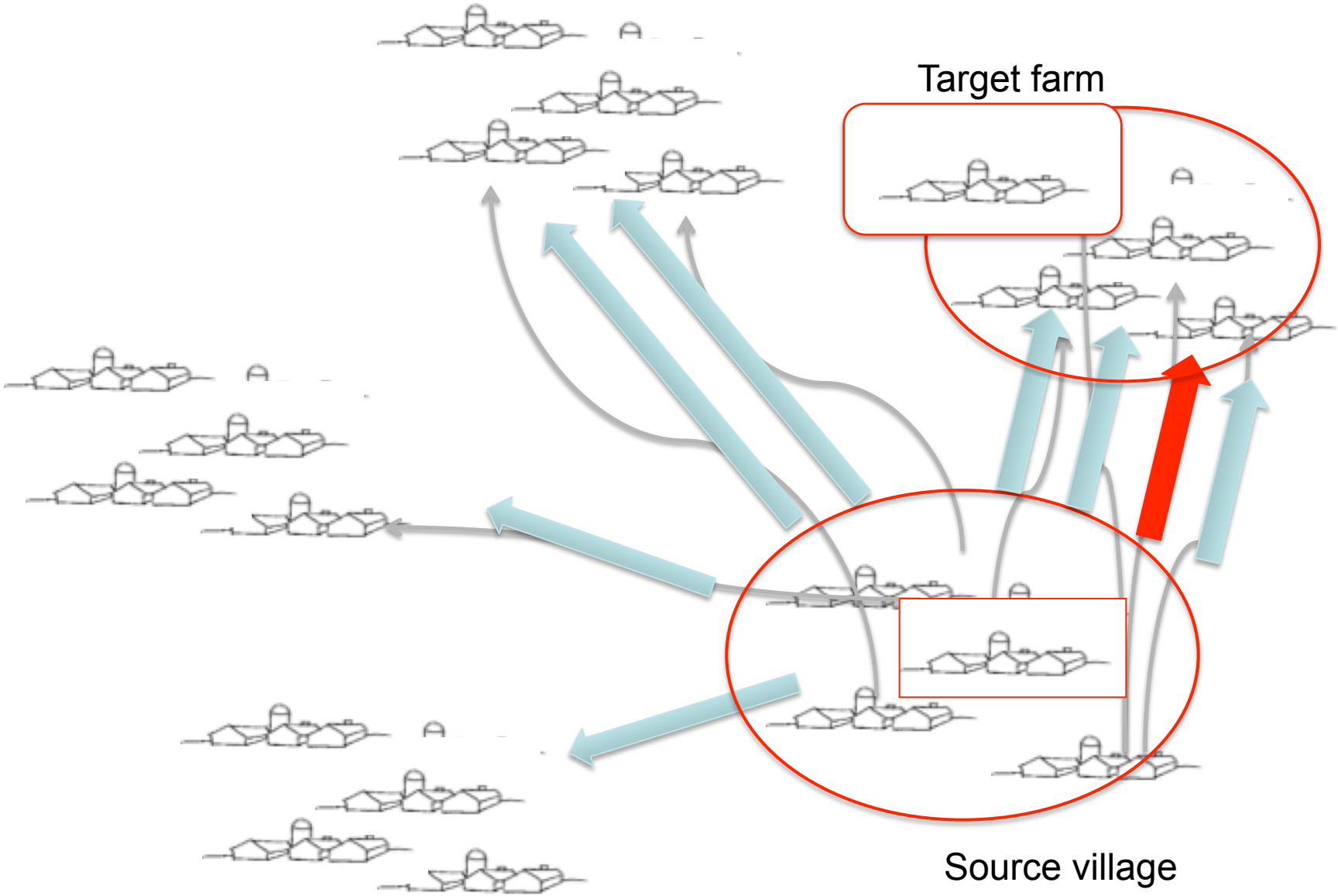
- Crucial for spreading the disease
- For simulation: number of individual animals moved on farm level (network of movements between farms)
- Not available in all situations
  - Due to data protection issues => data on administrative unit only available
  - Or not available at all village (= epidemiological unit)

Animal Movements

- Aggregation of movements on administrative unit or village level possible, but farm level data still used for precise modelling of the disease and flexibility (if farm level data are available)

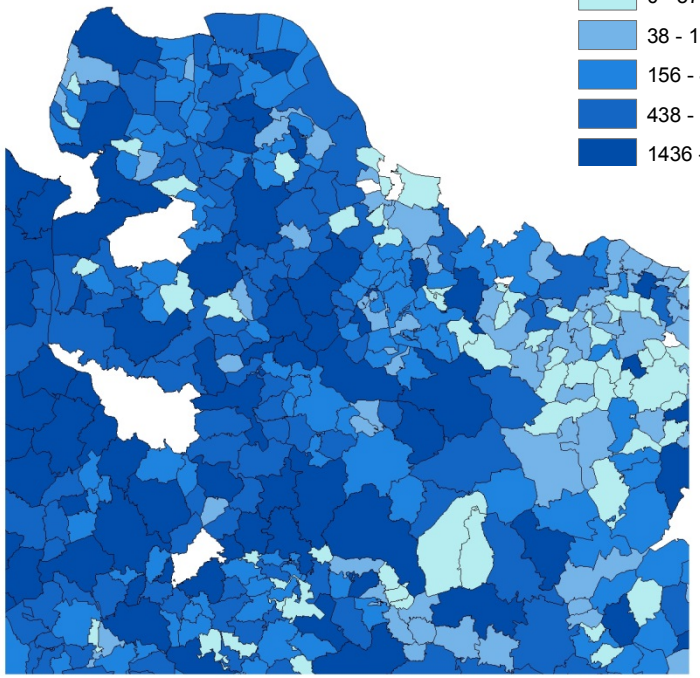
=> Hybrid approach

  - Individual infected farm within a source village
  - Randomly chosen movement from this village
  - Leads to target village
  - Randomly chosen individual farm within the target village will be infected

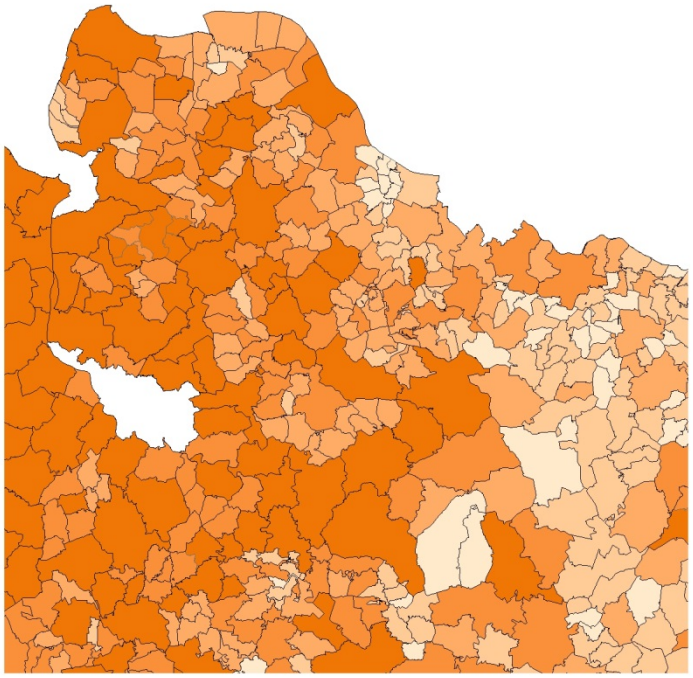

Target farm
Source village

Animal movements evaluation

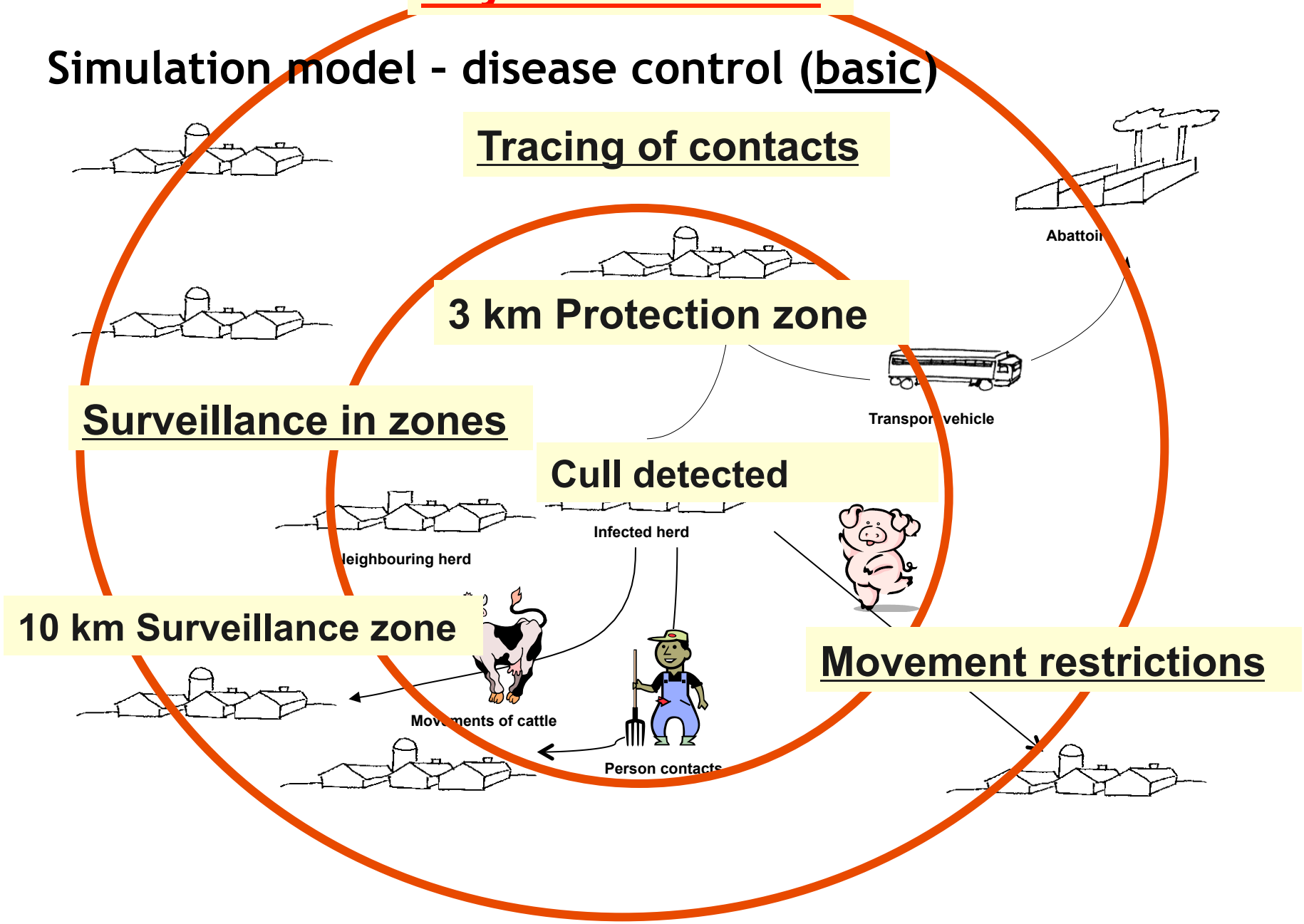
In degree



Cumulative affected



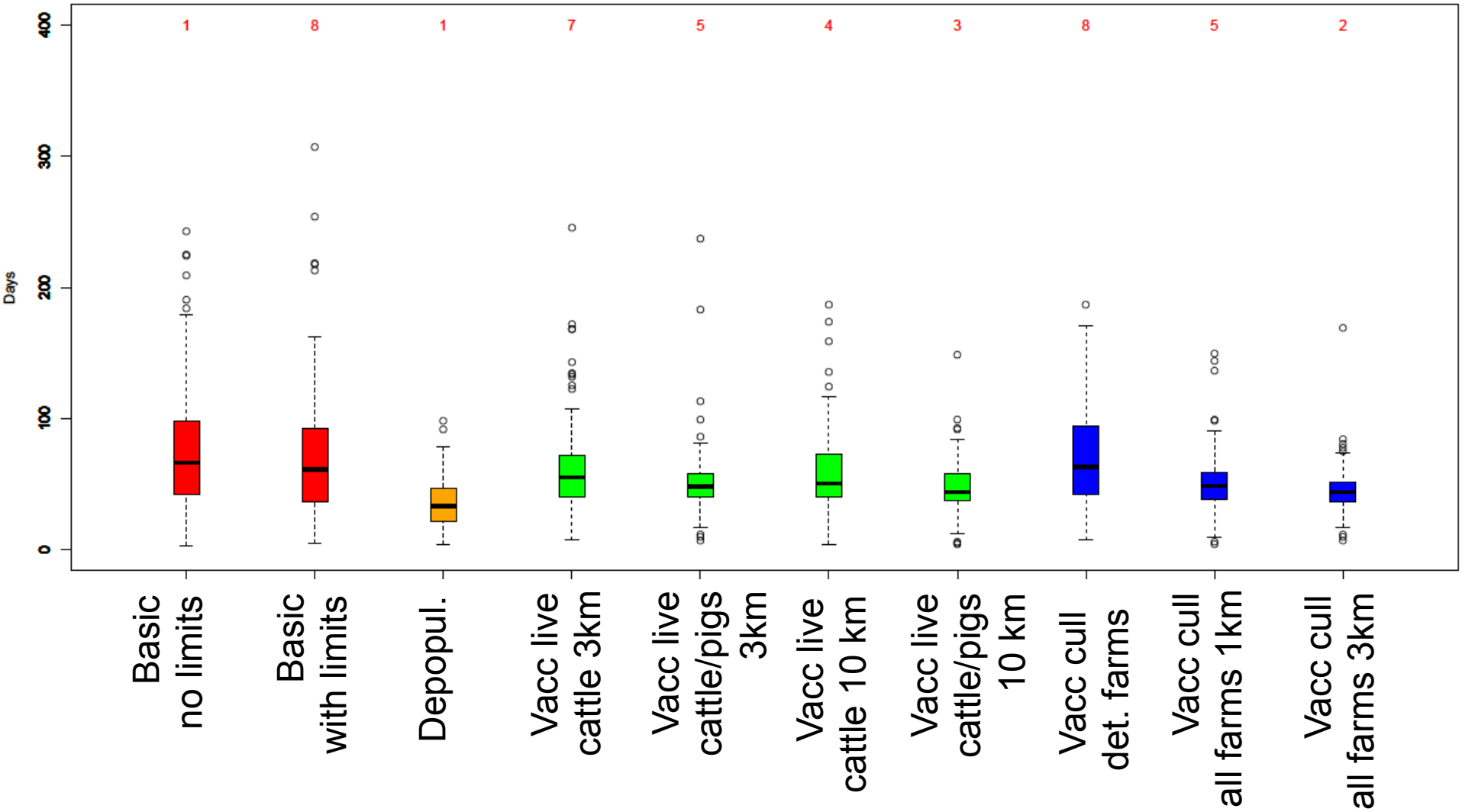
Simulation model - disease control (basic)



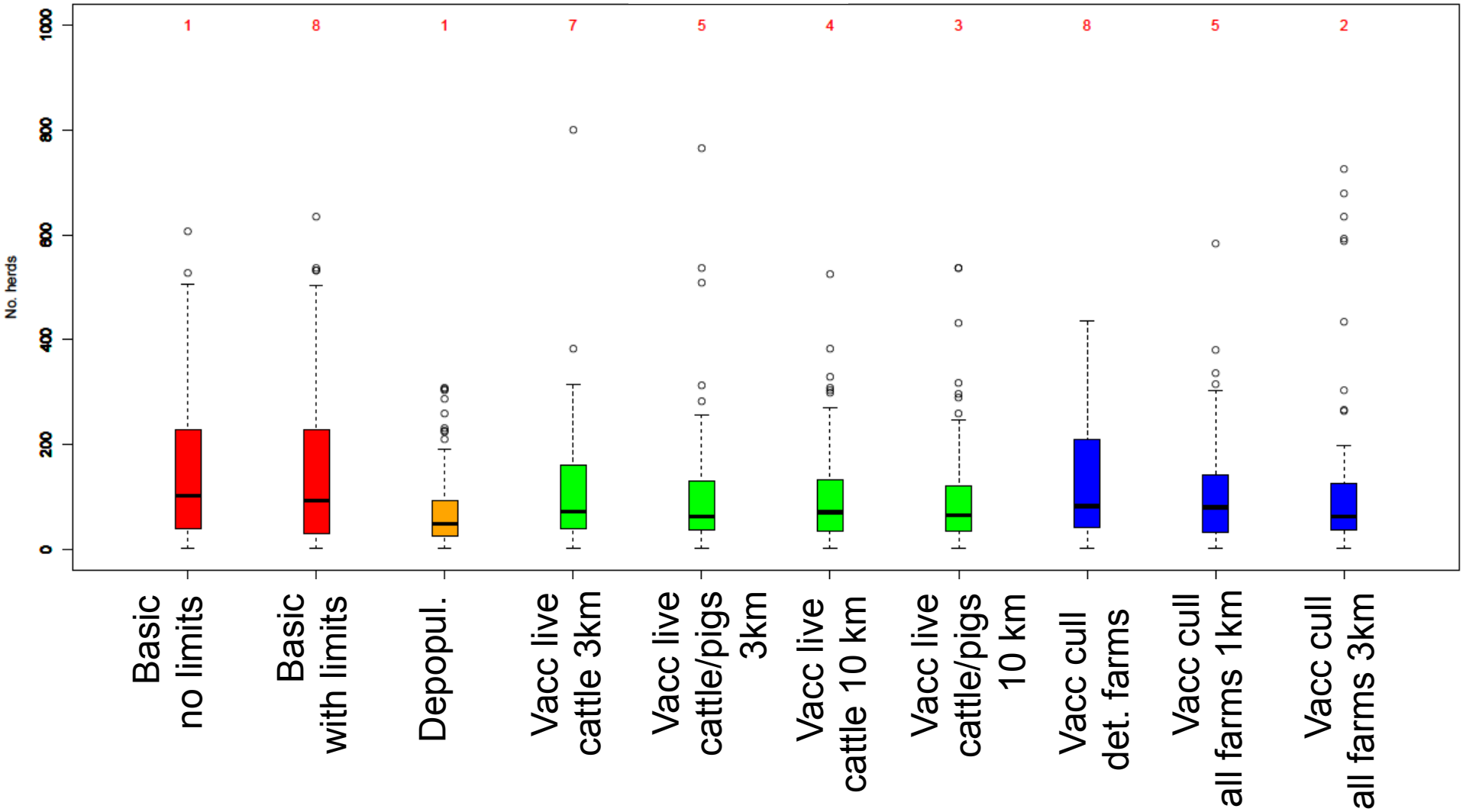
- Comparison of different scenarios
  - **Basic** – no resource limits
  - **Basic** – *with resource limits*
  - **Depopulation** within 1 km zone
  - **Vaccination ‚to live‘** *of cattle* in 3 km/10 km zone
  - **Vaccination ‚to live‘** *of cattle and pigs* in 3 km/10 km zone
  - **Vaccination ‚to cull‘** of *detected farms* in 3 km zone
  - **Vaccination ‚to cull‘** *of all farms* in 1km/3 km zone

- Preliminary running of scenarios
  - 100 simulations per scenario
  - Stop criteria
    - If more than 1000 herds are infected (excluding the culled herds)
    - AND time >90 days
  - Duration of epidemic and number of infected herds

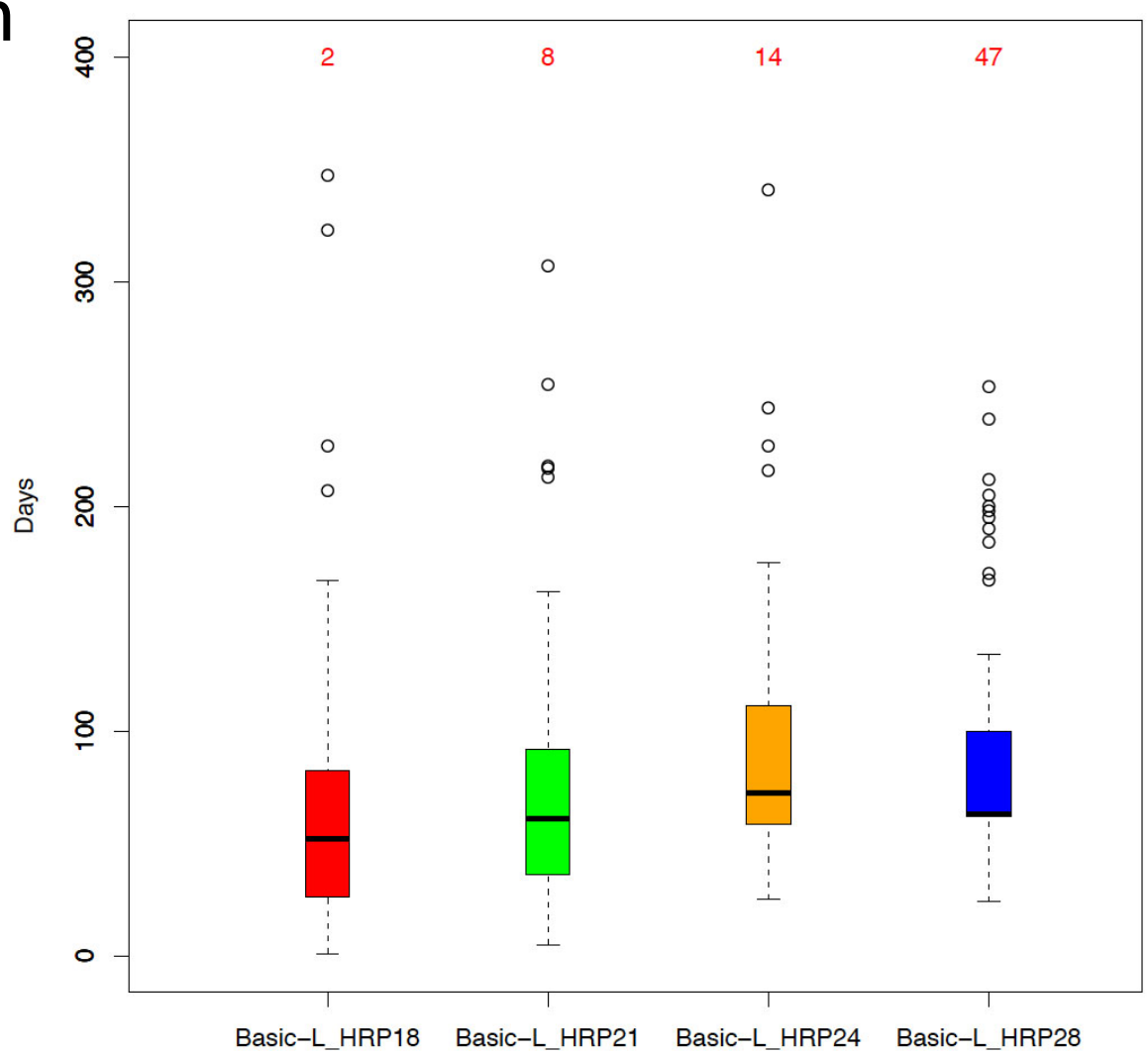
Preliminary results – duration of epidemic



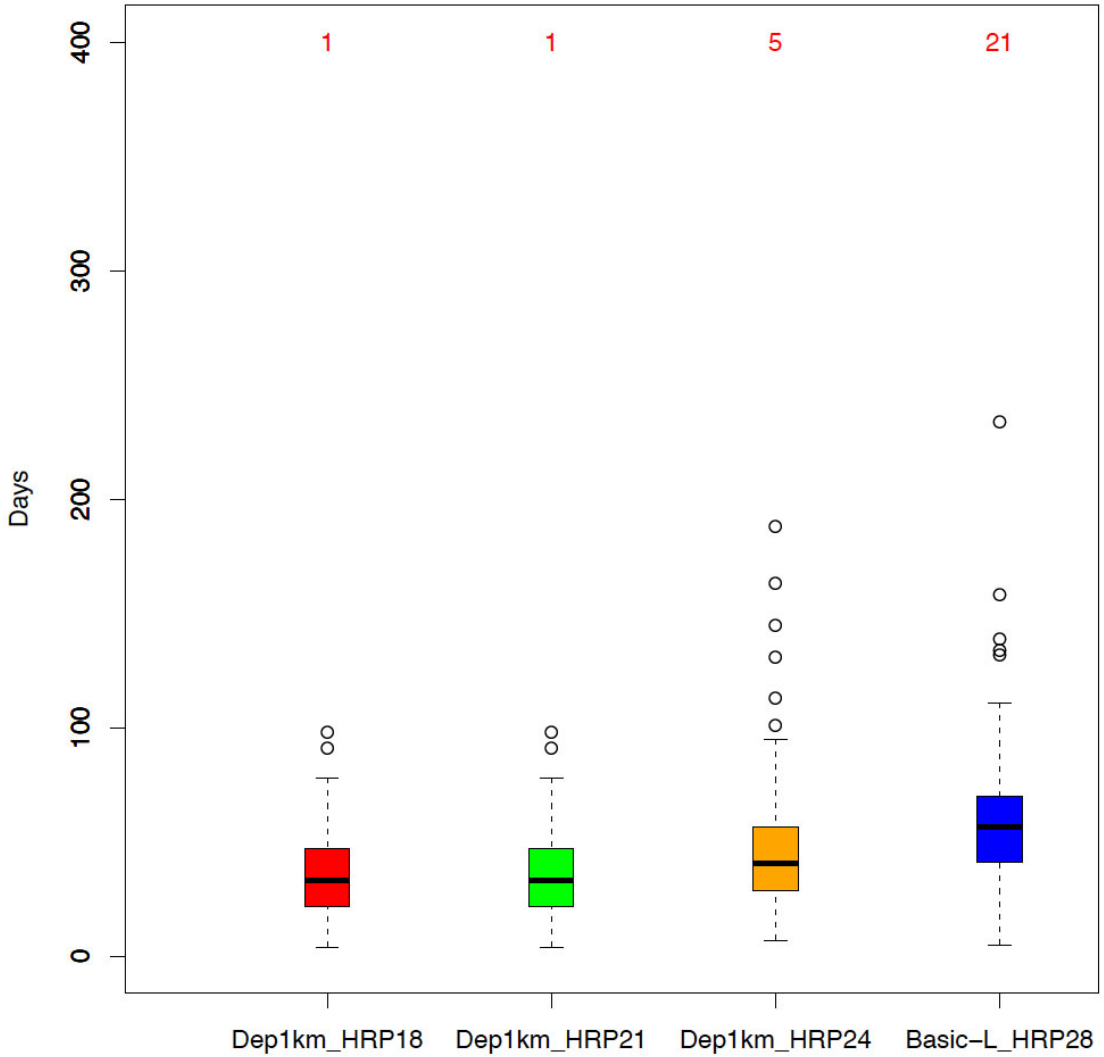
Preliminary results – infected herds



Sensitivity analysis – high risk period – basic scenario duration



Sensitivity analysis – high risk period – depopulation duration



Preliminary results

- Output similar, except for the number of extreme runs (stop criteria)

- High-risk-period sensitivity analysis shows influence of this parameter, but more detailed investigation necessary (daily modification)

Summary

- Model is suitable for simulating movements on administrative unit and village level as well as farm level depending on the availability of data

  ⇒ more widely applicable for countries and regions

- Provides a tool for management and decision makers

Further work needed to optimise this tool for policy makers and epidemiologists

- Sensitivity analysis of different parameters
- Implementation of additional control options
- Different combinations of control tools (e.g. vaccination and culling)

Further work needed to optimise this tool

- Conditions that favour vaccination-to-live
  - With and without large export of animals or products
- Investigate resource limits
  - staff, vaccines, culling capacities
- Economic effects of different control options
- Input-data-files for easier use

Thank you very much

State veterinary service
Veterinary association
Meat processing industry
Milk processing industry
Inseminator organisations
Rendering industry