WiBISS: A tool to estimate economic benefits of African swine fever wild boar vaccination for pig producers

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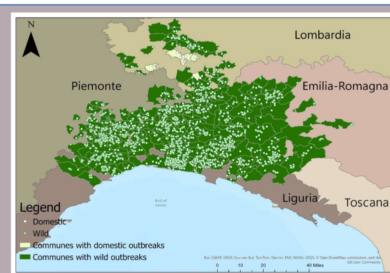
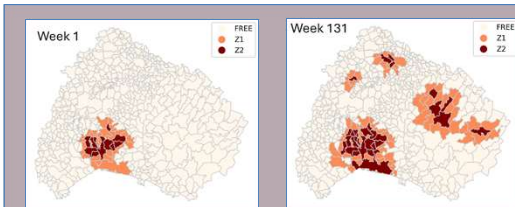
Introduction

- North-west Italy has been affected by ASF since 2021, mainly in wild boar (%) but ASF has also now reached the domestic pig population
- ASF control in wild boar has proved to be hard for several reasons (mobility, density, public resistance to culling, landscape)- vaccination is a promising option
- We developed **WiBISS** (Wild Boar Immunization Simulation System), a **cellular automata model** that estimates the economic impact for domestic pig farmers through the avoidance of spread by use of ASF vaccination in wild boar.



ASF outbreak distribution and municipalities affected by species (wild boar in darker colour and domestic pigs in lighter colour)



Example of model results for modules 1 and 2 at two different time steps

Methods

WiBISS model integrates outbreak data (WOAH), pig production data (IZSSUM), and vaccine characteristics (VACDIVA, CSF literature) into the following three modules.

1. ASF VACCINATION SIMULATION

Each **ASF notification** in wild boar = **cells** in the simulation.
Cells transition between these states:

UNVACCINATED → INFECTED
UNVACCINATED → VACCINATED
VACCINATED → UNVACCINATED → INFECTED

Transition rules based on probability

Vaccination probability ($P_{V,i}$) — **Vaccination radius**

$$P_{V,i} = \epsilon_i R_F \text{ with } \epsilon_i = \begin{cases} \epsilon_0 & If\ \ i < T_e \\ \epsilon_{i-1} - \left(\dfrac{\epsilon_{i-1} - \epsilon_r}{T_r + T_e}\right) & If\ \ i \geq T_e \end{cases}$$

ϵ_t = reduced vaccine efficacy
ϵ_0 = initial vaccine efficacy
T_r = time to achieve ϵ_t
T_e = time between v and start of ϵ_t

2. RESTRICTION ZONES SIMULATION

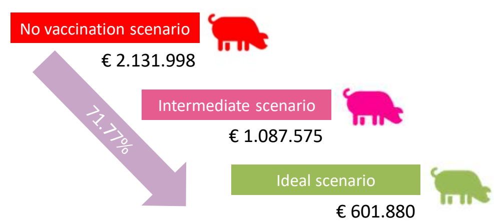
Restriction zones (**FREE**, **RZ1** and **RZ2**) were modelled at the **municipality level.** Municipalities transition from: **FREE** → **RZ1** and **RZ1** → **RZ2** based on number of ASF wild boar cases and neighboring space-time risk calculated in the previous step.

3. LOSS ESTIMATE

$$NP = \frac{C}{M} \cdot Z_2 \cdot W \cdot P_F \cdot R$$

M= duration of the study in months
W= average pig weight
Z_2= months in RZ2
C= capacity (number of pigs of each type of farm)
P_F and R = price adjustments by type of product and RZ

Results



- **Without vaccination**, all 2,130 agents were infected and economic losses reached €2.13M.
- In an **ideal scenario** (early intervention, 75% vaccination success, 50 km radius) losses were reduced to €601,880 **(reduction of 71.8%)** and limited spread.
- In an **intermediate strategy scenario** (8-week delay, 55% vaccination success, 30 km radius) showed **92.8% of agents uninfected**, 84.3% fewer restricted municipalities, and losses reduced to €1.09M (–49%).
- Higher vaccination rates and larger radii improved outcomes, with optimal reductions at 75% and 40–50 km.

Discussion and Conclusion

- WiBISS demonstrates that **economic losses can be reduced by up to 1.96x** under optimal conditions when vaccination is applied compared to non-vaccination scenarios
- The model focuses on **economic impact** not disease transmission modelling, simplifying analysis and enhancing practical utility
- Despite the absence of an approved ASF vaccine, WiBISS uses assumptions from CSF vaccination experience in wild boar for inputs such as vaccination coverage and bait uptake, introducing uncertainty, and assumes uniform vaccine efficacy and distribution. Several stochastic scenarios account for this limitation. Model realism is enhanced through adaptability to existing data and streamlined, replicable structure
- Early response is critical; delays lead to unavoidable baseline losses.
- Large-scale vaccination zones reduce losses but may be logistically unfeasible in many field scenarios
- Future improvements envisaged for this tool include an online platform to input user-specific campaign parameters
- WiBISS supports **informed decision-making,** emphasizing **cost-effective vaccination planning**

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