# Modeling the ASF (African Swine Fever) spread and risk assessment for Poland

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## Problem:

Recent rapid spread of the African Swine Fever (ASF) in the Northeast Poland during summer 2017 [Fig. 1] encourages us to prepare risk assessment for the whole country and predict future geographical transmission paths. African swine fever is viral infection which causes acute disease in domestic pigs and wild boar. Although the virus does not cause disease in humans, the impact it has on the economy, especially through trade and farming, is substantial. The occurrence of swine fever is associated with huge costs for pork producers whose share in GDP in Poland is estimated to be about one-third of national spending on science. As a consequence of ASF in Poland the value of pork and pig exports have been already reduced by hundreds millions of EURO.

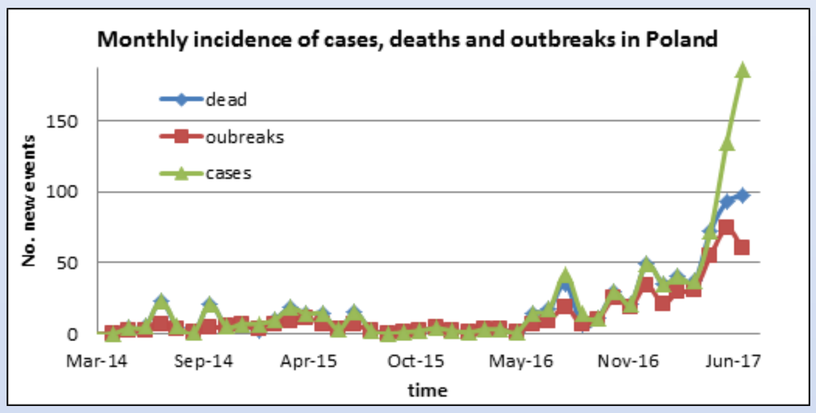


Fig. 1) ASF in Poland until August 2017

**Aims:** We focus on a predictive stochastic ASF model based on empirical geographical data incorporating organizational network of regions, empirical forest, swine, and wild boar density as well as theoretical organizational structure of the pork production supply chain. This model would be equipped with decision support systems as a tool for epidemiologists. In the preliminary setup, we perform early epidemic growth estimation and simulate landscape-based propagation.

**Methods and Data**: The early growth estimation can be easily done by matching incidence trajectory to the exponential function, resulting in the approximation of the force of infection (*inf*). With these calculations the basic reproduction rate of the epidemic ($R_0$), the effective outbreaks detection and elimination times ($D$) could be estimated. In the spatial model we use forest coverage, pig population in poviats and the distance between centroids of poviats. We use pseudo-gravitational models of short and long-range interactions referring to the socio-migratory behavior of wild boars and the pork production chain. We estimate the model parameters specific for Poland, using a prior Russian and Ukrainian data on ASF spread.

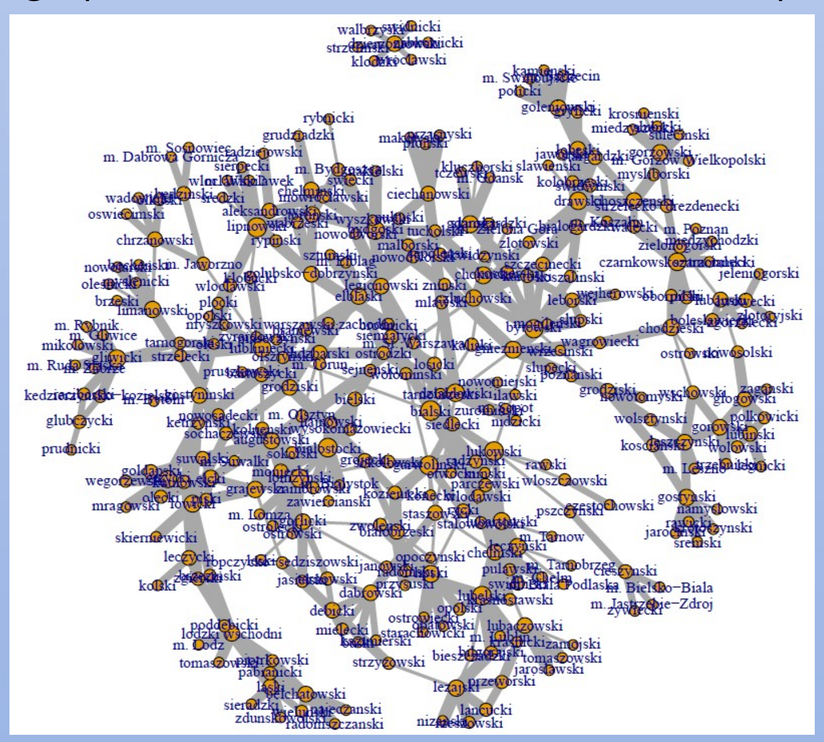

Fig. 2) Reorganized map of Poland according to ASF risk

## Preliminary Results - Early detection:

The early detection method in zeros approximation can be done by fitting the incidence curve to the exponential function, resulting estimation of the infectivity coefficient per month (*inf*~1.25). According to simplified relation in SID (Susceptible, Infectious, Detected) model $R_0=inf*D$, we observe that detection and elimination time ($D$ ~24 days) is critical to satisfy epidemic condition ($R_0$=1). It is enough to control epidemic with elimination time $D$ shorter than 3 weeks (where two weeks are the time from infection to the first clinical symptoms).

**Preliminary Results - Landscape-based propagation:** We run set of simulations for selected subspace of parameters *a*- swine amount significance, *b*- disease vectors (wild boards) significance, *c*- pork production chain significance.

$$p_{ij} \sim \frac{a(P_i * P_j)}{1+d_{ij}} + \frac{b(F_i * F_j)}{1+d_{ij}^2}, \quad g_{ij} \sim p_{ij} * c$$

Where: *a*, *b*, *c* – simulation parameters; *i*, *j* – poviats; *P* – normalized amount of pigs; *F* – coverage of forests; $p_{ij}$ -probability of infection from a neighbor; $g_{ij}$ -probability of infection from a whole networks; $d_{ij}$ -angular distance between centroids of poviats.

We use the simplest SI (Susceptible, Infectious) model on the level on poviats, where with probability $p_{ij}$ disease can be transmitted from already affected poviat *i* to an previously not affected poviat *j*, which is a neighbor to *j*. Long distance transmission can be done with probability $g_{ij}$.

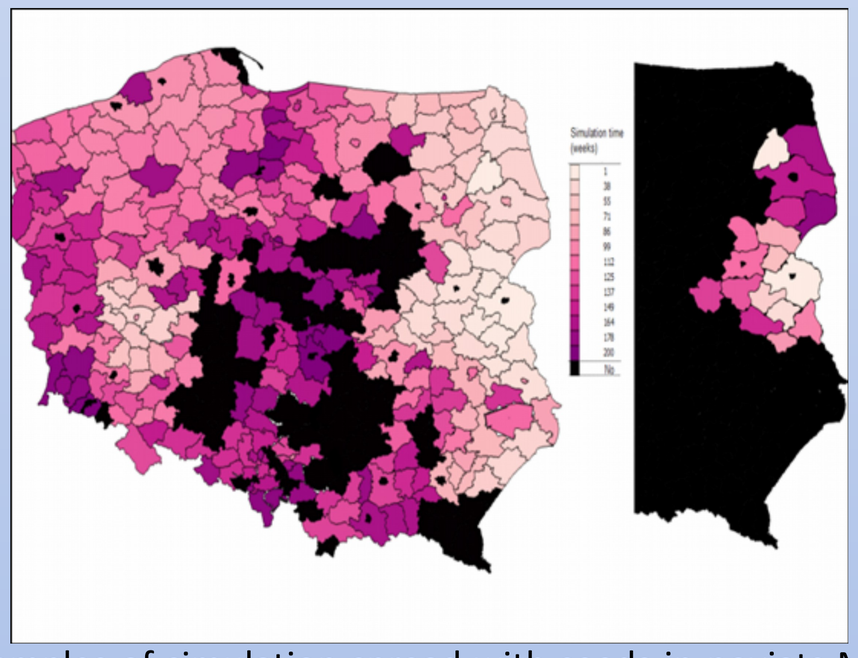


Fig. 3) Examples of simulation spread with seeds in poviats Mońki and Biała Podlaska for next 4 years with possible propagation barriers around invaded infected regions. [Left] Medium swine and vector significance (*a*,*b*), high pork production chain factor (*c*). [Right] Low swine and vector significance (*a*,*b*), no pork production chain factor (*c*).

**Preliminary Conclusions:** Early epidemic growth estimation indicates that to keep the epidemiological status quo will require a very fast response from veterinary services (less than one week after detection to eliminate a single outbreak). Spatial modeling in a certain range of parameters proves the existence of a natural protective barrier within boarders of the 'Congress Poland' [Fig. 3]. The spread of the disease to the 'Greater Poland' should result in the accelerated outbreak of ASF [Fig. 2]. In future analysis we will reconstruct the most likely future paths of infection and classify regions into risk groups.