African Swine Fever Propagation in Eastern Europe and Early Warning Model for Poland

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ASF propagation in Eastern Europe:

We analyzed 3230 observations (infection events registered to OiE) from February 2014 to November 2017 to their respective with time, longitude and latitude (with administrative unit) in Eastern Europe, where at least one house swine or wild boar case was reported. We take special attention to 721 observations in Poland.

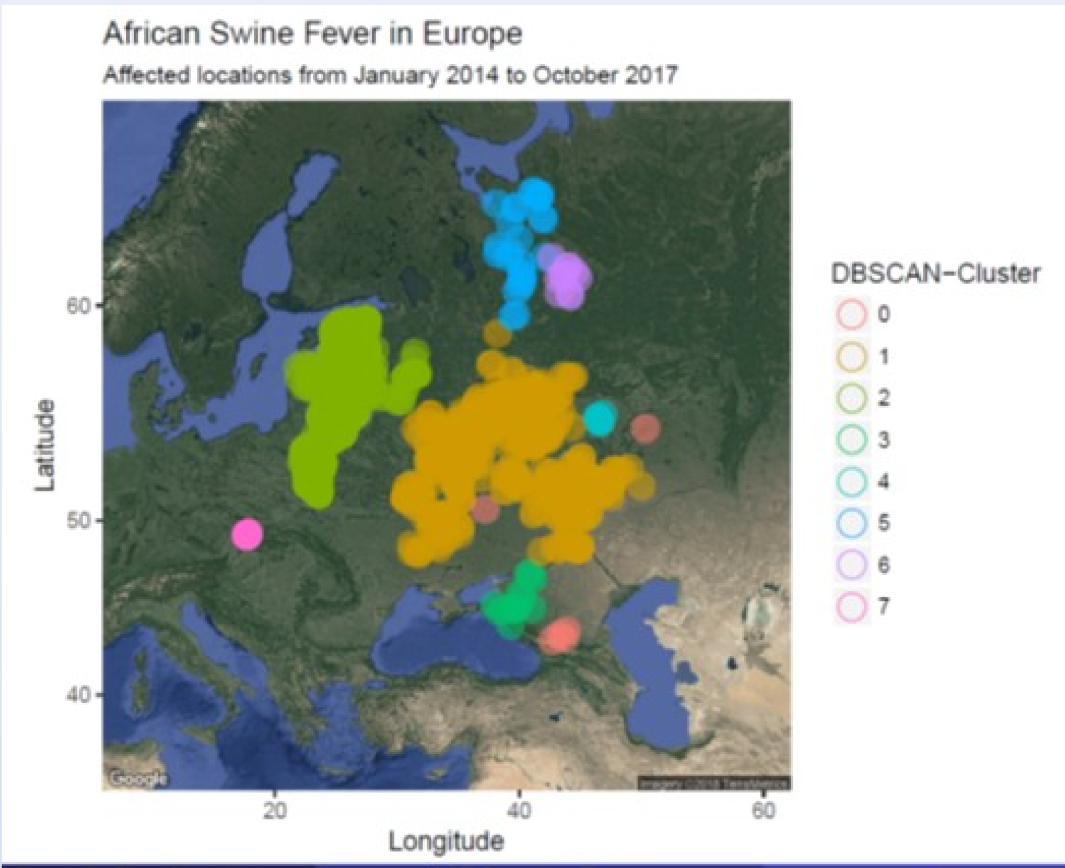


Fig. 1) DBSCAN clustering of infection notifications in geographical space. Northern (Baltic States and Poland) and Southern (Ukraine and Eastern Balkan States) branches are clearly observable.

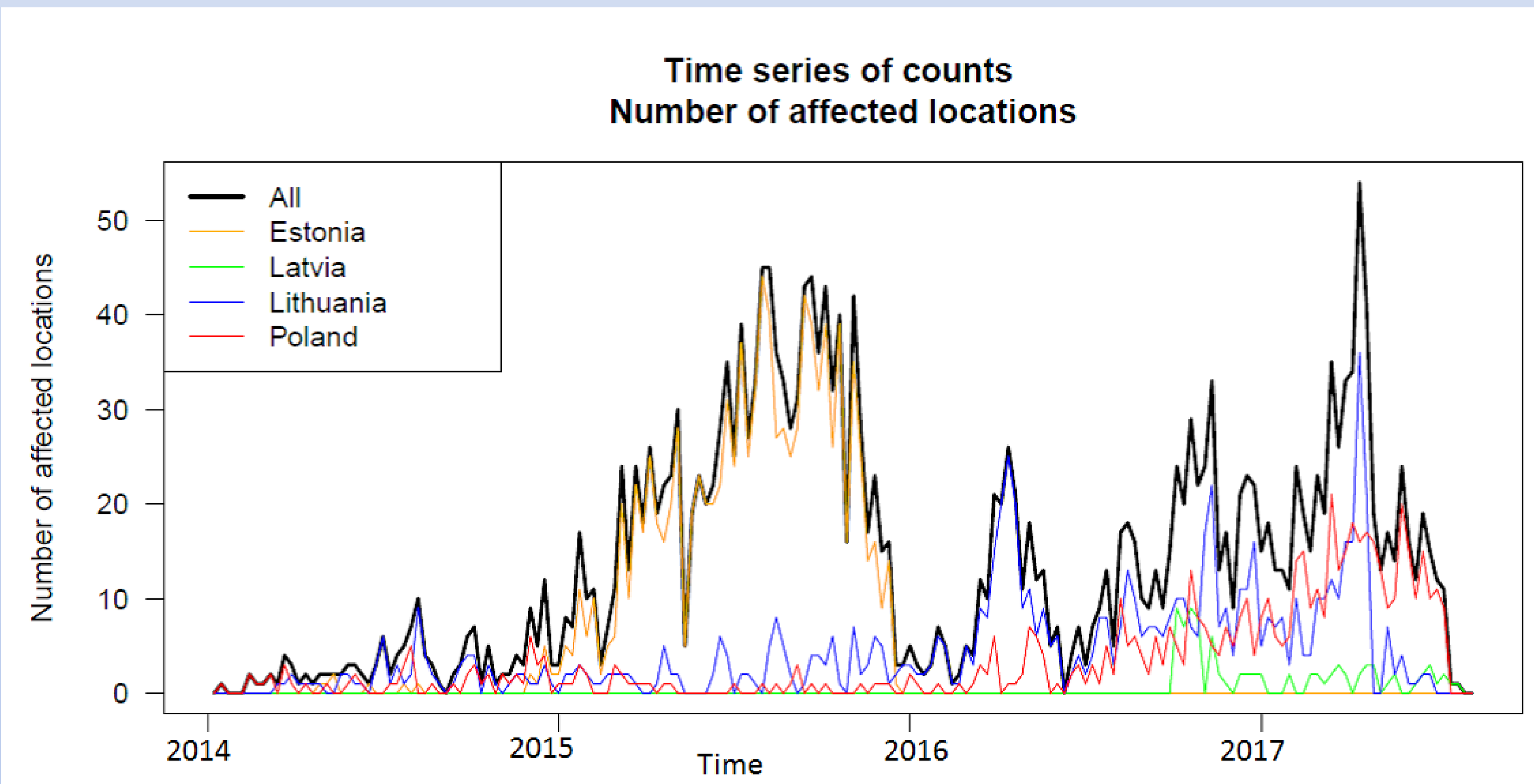
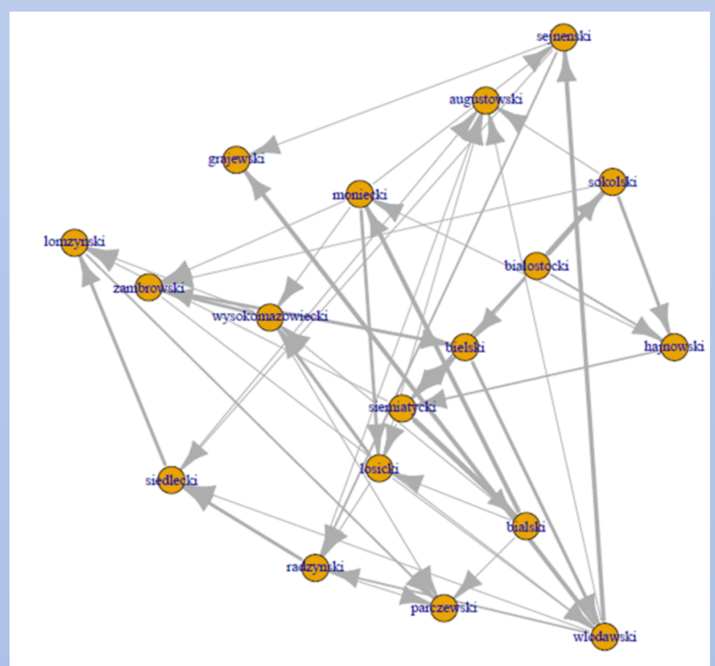


Fig. 2) Amount of places affected in weekly notification registry (pig/wild pig infection registry) per country. It reveals spatio-temporal "wave" (Belik et al. 2011) character of propagation.



Effect	Univariate Tests of Significance for arrival_time SS	F	p
dist to boarder	13405334	112.68	0.02
swine heads	41404	0.35	0.56
forest cov	386987	3.25	0.09
Error	1784447		

infection - Odds Ratios (powiat1)
Distribution : BINOMIAL, Link function: LOGIT
Modeled probability that kod = 1

Effect	Level of Effect	Column	Odds Ratio	Lower CL 95.0%	Upper CL 95.0%	p
Intercept		1				
boarder		2	0.104497	0.039902	0.273663	0.000004
swine		3	1.000016	1.000007	1.000025	0.000751
forest		4	1.030135	0.986176	1.076053	0.182094

Regression Summary for Dependent Variable: number of cases)
R= .73085690 R2= .53415180 Adjusted R2= .41768976
F(2,8)=4.5865 p<.04710 Std.Error of estimate: 31.978

N=11	b*	Std.Err. of b*	b	Std.Err. of b	t(8)	p-value
Intercept			-62.5642	40.79639	-1.53357	0.163678
swine	0.813589	0.268631	218.6065	72.17960	3.02865	0.016343
forest	0.353494	0.268631	1.4202	1.07927	1.31591	0.224660

Fig. 3) Outbreaks in Poland. Infections paths with only arrival time as predictor (left). Regression models (right). Dependent variables: explained variable is 0/1 (infected/not infected county); explained variable is integer (number of events understood as sum of outbreaks and cases in county); explained variable is time (arrival time of ASF for given county). Explaining variables: distance to the Belarus border; heads of pigs, coverage of forests, human population.

The most important conclusion form regressions is, that pig heads strongly explain both probability of introducing ASF as well as epidemic size (which is in contradiction to Estonian study (Depner, et al. 2017)). On the other hand, the forest coverage explains a little the arrival time of ASF (the same as in Estonian study (Depner, et al. 2017)).

Early warning model for Poland:

380 Polish counties (poviats) have been analyzed, where 23 (located in Northeast Poland) have been affected (until 10.12.2017) for spatial propagation (risk assessment for future). We run set of simulations of SIR model for selected subspace of fitted parameters based on historical chains. Motivated by the gravity law model (Belik&Brockmann, 2007) the probability of transmission of the infection to a new county is defined as:

$$p_{ij} \sim \alpha \left[(1-\beta) \frac{P_i P_j}{1+r_{ij}} + \beta \frac{F_i F_j}{1+r_{ij}^2} + \gamma \frac{H_i H_j}{1+r_{ij}} \right], \; g_{ij} \sim p_{ij} \alpha^*$$

Here α – total infectivity; β– disease vectors (wild boards) significance, $1-\beta$–swine amount significance , γ - human failure to restrictions , α^* – far distance infectivity; i, j – poviats; P_i – normalized amount of pigs; F_i – forest coverage; H_i – normalized human population; p_{ij} – probability of infection from a neighbor; g_{ij} _probability of infection from the whole network; r_{ij} – angular distance between poviat centroids.
Recovery is introduced as a very small probability, while for a given Polish historical outbreak it does not increase the fit.

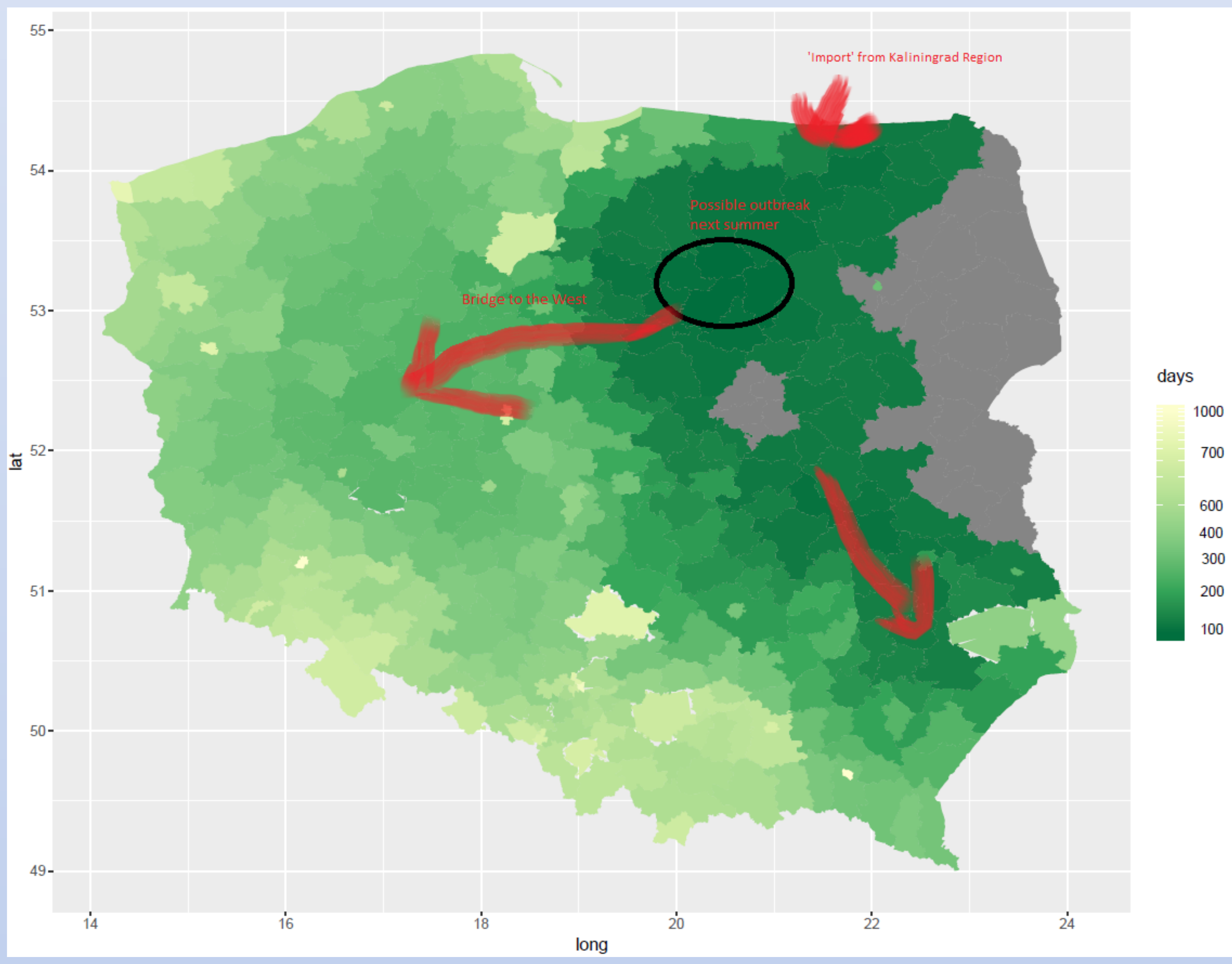


Fig. 4) Most likely introduction time (in days) according to the model with possible corridors.

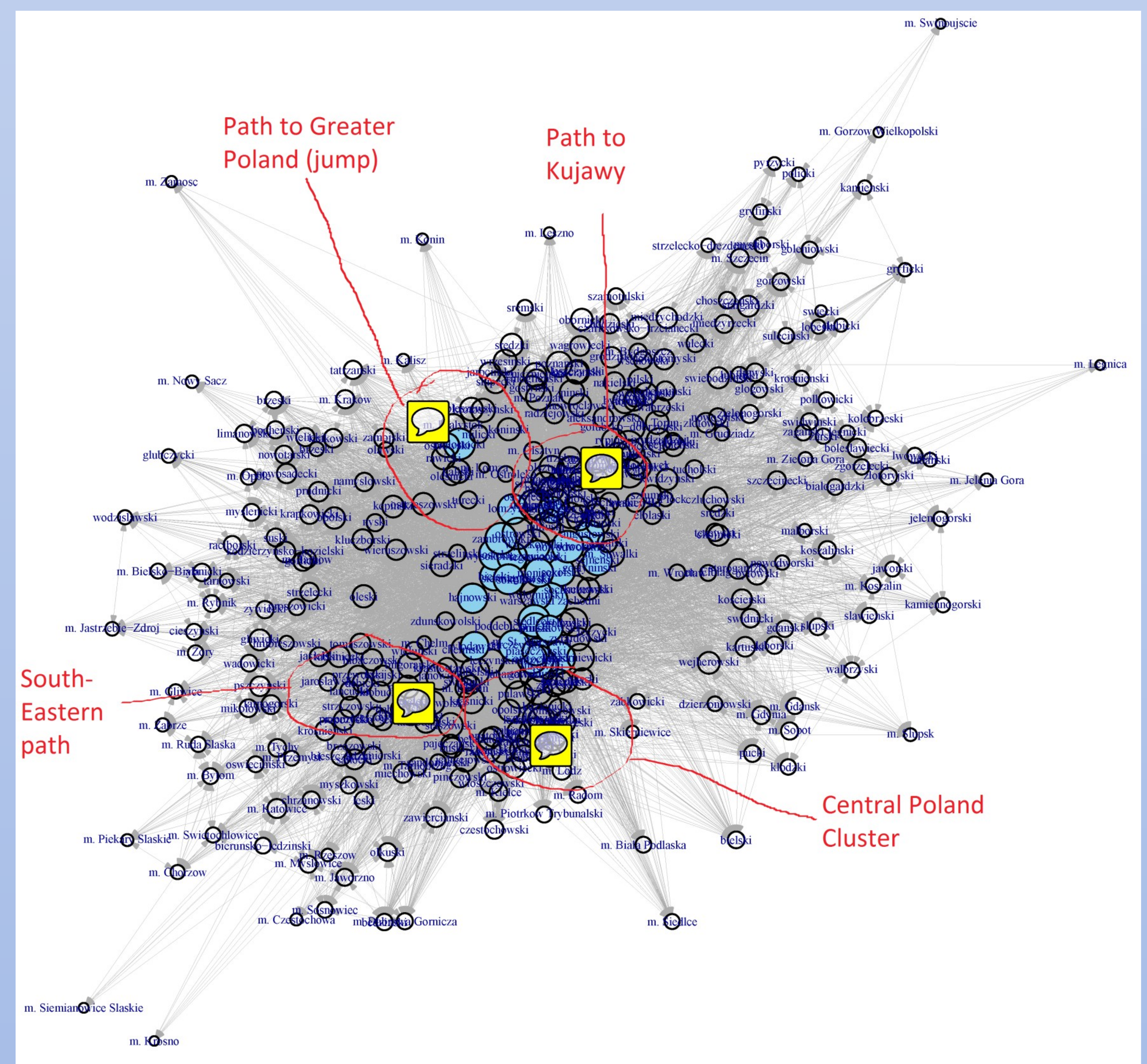


Fig. 5) Most likely transmission paths according to the model. High betweenness centrality of Greater Poland counties and high clusterization of Kujawy/Masovia region could indicate the most important prevention directions.

References

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