Lesson plan – GM Maize – Worksheet

Introduction:

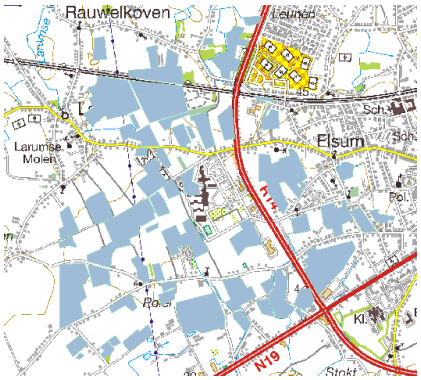
The Centre for Agricultural and Food Economics, of the Faculty of Applied Bioscience and Engineering, at the Catholic University of Leuven, in Belgium, has conducted some research, a few years ago, to the economic consequences of the introduction of genetically modified crops into European agriculture. This research was conducted within the framework of the SIGMEA project, which was funded by the European Commission.

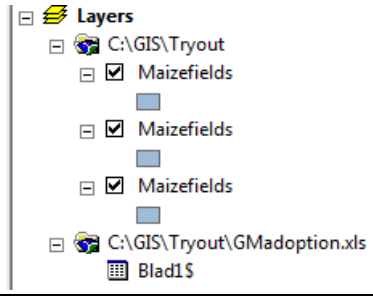
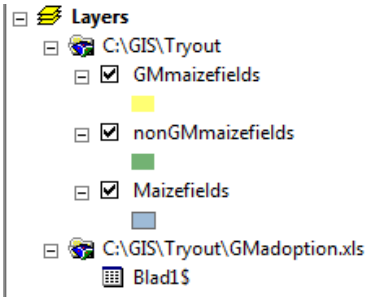
European farmers are worried about the potential cross-pollination between genetically modified (GM) crops and traditional crops, if genetically modified crops would be introduced in agriculture. If non-GM maize plants get pollinated by GM plants, farmers who grow certified non-GM maize might no longer be able to sell their harvest without traces of GM, potentially losing a non-GM market price premium. Within the project, among other calculations, as a case-study, the cost implications of introducing genetically modified oilseed rape in a region Beauce, in France, were simulated. The simulations were made with the use of a GIS dataset, containing data of oilseed rape fields in that region.

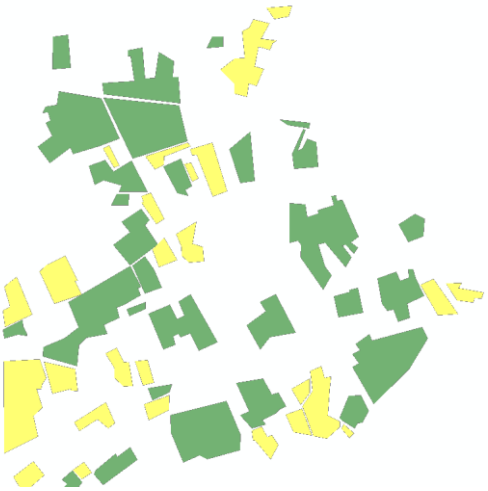
In practice, it was investigated how many non-GM oilseed rape fields could be pollinated by GM pollen, given the assumption that pollen could travel up to 50 meters. This analysis was conducted for three scenarios; one with 25% adoption (25% of the oilseed rape in the region is GM), one with 50% adoption and another with 75% adoption.

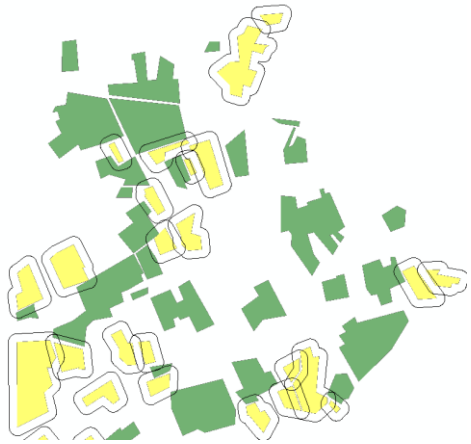
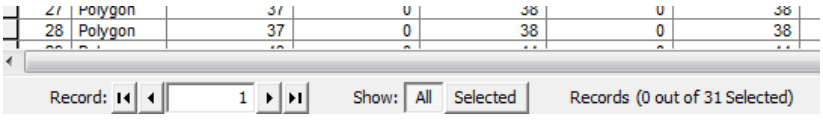
Description of the exercise:

In this exercise we will conduct similar simulations. We will simulate the hypothetical scenario of 50% adoption of GM maize, and we will assume that pollen can fly up to 50 meters and fertilize plants. As a case study, we will use a GIS dataset containing a sample of 56 maize fields in Geel, Belgium. First we will use GIS to calculate the area of non GM Maize that could be pollinated by GM crops. Then we can combine this simulated data with real world data about maize yields and prices, to calculate the costs associated with potential commingling in the case-study area.

number	***Instruction***	***iNotes***	*Teachers' / Trainers' activity*	*Pupils' / participants' activity*
1	Open ArcMap from the windows start menu			X
2	Add the data layer *"Maizefields.shp"* in ArcMap: If you like, you can add the map *"16Map.tif"* to show the fields on top of a map (see screenshot).  ***Important**: You probably have no rights to edit files that are stored on the server, therefore you should export the layer to your own folder (right-click on the layer > Data > Export Data, browse to the right folder and save it as "Maizefields.shp"*	1	□	X

	We will simulate 50% adoption, creating an Excel file with two columns. The first column (data field) should be called "*Fieldnr*". Based on this field, we will later join this table to the data layer *"Maizefields.shp"*. In the second column, that has to be called *"GM"*, we will distribute randomly the values 0 or 1. 1 means that on the field GM maize is sown, 0 means a field with conventional (non-GM) maize.			
3	Add the field *"Surface"* to the attribute table of the data layer *"Maizefields.shp"*. Choose float as data type.	7	☐	X
4	Creating the Excel file: - Open a new Excel worksheet - Give in the names of the data fields (*"Fieldnr"* and *"GM"*) in the first row - In the field *"Fieldnr"* you number the fields from 1 to 56 (these numbers refer to the maize fields in the data layer *"Maizefields.shp")* - In the second field, *"GM"*, you randomly distribute the values 0 and 1. You can use the Excel-function RANDBETWEEN(0;1) for doing this automatically. - Save the Excel file and name it *"GMadoption"*.	2	☐	X
5	Add the Excel table *"GMadoption"* in ArcMap.	1	☐	X
6	Join the table *"GMadoption"* to the data layer *"Maizefields.shp"*. Base the join on the common field *"Fieldnr"*.	3	☐	X
	Now it is time to let ArcMap make a distinction between the GM maize fields and the non-GM maize fields:			
7	Copy the data layer *"Maizefields.shp"* and paste it into the layers twice, until you have the layer three times. 	4	☐	X
8	Rename the two top layers in *"GMmaizefields"* and *"non-GMmaizefields"*. Change the color of the layers by clicking on the colour boxes. 	5	☐	X
9	Query the data layers so that the layer *"GMmaizefields"* only shows GM maize fields (GM=1), and the data layer	6	☐	X

	"nonGMmaizefields" only shows non-GM maize fields. ArcMap will now show the GM maize fields in yellow and the non-GM maize fields in green.			
	 Now you can check visually if the random distribution of 0 and 1 in the data field *"GM"* actually results in about 50% GM maize fields. See the illustration below. Normally it should be ok. Another way of checking the distribution is in the attribute table. With a total of 56 maize fields, the number of GM maize fields should be about 28. You can check this by opening the attribute table of the layer *"GMmaizefields"* and looking at the total number of records. But, even if the distribution of GM and non-GM fields is about 50/50, the simulated area could be biased when, by coincidence, a lot of bigger fields got the value 0 or 1. In the first case, the area of non-GM can be significantly higher than 50%, in the second case the area of GM fields can be too high for a 50% simulation. In the illustration, it seems that a lot of bigger fields got the value 0, thus being non-GM, resulting in a higher area of non-GM maize. For this reason, this particular simulation might be rejected for later analysis, o, a larger number of simulations should be generated and analysed, or the area-bias of the particular simulation should be investigated. In order to have an idea of the degree of area-bias in our simulation, we will compare the areas of GM and non-GM fields. In ArcMap, we can automatically calculate the areas of the fields in the attribute table and look up some statistics, including a frequency distribution. This is what we will do in the next steps:			
10	Let ArcMap calculate the area of the maize fields automatically and check the statistics Repeat step 9 and 10 for the data layer *"nonGMmaizefields"* and compare the total surface of the GM maize fields and the non-GM maize fields. The distribution should be about 50/50.	8	□	X
11	If they are not already expressed in meters, change the map and display units of the data frame to meters.	15	□	X
	Now we are going to investigate which GM maize fields are located within a distance of 50 meters from a non-GM field. The fields that are within 50 meters, cause problems of co-existence, given the assumption we made that pollen can travel up to 50 meters and fertilize non-GM maize plants. We start with creating a buffer zone of 50 meters around the GM fields.			

12	Create a buffer zone of 50 meters around the GM maize fields HINT: for visual purposes make the color of the buffer zones transparent. Therefore, change the color of the layer with the buffer zones to *"hollow"*. Your result might look like this: 	9	□	X
	Now we can let ArcMap automatically calculate the intersection between the layer with the buffer zones and the non-GM maize fields. This way we can visually identify the "problems" for co-existence in the case-study area and even calculate (like we did with the area of the fields) the surface of non-GM fields, that can be fertilized by GM pollen.			
13	Calculate the intersection between buffer zones and non-GM fields	10	□	X
	ArcMap now creates a new layer, showing the intersections. Your final result might look like this: 			
14	Export your map showing the intersections as GMmaize*yourname*.pdf and save it in your portfolio on Moodle.	42	□	X
	The number of "problems" for co-existence can found easily, by checking the number of records in the attribute table of the layer with the intersections. This illustrating simulated example counts 31 "problems". You can find the sum of the areas of all the problem zones by checking the statistics (see step 10) of the data layer with the intersections. 			

	Now you have completed a spatial analysis of the simulated consequences of introducing GM maize in the case study area! You can now use the total area of field zones at risk of cross pollination you just simulated, to calculate the cost of the price premium that non-GM farmers might forego when their crops get pollinated by pollen from neighbouring fields with GM maize.

Cost calculations:

Do not read any further, first try to answer the question.
What additional real-world data do you need to perform the cost calculation?

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As an answer to the question above, you could have thought of the grain maize yield, a price premium for non-GM, the market price for grain maize.

So, to complete the calculations you need to do the following:

Look up the average yield of grain maize in Belgium.
Find an indication of a price premium for certified non-GM commodities.
Find an indication of a market price for grain maize.

It might be necessary to recalculate the data you find to the right base and the right currency.
Combine this information in an equation and you will have built a model to calculate simulated potential costs of co-existence in the case study area.

Congratulations for your persistence!

References:

Daems, W., M. Demont, K. Dillen, E. Mathijs, C. Sausse, and E. Tollens. "*Economics of spatial coexistence of genetically modified and conventional crops: Oilseed rape in Central France.*" Working Paper, n° 96, Katholieke Universiteit Leuven, Leuven, 2007.

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