Risk Terrain Modelling

Petr Kubíček

kubicek@geogr.muni.cz

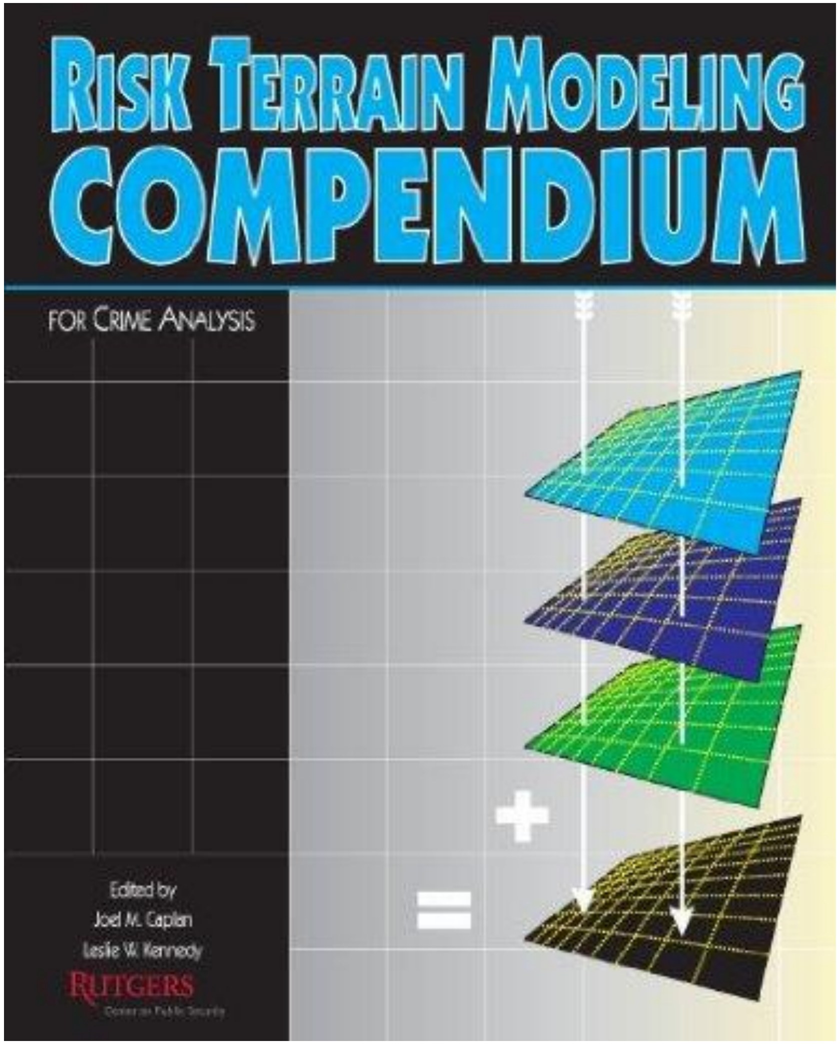
Laboratory on Geoinformatics and Cartography (LGC)
Institute of Geography
Masaryk University
Czech Republic

Predictive Crime Analysis

- „Predictive policing in the context of place is the use of **historical data** to create a **spatiotemporal forecast** of crime **hot spots**
- that will be the **basis for police resource allocation** decisions with the expectation that having officers at the proposed place and time **will deter or detect criminal activity**."

Risk Terrain Modeling Prediction

- Risk terrain modeling (RTM) is an **approach to risk assessmen**t in which separate **map layers** representing the influence and intensity of a **crime risk factor** at every place throughout a geography is created in a geographic information system (GIS).
- Map layers are combined to produce a **composite "risk terrain" map** with values that account for all risk factors at every place throughout the geography.
- Available in PDf – ask your lecturer ☺



RTM steps

1. Select an outcome **event** of particular interest
2. Choose a study **area**
3. Choose a time **period**
4. Obtain **base maps** of your study area
5. Identify **aggravating** and **mitigating** factors related to the outcome event
6. **Select** particular **factors** to include in the RTM
7. **Operationalize** the spatial influence of factors to risk map layers
8. **Weight** risk map layers relative to one another
9. **Combine** risk map layers to form a composite map
10. **Finalize** the risk terrain map to **communicate** meaningful and actionable information.

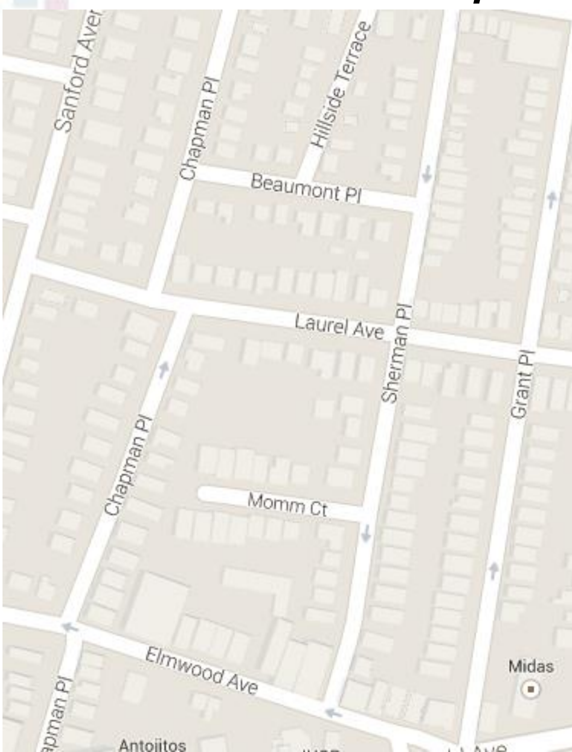
Step 1 -2

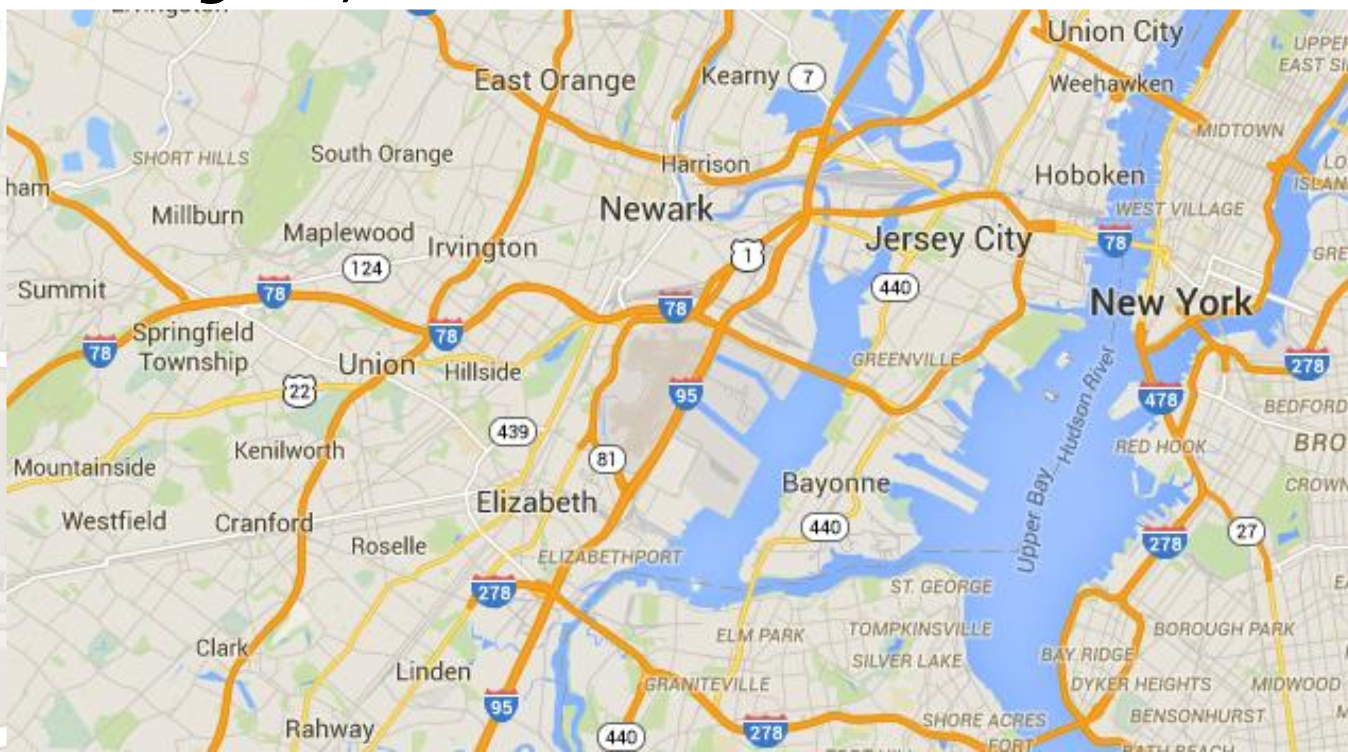
1. Select an outcome **event** of particular interest

Gun shooting incidents.

2. Choose a study **area *on which risk terrain maps will be created.***

The Township of Irvington, NJ.





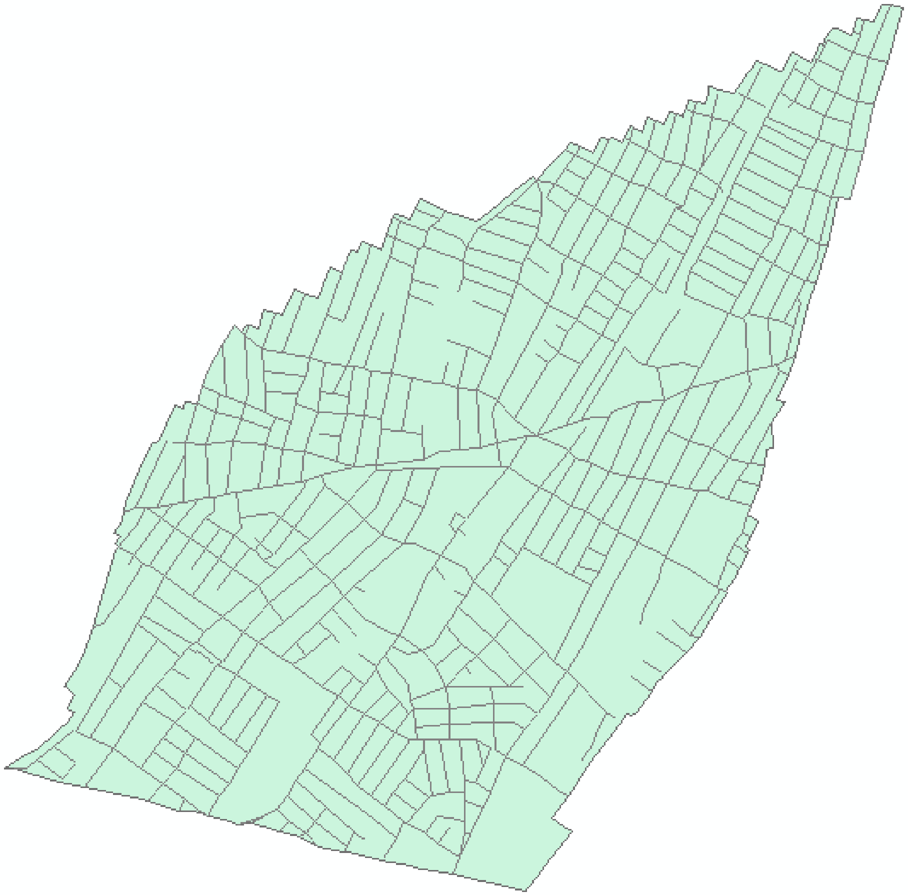
Step 3

STEP 3: Choose a time period to create risk terrain maps for.

- Six month time period: January 1 to June 30.
- It is expected that this time period will adequately assess the place-based risk of shootings during the next 6-month time period (July 1 to December 31).
- **Data availability and comparability ?? Is it really justifiable and valid for the Czech Republic?**

Step 4

- ***STEP 4: Obtain base maps of your study area.***
- Two base maps were obtained from Census 2000 TIGER/Line Shapefiles:
  - 1) Polygon shapefile of the Township and
  - 2) **Street centerline** shapefile for the Township.



Step 5

STEP 5: Identify aggravating and mitigating risk factors that are related to the outcome event.

- Three **aggravating factors** were identified based on a ***review of empirical literature***:
  - dwellings of known gang members (**habitual offenders**),
  - locations of **retail business infrastructure (**bars, strip clubs, bus stops, check cashing outlets, pawn shops, fast food restaurants, and liquor stores),
  - locations of **drug arrests** (places, where the police action happened).

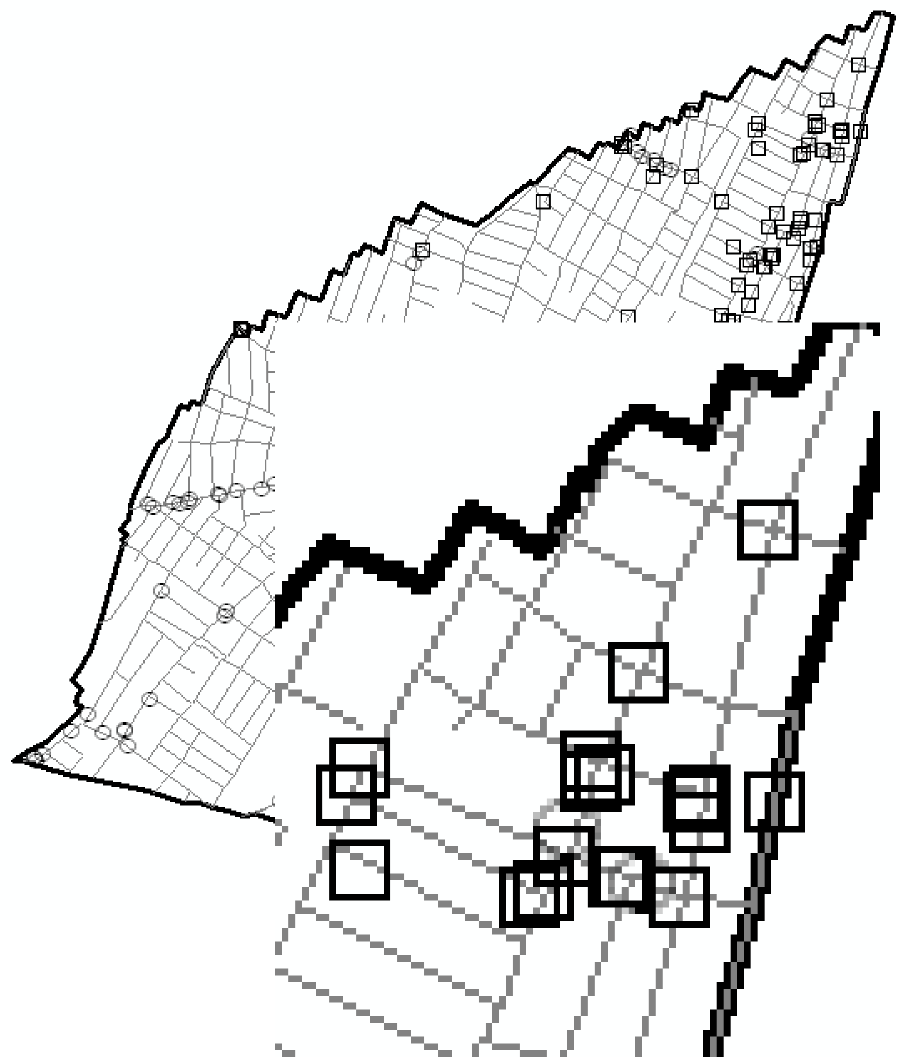
Step 6

- ***STEP 6: Select particular risk factors to include in the risk terrain model.***
- All three risk factors identified in Step 5 will be included.
- Raw data in tabular form (i.e. Excel spreadsheets) was provided by the Township police and the many **datasets they maintain, validate and update regularly to support internal crime analysis and police investigations**.
- Attributes + **addresses** + time stamps + ??
- **State of the art of the investigation including the punishment and legal procedure.**

Step 7

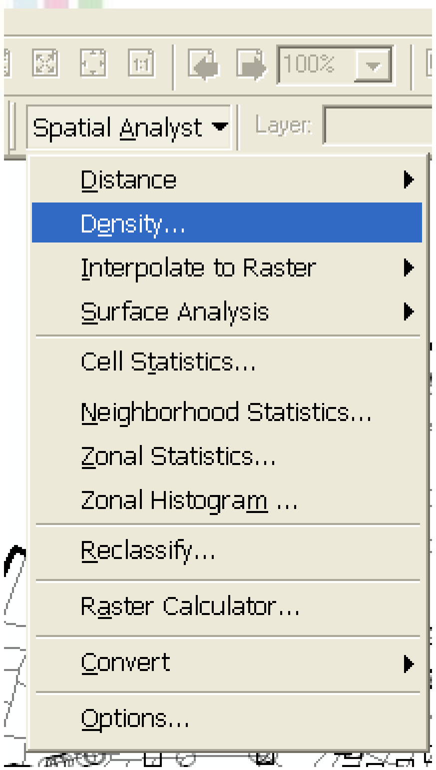
- ***STEP 7: Operationalize risk factors to risk map layers.***
- The tabular data was geocoded to street centerlines of Irvington to create point features representing:
  - the locations of gang members' **residences** (hiden on the map to protect the gang members),
  - retail **business outlets**,
  - and **drug arrests**,

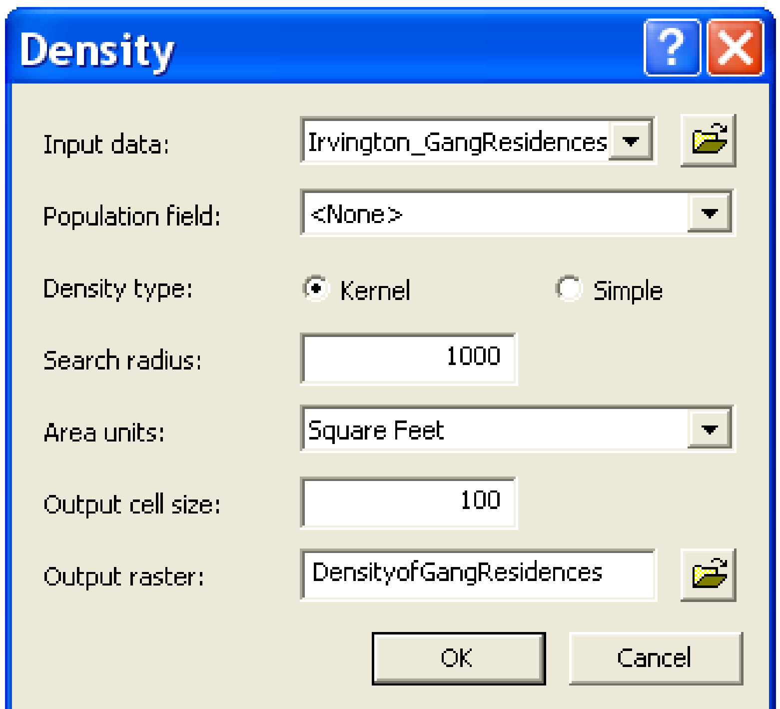
  respectively as three separate map layers.

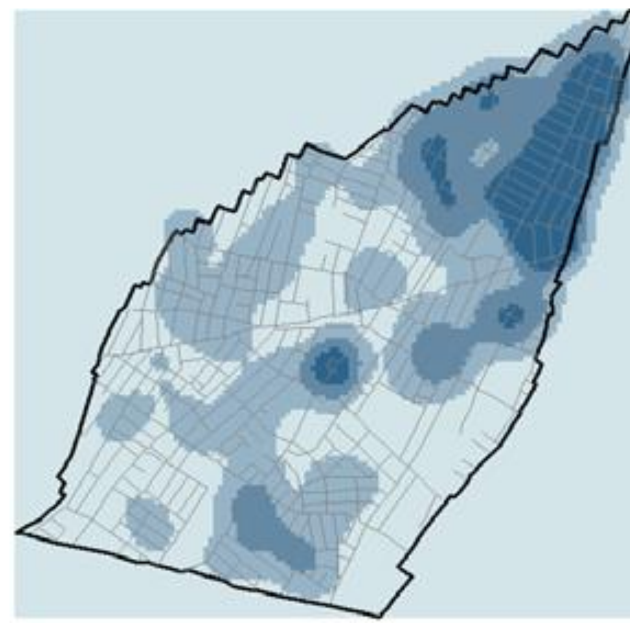


Step 7a – gang member residence

The spatial influence of the "gang members' residences" risk factor was operationalized as: "Areas with **greater concentrations of gang members residing will increase the risk of those places having shootings**." So, a **density map** was created from the points of gang members' residences.

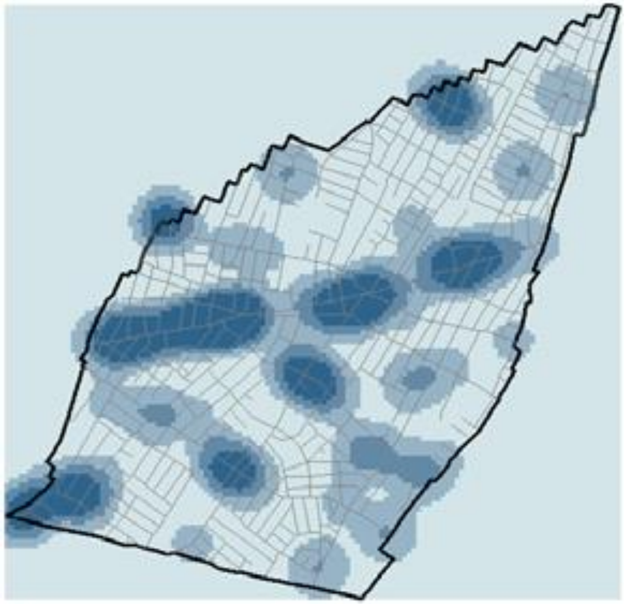






Step 7b - infrastructure

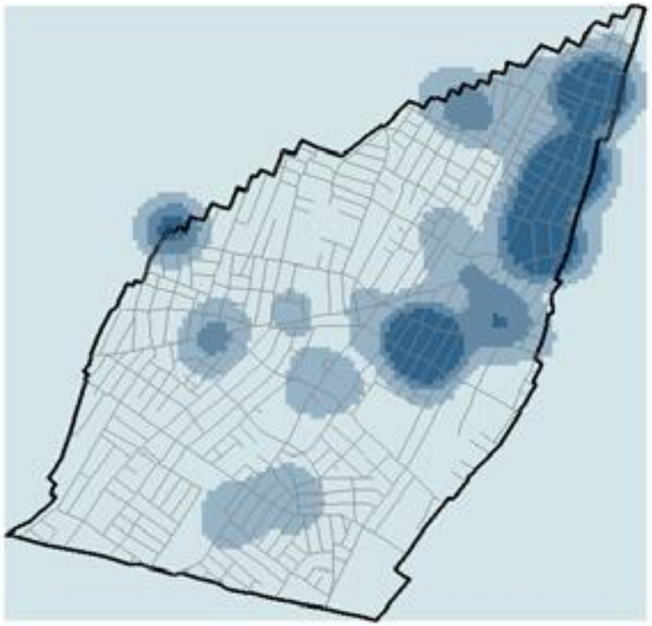
- The spatial influence of the “infrastructure” risk factor was operationalized as:
- “**High concentrations** of bars, strip clubs, bus stops, check cashing outlets, pawn shops, fast food restaurants, and liquor stores **will increase the risk** of those dense places having shootings.”



Step 7C – the drug arrest

the "drug arrest" risk factor was operationalized as:

- "Areas with **high concentrations** of drug arrests **will be at a greater risk for shootings** because these arrests create new 'open turf' that other drug dealers fight over to control."



Step 7 – map density method details

- **Kernel density** values were calculated for each of the risk map layers so that *points lying near the center of a cell's search area would be weighted more heavily than those lying near the edge*, in effect smoothing the distribution of values.
- Cells within each density map layer were **classified into four groups according to standard deviational breaks**. The dark blue colored cells had values in the **top five percent** of the distribution and were considered the "**highest risk**" places.

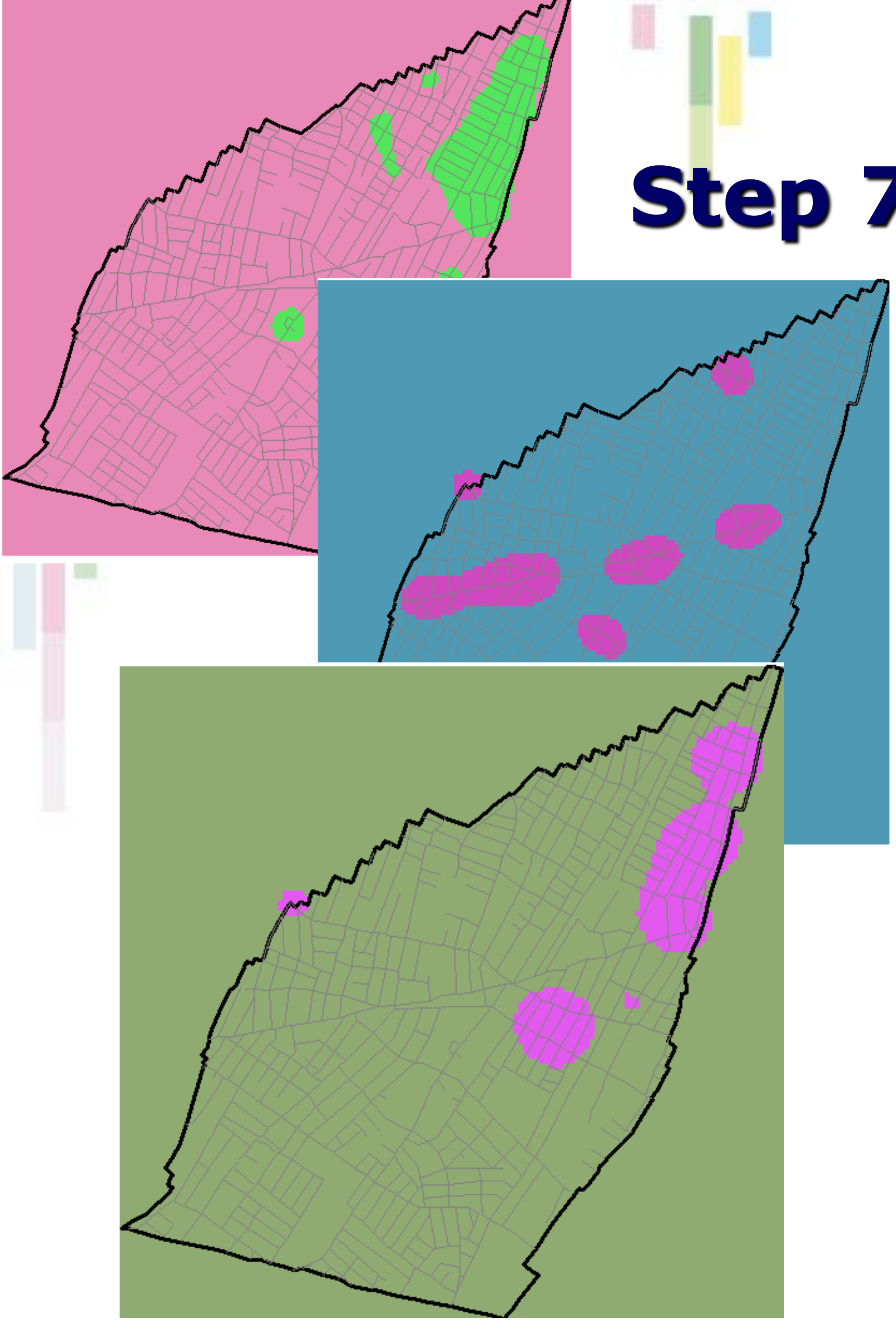
Step 7d – distance from infrastructure

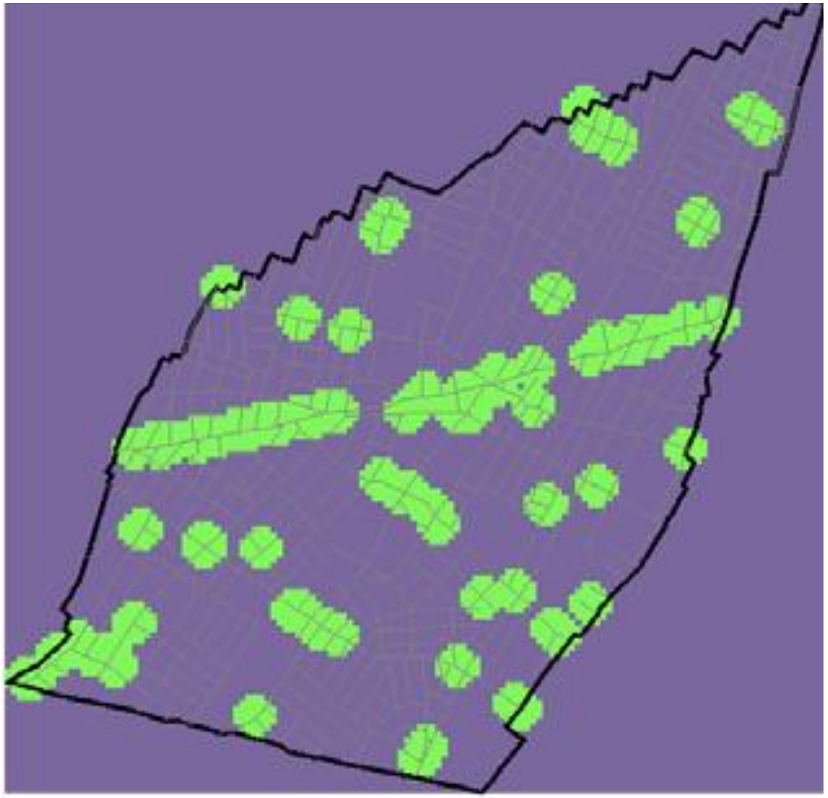
- The spatial influence of the "infrastructure" risk factor was also operationalized as:
- "The **distance of one block**, or about 350ft (app. 100 m), from a facility poses the greatest risk of shootings because **victims** are often **targeted** when **arriving** at or **leaving** the establishment."

7e – final operationalization

- **We** are only interested in knowing where places are the most at risk for shootings, so we used a **binary-valued schema** to designate the "**highest risk**" places across all four risk map layers.
- The highest risk places of each risk map layer, respectively, will be given a value of "1"; all other places will be given a value of "0".
- All risk factors are operationalized as **aggravating factors**, so these values will **remain positive**.

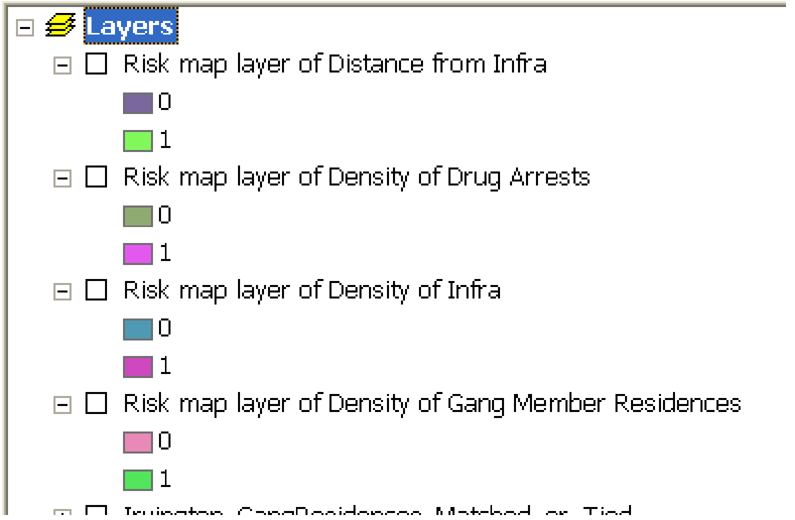
Step 7 - reclassification





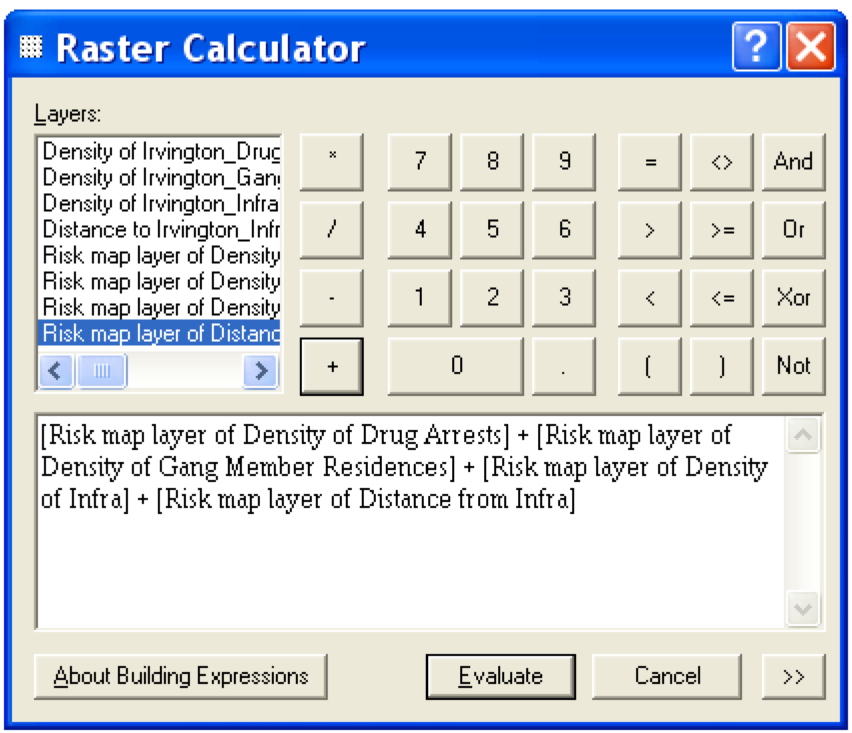
Step 7 – final comparison

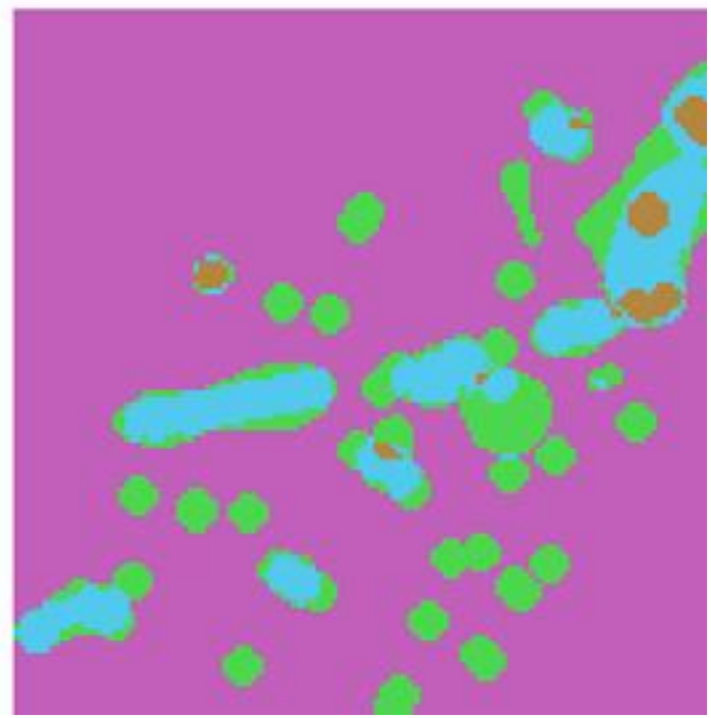
- We now have **four (final) risk map layers, operationalized from three risk factors.**
- **Binary** reclassification – 0 – 1
- The cells of different map layers are the same size and were classified in a standad way, the risk **map layers can be summed together** to form a **composite risk terrain map**.



Step 8 + 9 - *Inter Risk Map Layer Weighting and CRTM*

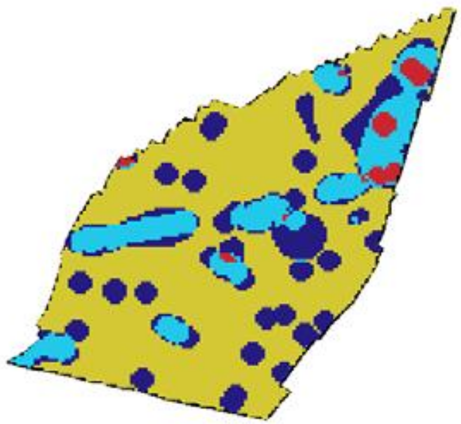
All risk **map layers** will carry equal weights to produce an **un-weighted risk terrain model**. It is assumed, for example, that being in a place with a high concentration of drug arrests **poses the same risk** of having a shooting as being in a place with a high concentration of gang member residences. Unless we know better ☺ !!



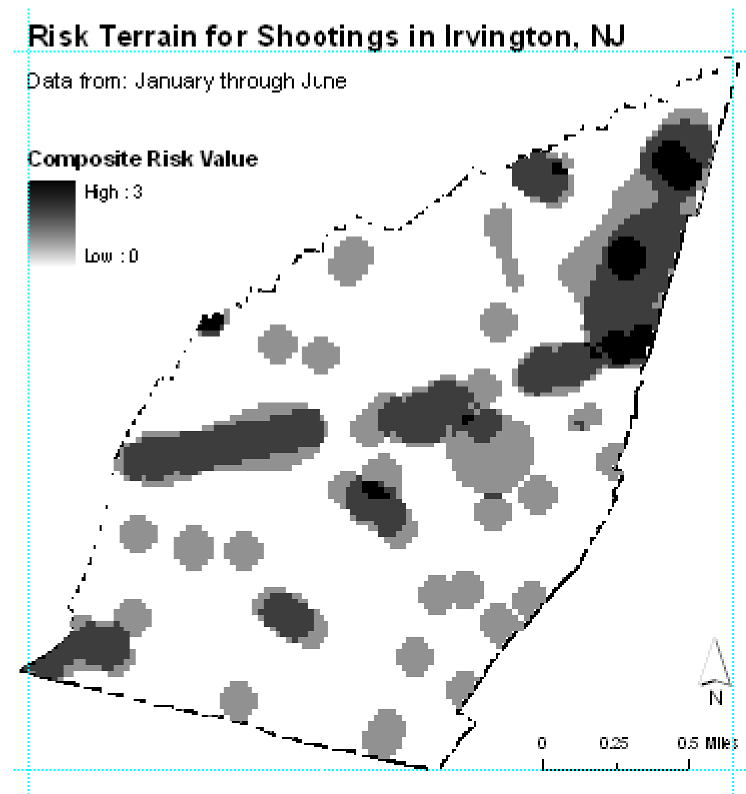


STEP 10 - Finalize the Risk Terrain Map to Communicate Meaningful Information.

- Clip our risk terrain map to the boundary of Irvington.



- produce a final map with shades of grey and layout.

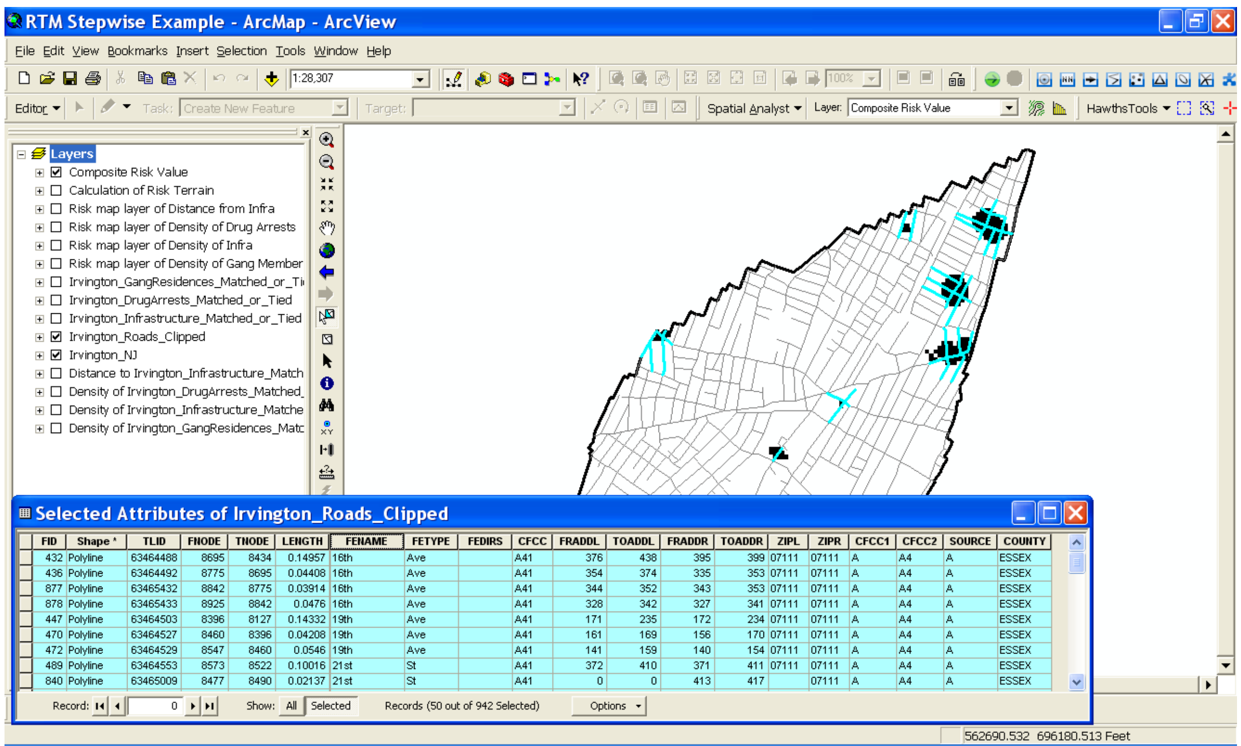


Step 10 – make the risk count

- convert the risk terrain map from raster to vector we can (still using the regular structure converted to square polygons):
- **count the number of shootings that actually occur in the high-risk areas during the subsequent time period**;
- calculate the **square area** of the highest risk areas (i.e., places with a composite risk value of 3);

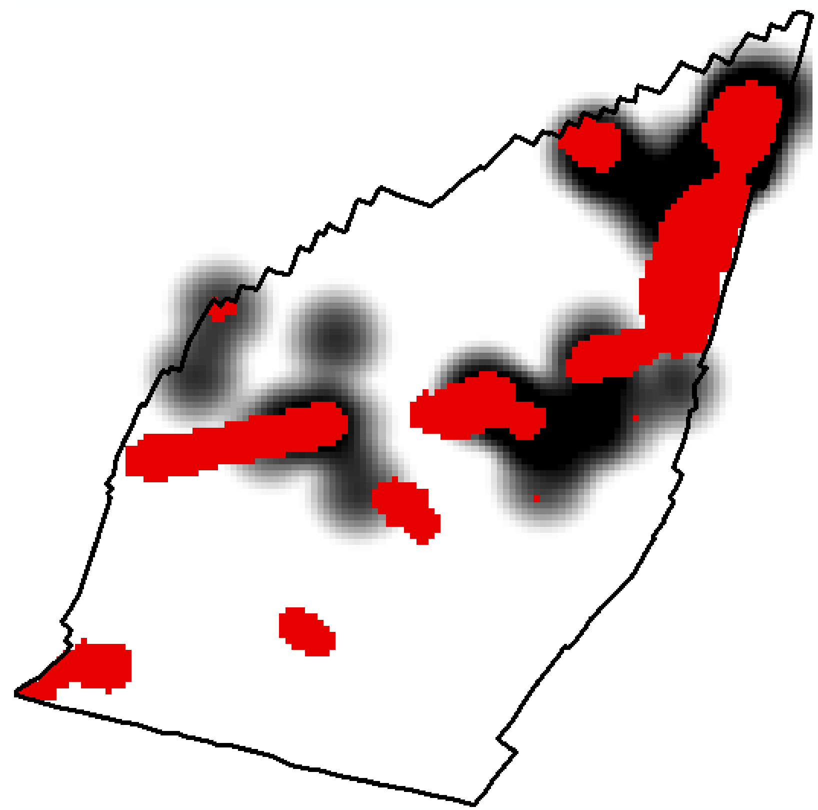
Step 10 – make the risk count

- Select all street segments within these areas to inform police commanders about where patrols might be increased.
- Operationalise the command and controll on the day by day basis.



RTM validation

- **Comparison with the subsequent time period (June 1 – December 31) – high risk RTM classes and hot spot analysis of actual shooting accidents.**
- About 50% (15 out of 31) of the shootings during the subsequent time period (July 1 to December 31) happened in these high-risk cluster areas.



Things to remeber

- **Remember**, risk terrain modeling is only a *tool for spatial risk assessmen*t; it is not the solution to crime problems.
- You (the analyst) give **value and meaning to RTM**, so be innovative in your thinking about risk factors and how risk terrain maps can be applied to police operations.

Melanie Kunz - journal articles based PhD thesis

- **INTERACTIVE VISUALIZATIONS OF NATURAL HAZARDS DATA AND ASSOCIATED UNCERTAINTIES**
- **ETH Zurich**
- **Supervised by Lorenzo Hurni**
- based on **five scientific publications** + an introductory and a concluding section.
- The articles are structured in three sections:
  - Paper 1 and Paper 2 focus on the **visualization of natural hazards**
  - Paper 3 addresses the **visualization of uncertainties in the field of natural hazards**
  - Paper 4 and Paper 5 finally present the developed **prototype** and **provide feedback of hazard experts** as well as a comparison with existing systems.

Paper 1

How to enhance cartographic visualizations of natural hazards assessment results

- Melanie Kunz & Lorenz Hurni
- **The Cartographic Journal 48(1): 60-71,**
- **Abstract :**
- *The objective of this research is to offer suggestions for enhanced hazard visualizations to facilitate hazard management tasks and decision making. Existing cartographic shortcomings are identified based on an extensive analysis of hazard visualizations and an expert survey. These shortcomings are discussed and improvements for important cartographic elements are presented.*

Paper 2

Cartographic visualizations of quantitative assessment results for multiple natural hazards

- Melanie Kunz, Adrienne Grêt-Regamey & Lorenz Hurni
- **5th Canadian Conference on Geotechnique and Natural Hazards, 2011, Kelowna, BC, Canada**
- ***Abstract*** *Cartographic visualizations have proved to be effective means to communicate these results. However, the large volume of available data, the presence of multiple natural processes and the heterogeneity of the user group pose visualization challenges. In this paper, we* ***analyze results of natural hazards assessments and present cartographic techniques for the visualization of multiple natural hazards.*** *In addition, we discuss how* ***interactive cartographic information systems*** *can facilitate the communication of hazard related data among experts.*

Paper 3

Visualization of uncertainty in natural hazards assessments using an interactive cartographic information system

- Melanie Kunz, Adrienne Grêt-Regamey & Lorenz Hurni
- **Natural Hazards,**
- ***Abstract:***
- ***Natural hazard assessments are always subject to uncertainties*** *due to missing knowledge about the complexity of hazardous processes as well as their natural variability. Decision makers in the field of natural hazard management need to understand the concept, components, sources, and implications of existing uncertainties in order to reach informed and transparent decisions. Until now, however, only few* ***hazard maps include uncertainty visualizations which would be much needed for an enhanced communication among experts and decision makers in order to make informed decisions possible.***

Paper 4

Customized visualization of natural hazards assessment results and associated uncertainties through interactive functionality

- Melanie Kunz, Adrienne Grêt-Regamey & Lorenz Hurni
- **Cartography and Geographic Information, 2011**
- **Abstract:**

The challenge of this research is to overcome these existing shortcomings by combining high quality cartographic visualizations of natural hazard data as well as associated uncertainties with interactive functionality. *In this paper we* ***summarize requirements that have to be considered, suggest functionalities necessary to perform natural hazards management tasks, and present a prototype of an expert system for the visualization and exploration of natural hazards assessments results and associated uncertainties.***

Paper 5

Interactive functionality of cartographic information systems for natural hazards data – comparison of selected geoportals with an expert system

- Melanie Kunz and Lorenz Hurni
- **25th International Cartographic Conference ICC, 2011, Paris, France (LNGandC)**
- *Natural hazards assessment results are often presented in form of cartographic visualizations. Due to the advantages of* ***interactive systems hazard representations are increasingly integrated in web-based information systems.*** *In this paper we give an* ***overview on functionality and included data of freely accessible Swiss Geoportals, compare them to an expert system, and finally present how this expert system can facilitate natural hazards management tasks.***