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## Monitoring of infection pressure of American Foulbrood disease by means of Google Maps

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### Anotace

Tento článek popisuje možnosti Google Maps jako nástroje pro podporu rozhodování při řešení prostorových problémů spojených s nemocí moru včelího plodu. Tato nemoc představuje vážný problém pro včelaře na celém světě. Jeho řešení vyžaduje použití všech dostupných dat a znalostí v příslušných rozhodovacích procesech. Prostředek Google Maps nabízí geografický přístup, který umožňuje použít stávající znalosti k modelování a analýze těchto problémů, a tak přispět k jejich řešení.

### Klíčová slova

Prostorový rozhodovací problém, systémy pro podporu rozhodování, GIS, Google Maps, mor včelího plodu, infekční tlak .

### Abstract

This article describes the options on Google Maps as a tool for decision support in solving spatial problems associated with the American Foulbrood disease. This disease is a serious problem for beekeepers worldwide. The solution to these problems requires the application of all available knowledge in the relevant decision-making processes. The Google Maps offers the geographical approach that represents a new way of thinking and solutions to existing spatial problems. This approach allows to apply existing knowledge to model and analyze these problems and thus help to solve them.

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### Key words

Spatial decision problem, decision support systems, GIS, Google Maps, American Foulbrood disease, infection pressure.

### Introduction

We can say that only few animals are as important as honeybees. Without them, agriculture as it is now could not exist because crops mainly require pollination by bees in order to grow. By working to improve the welfare of bees, authors offer to use Google Maps. Honey bees, as they forage for nectar and pollen, play a vital role in the environment and in preserving biodiversity by pollinating both wild flowers and many agricultural crops. Honey bees are the most economically valuable pollinators. In 2005, they pollinated €153 billion-worth of human food, representing 9.5% of the total agricultural production value (Gallai et al., 2009). For example The economic value of pollination of such crops is estimated at £120m-£200m annually in the UK –

and this is in addition to the production of honey, beeswax and other hive products. The essential and valuable activities of bees depend upon beekeepers maintaining a healthy population of honey bees.

Gallai's study also determined that pollinator disappearance would translate into a consumer surplus loss estimated between €190 to €310 billion. Without bees, many fruit, seed and nut yields would decrease by 90% (Klein et al., 2007). In fact, the value of beef and dairy products that come from forage legumes accounts for 7.6% of the total agricultural production value, about 80% of the pollinated production value (Gallai et al., 2009). "There has been widespread concern over status of bees worldwide in recent decades (Allen-Wardell et al. 1998, Kearns et al. 1998) with number of

publications documenting large scale declines...” (Abrol 2012, page 206). Animal pollination provides a critical service to ecosystems, both biologically and economically speaking. Insects are the most important animal pollinator groups, with approximately 70 percent of angiosperm (flowering plants) plants being insect pollinated (Free 1993, Schoonhoven et al. 1998). Among the pollinating insects, bees are one of the most important and specialised groups (Danforth et al. 2006). It is known that there are more than 19000 valid species of bee on the Earth described thus far. At the other hand there are likely to be many more species that are to be described.

Morphologically bees are adapted to collect, manipulate transport and store pollen very effectively and efficiently. Bees species exhibit both generalist and specialist foraging behaviour, thus making them very important economically and ecologically (Waser and Ollerton 2006). Highly

specialized pollination systems, such as figs and their wasp or orchids that deceive bees in trying to make them mate with their floral organs, are intuitively appealing to most people and have, therefore, gained far more attention both in popular and scientific literature than the more generalized pollination systems. For a long time the dominant view was that many, or perhaps even most, plant–pollinator interactions were specialized. In 1996 Waser and his colleagues tried to stir things up by writing an article in which they argued that, in contrast to common belief, generalization was widespread in plant–pollinator systems.

Beekeeping is essential to modern agriculture for the many commercial crops. Currently, beekeeping however is complicated by the very dangerous disease - American Foulbrood Bee disease (AFB). The name is derived from the foul odor of the brood chamber in an infected colony. AFB is caused by the spore-forming bacterium known as *Paenibacillus*

Region	Cadastral	Village	GPS	Date of confirmation of an outbreak	Termination date of outbreak
České Budějovice	621919	České Budějovice	49°0'47.000"N, 14°22'57.000"E	5.4.2011	20.4.2011
Český Krumlov	622931	Český Krumlov	48°45'3.000"N, 14°12'49.000"E	22.4.2011	27.5.2011
Český Krumlov	622931	Český Krumlov	48°37'37.000"N, 14°18'24.000"E	2.5.2011	11.5.2011
Český Krumlov	622931	Český Krumlov	48°39'56.000"N, 14°10'4.000"E	10.3.2011	18.5.2011
Český Krumlov	622931	Český Krumlov	48°45'50.000"N, 14°10'48.000"E	18.8.2011	20.9.2011
Český Krumlov	622931	Český Krumlov	48°48'10.163", 14°18'30.585"E	8.3.2011	15.3.2011
Jindřichův Hradec	770230	Třeboň	49°00'53.28"N, 14°47'56.60"E	09.04.2009	27.05.2009
Jindřichův Hradec	624322	Lomy u Kunžaku	49°06'26.77"N, 15°09'31.28"E	10.08.2009	15.09.2009
Písek	700771	Maletice	49°14'21.14"N, 14°11'22.97"E	24.09.2009	29.10.2009
Písek	700771	Maletice	49°14'21.14"N, 14°11'22.97"E	24.09.2009	29.10.2009
Prachatice	608530	Budilov	49°05'11.66"N, 13°51'01.13"E	13.05.2009	17.06.2009
Strakonice	675181	Krty-Hradec	49°17'45.61"N, 13°51'01.73"E	22.04.2009	19.06.2009
Strakonice	675181	Strakonice	49°15'2.000"N, 14°0'55.000"E	11.4.2011	12.5.2011
Strakonice	675181	Strakonice	49°13'11.000"N, 14°1'51.000"E	17.3.2011	12.5.2011

Source: State Veterinary Administration of CR

Table 1 Existing spreadsheet of American Foulbrood disease in CR.

larvae. The *Paenibacillus* larvae endospores are the contagion for AFB. AFB disseminates rapidly through a colony and can result in significant losses in colony production and death of the colony (Hamdan 2010). This disease is a great problem for beekeepers world-wide and causes them considerable economic loss (Forsgren, et al. 2005). The appearance of the AFB in the colony of bees, has a huge economical impact on the bees market as through the diminution of the production of honey and wax, and an agricultural impact – because the bees are the main pollinator of the plants (Chirila et al. 2007).

It is quite understandable that the competent authorities and institutions take a range of measures. Prerequisite for the effectiveness of these measures is detailed evidence of this disease. The existing conventional spreadsheets no longer fulfil its purpose. However, few countries have either control programs for American foulbrood or tracing systems to allow certification of the origin of bee products. It is known that it is possible to test honey for *P. l.* larvae to estimate spore concentration, and to dilute contaminated honey with well honey so that the final concentration is less than the lowest reported to cause infection when fed to bees – that is, 50 million spores per liter. If an additional safety margin of two orders of magnitude were applied for spore levels in honey, then honey with less than 500,000 spores per liter could be considered safe. So called polymerase chain reaction protocols have been developed for the direct detection of *P. l.* larvae spores in honey samples, although these do not differentiate between *P. l.* larvae and *P. l.* *pulvificiens*. (Lauro et al. 2003). At the other hand the offered use of discussed Google Maps can help to beekeepers better make spatial conditions decision in field of their own activities in the apiculture.

## Material and methods

AFB is not only defined by its localization, but also intensity and time course. Decisions made in this matter are very serious and difficult. In connection with this disease, some authors also mention so-called infection pressure from the environment (Přidal, 2012). This pressure is specified by the distance to the nearest outbreak, its severity, current state and repeatability. The AFB is then also necessary with regard to these attributes to be analyzed and monitored (Shimanuki, et al. 2000). Decisions made in this context are very hard and can have very serious economic repercussions for

beekeepers. Problems associated with the AFB belong to the category of spatial problems.

One of the tools, that can help us to analyze and deal with these problems, can be so called Decision Support Systems (DSS) (Power 2002). The DSS is a computer-based information system that supports business or organizational decision-making activities (Maxwell, 2008). A special category of DSS is called Spatial Decision Support Systems (SDSS). SDSS is an interactive, computer-based system designed to support a user or group of users in achieving a highest effectiveness of decision making while solving a structured spatial decision problem (Sugumaran, Degroote 2010, Ascough, et al. 2002). Typical SDSS provide a framework for integrating:

- analytical modeling capabilities,
- database management systems (DBMS),
- graphical display capabilities,
- tabular reporting capabilities,
- decision-maker's expert knowledge (Binda, Sharma 2008).

SDSS category includes primarily *Geographic Information Systems* (GIS). The possibilities of using these tools in solving spatial problems report a number of authors (Johnson 2005, Pandey, Harbor, Engel 2001). However, the financial costs of GIS are quite high. In this context, is offered as additional support options to solving these problems means Google Maps (Gibson, Erle, 2006). Google Maps is a web mapping service application and technology provided by Google which uses JavaScript extensively. Google Maps powers many map-based services, including the Google Maps website, Google Ride Finder, Google Transit. These services are focused mainly to car drivers. "Google's map interface allows users to integrate data using only ten lines of code" (Butler 2006). The Google Maps API is free for commercial use in a case if the webservice is not generating more than 25 000 map accesses a day. At the other hand some persons have own reverse-engineered tool and produced client-side scripts and server-side hooks which allowed a user or website to introduce expanded or customized features into the Google Maps interface.

- Support in solving problems with AFB may be monitoring the form of a designed interactive map using Google Maps. The aim of such map must be the following:

- locate existing outbreaks of AFB,
- analyze of these outbreaks, in terms of severity and time.

If such an interactive map to perform the functions SDSS must offer other features than simply display of status, ie the occurrence of AFB. This function should be to objectify of potential decision to determine the place for beekeeping with respect to the intensity of the infection pressure.

## Results and discussion

The process of creating interactive maps must be based on a thorough analysis of all available attributes. If it is not, there is a risk that the resulting maps will be biased. Most of the spatial problems are complex and require the use of analysis and models. Such problems are very frequently semi-structured or ill-defined because all of their aspects cannot be measured or modelled. The key issue of such a solution must be work with the so-called layers (Crampton 2011). Generally, these overlapping layers of vector data, attribute data combination can lead to the creation of a new data layer. This layer often provides more useful data to analyze the problem.

The possibility to work with layers is typical for GIS tools. This matter may be to some extent implemented in Google Maps by means of additional programming. The Google API allows other data to be fed to it and displayed as a Google map. (Crampton 2011). *“An API defines a standard way for one program to call code that lives within another application or library. The Google API defines a set of JavaScript objects and methods that you use to put maps on your own web pages.”* (Gibson, Erle 2006).

Google Maps API is very well documented and thousands of examples of how to use them are available. Therefore, it is easy to write your own application. Because the tool can use XML, it is easy to integrate application with other data sources, and also allows easy export of data to other applications. Another advantage is that the Google Maps API is free for commercial use in a case if the webservice is not generating more than 25 000 map accesses a day.

Example of such corresponding source code may be next.

```
<!DOCTYPE html>
<html>
<head>
```

```
<title>Map demo</title>
<meta http-equiv="Content-Type"
content="text/html; charset=UTF-8">
<script src="http://maps.googleapis.com/
maps/api/js?sensor=false">
</script>
<script type="text/javascript">
var data = [
{ lat: 50.130586, lng: 14.373493, text:
„2005“ },
{ lat: 50.284265, lng: 14.856271, text:
„2007“ }];
var initMap = function()
{var map = new google.maps.Map(document.
getElementById(„map_canvas“),
{zoom: 10,center: new google.maps.
LatLng(50.130586, 14.373493),
mapTypeId: google.maps.MapTypeId.
ROADMAP});
for (var i in data) {
addMarker(map, data[i]);}
var addMarker = function(map, obj)
{var marker = new google.maps.Marker({map:
map,position:
new google.maps.LatLng(obj.lat, obj.
lng)});
var infoWindow = new google.maps.
InfoWindow({
content: „<p>Rok: „ + obj.text + „</p>“});
google.maps.event.addListener(marker,
„click“, function()
{infoWindow.open(map, marker);});}
window.addEventListener(„load“,
initMap, false);
</script>
</head>
<body>
<div id="map_canvas" style="width: 800px;
height: 600px;"></div>
</body>
</html>
```

In the first part of the source code is adjusted a set of used variables that are applied in the API in this particular case. Another part of the source code is its own application logic that responds to the activity of the beekeeper, as shown below. In this logic applications are processed event caused by user actions. The output of this part of the program is required and appropriate information which is displayed on the map. The penultimate line

```
<div id="map_canvas" style="width: 500px;
height: 300px"> </div>
```

defines dimensions of the map.

The figure 1 below shows the use of layers in designed interactive map using Google Maps.

Beekeeper clicks on the place in which want to behave their beehives. The beekeeper deciding to place a hive to a new location has to take into

account all the potential risks of such location, i.e. concrete infection pressure from the environment. Possibility to specify a concrete infection pressure in the selected place shows the following figure 2.

In this way the user (beekeeper) may find the other

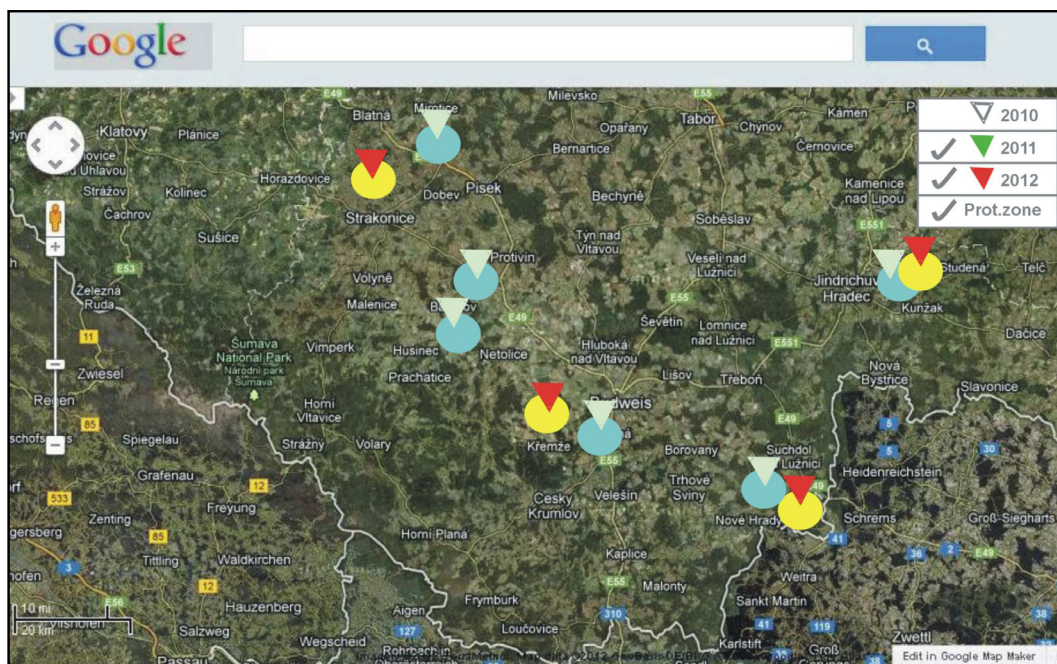


Figure 1: Work with layers (occurrences of the outbreaks in individual years - South-Bohemian Region) in the designed interactive map.

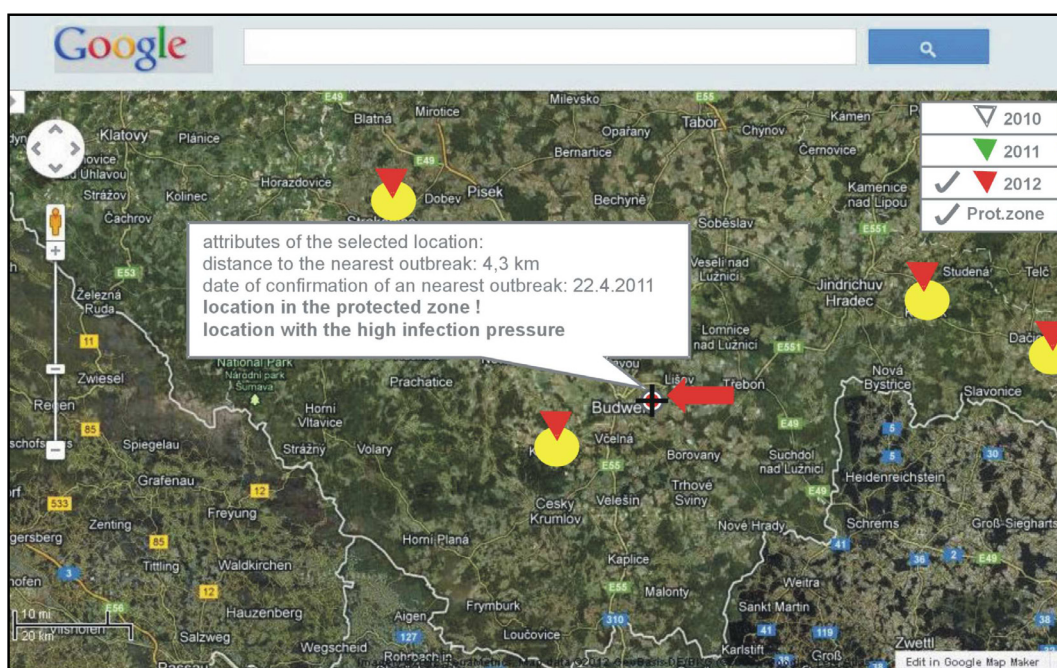


Figure 2: Representation of a concrete infection pressure in the selected place.

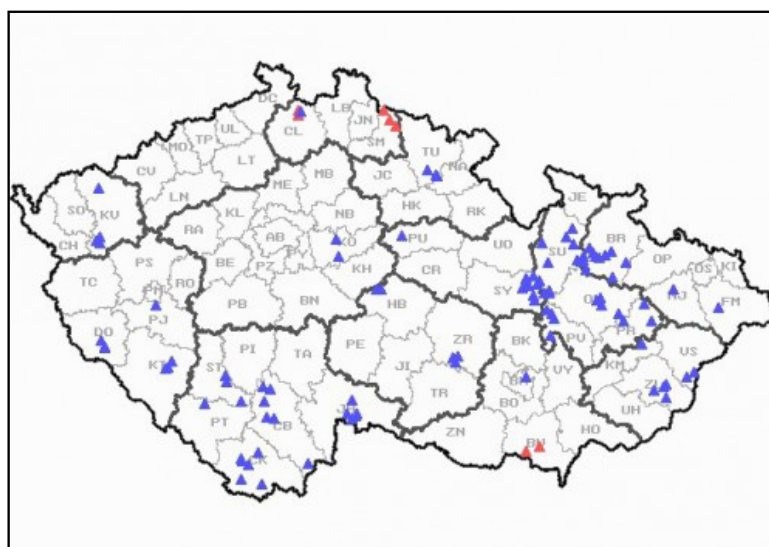


Figure 3: Outbreaks of AFB in Czech republic: status in 2011 year (source: State Veterinary Administration CR) <http://www.svs.cz/?lng=en&cat=0>.

important attributes of the selected place, which on help him to his final decision.

The situation about AFB, among other things monitors State Veterinary Administration of whose tasks are the following issues:

- Protection of Consumers from products of animal origin Likely to Be Harmful to human health.
- Monitoring of animal health situation and Maintaining it Favourable.
- Veterinary protection of the state territory of the Czech Republic.
- Animal welfare and animal protection.

One example of the outputs from information systems which are operated by the State Veterinary Administration CR is at the Figure 3.

## Conclusion

The proposed solution can considerably help to effectively monitor the spread of the AFB in CR. The designed interactive map generated this way can only fulfill its purpose, i.e. to minimize considerable economic losses associated with this disease.

The creation of the such final interactive map

should be implemented as in following steps:

- collection of available data (data from available records of the State Veterinary Administration CR, Czech Beekeepers union, Bee Research Institute at Dol),
- visualization of existing outbreaks in terms of its time and severity,
- location of corresponding protective zones,
- analysis of the current state by means of the layers,
- output: specification of appropriate recommendations.

Benefits of the proposed solution may be as follows:

- transparency of the specified recommendations in the form of maps,
- easily upgradeable,
- complete availability via the Internet.

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