# Advanced Pest Control of Olive Trees by Using Modern Technologies (GPS, GIS and Geodata)

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*Abstract:* - The goal of the described pilot project was to reduce time, cost and pesticides for efficient controlling of olive tree pests. The integration of modern technologies such as GPS (Global Positioning System), GIS (Geographic Information Systems) and the use of Geodata seem to provide a solution more ecological and beneficial. The proposed method aims at spraying only in the necessary region and not over the whole area as it had been done in the past. Through the combination of agronomic knowledge and technical know-how a GIS was built as a decision making tool in order to achieve the pursued goal. The results of the pilot project are also discussed in this paper and show that such (modern surveying) techniques become inevitable if we want to achieve maximum results (in pest control) and at the same time manage to reduce the pesticides and hence protect the environment.

*Key-Words:* - GIS, GPS, Risk Management, Geodata, Expert System, Database

## 1 Introduction

In the past, the fight against olive tree diseases in Greece was carried out by spraying the olive groves from the air using light-weight airplanes or helicopters.

As this way of dealing with the problem had a long-lasting negative ecological effect on the environment, the Greek Ministry of Agriculture and the European Union decided in 1996 to replace the airborne sprinkling procedures with terrestrial spraying vehicles or even back-sprayers. Thus it was decided to make a pilot project to see whether the efficiency of pest control can be increased by using modern surveying techniques such as GIS, Remote Sensing, GPS and Geodata.

Through the collaboration between the Local Authorities of the prefecture of Fokida (Τοπική Αυτοδιοίκηση Φωκίδας -ΤΑΦ) and company GEOMET Ltd. (Athens) a specific procedure and the necessary tools (hard- and software) were developed. This development was based on the long experience and agronomic knowledge of ΤΑΦ and the technical understanding and know-how of GEOMET Ltd. in the fields of GPS, GIS and GeoData.

The area of the pilot project was approximately 15.000 acres with a tree density of 110-130 trees per acre. The main goals were

- the testing of a logical model of the application under real conditions,
- the testing of the operability of the 'decision-making' tool,
- the choice of the most suitable spatial data which would be used for the application and
- final specifications for the hard- and software.

While the hardware specifications could be fulfilled by commercially offered equipment, this was not the case for the software. Thus the development of a specific program became a necessity. This software package was developed by company Terra Ltd. (Athens) under the supervision of Geomet Ltd.

The final product (called DACo) consited of

- a decision-making system / GIS (developed in ERDAS and ArcInfo environment),
- units of GPS (Leica GS5 with PalmV and ARCPAD, Garmin GPSMap 76S) and
- GPRS units.

The present paper describes the technical and economical factors of the DACo-system, as well as the outcomes of the pilot project. Furthermore, the improvement of the sprinkling procedure depending on the location of insect traps, the processing of the multi-temporal data, the planning and execution of the sprinkling, the surveying of the areas under investigation and the analysis of working time, cost and amount of used pesticides are discussed.

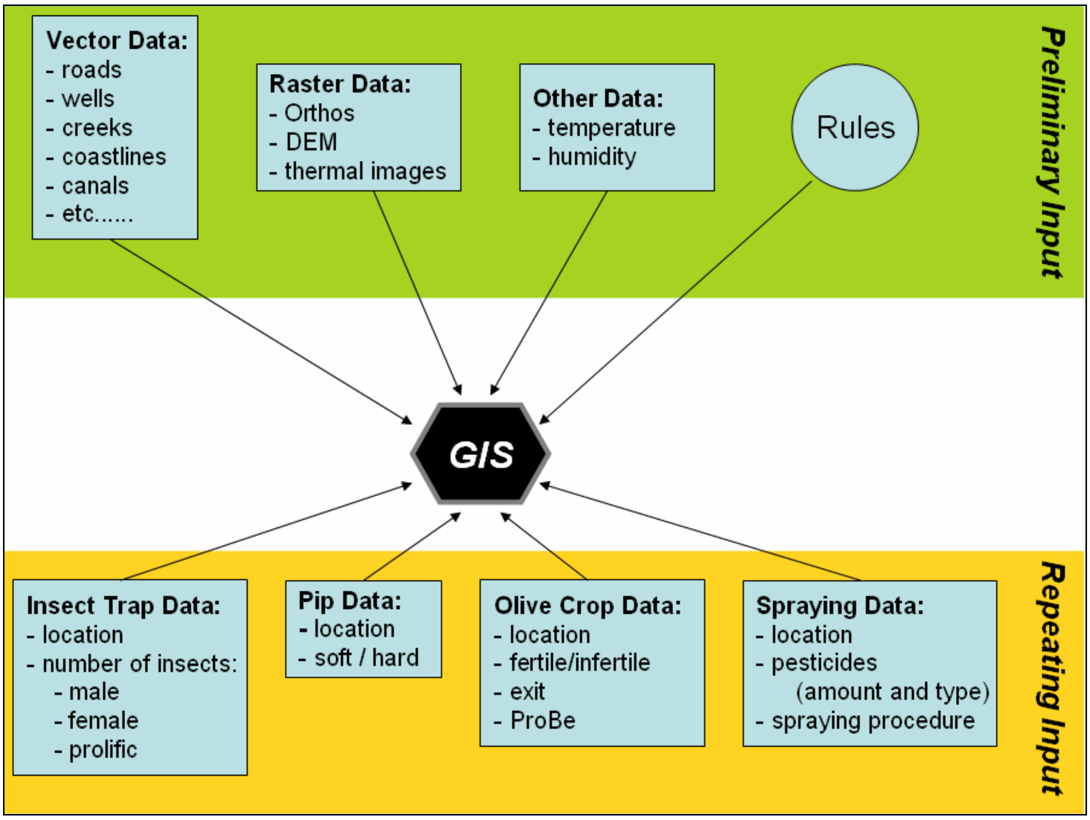


Figure 1: Input data for the GIS.

## 2 GIS Preparation

The task was to create an Expert System in form of a GIS in order to fulfil the demanded requirements. Since the behaviour and expansion of the olive tree pests depend on many factors (distance to various objects, terrain slope and orientation, humidity, vegetation etc.) the input data for the GIS' primary database had to be carefully planned (Figure 1):

- Raster data: aerial and spaceborne orthophotos, thermal Landsat images, (DEM) Digital Elevation Model
- Vector data: roads, wells, creeks, coastlines, bridges, water drilling, canals, regions of agricultural activities, regions of cattle activities, etc.
- Other data: meteorological data (temperature, humidity, information from other agronomic sources.

Each data-set was put on a different layer in the GIS and would provide important information for deducing the behaviour of the olive tree pests.

Additionally, aspects and slopes of the terrain together with their orientation were calculated, since they too affect the proliferation and spreading-out of the pests and also inform us about the accessibility to certain areas. After all needed information was imported into the database, rules depending on multiple components (entries of the database) were defined, in order for the GIS to work as a decision making tool.

During the whole procedure of the project (as described in the following workflow) the GIS database got more and more information, in order to provide the end-user with more and more precise information about where to perform the spraying.

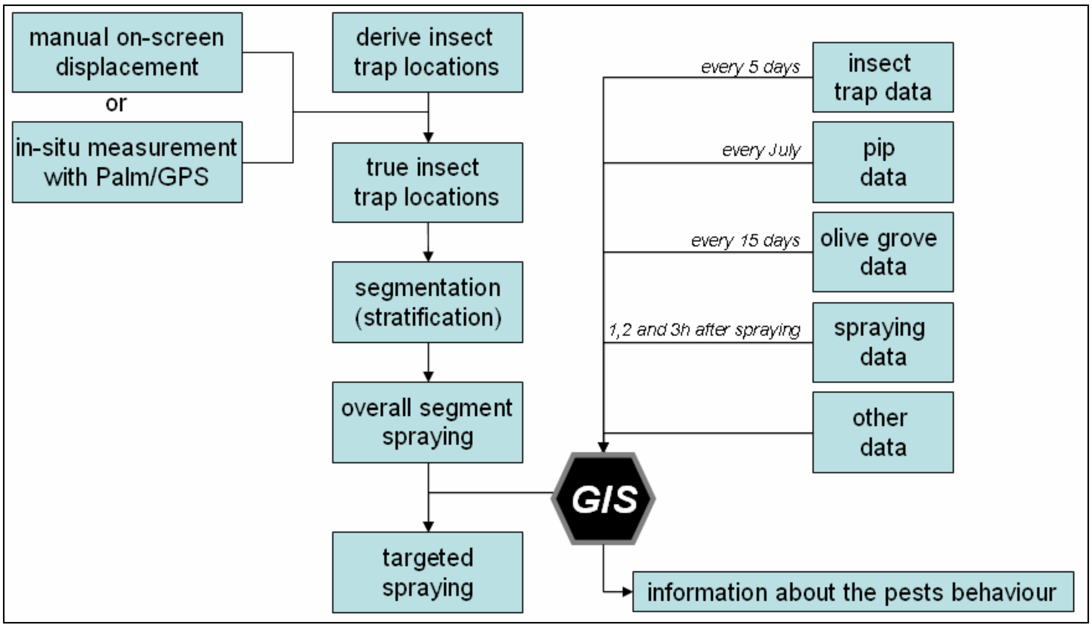


Figure 2: Proposed Workflow.

## 3 Proposed Workflow

In this section the proposed workflow is described (see also Figure 2).

The first step was to place insect traps (McPhail type) over the area under investigation. It was decided to place one insect trap every 1000 trees. Since the GIS holds tree density information, interim locations for placing the insect traps were automatically suggested by the GIS. Of course it may happen that an insect trap might not fall exactly on a tree (because individual trees are not registered in the GIS); hence post-processing (relocating of misplaced insect traps) had to be carried out. This correction of the position of the traps could be done in two ways:

- Either by manually moving the insect trap on screen so it was placed exactly on top of a tree in the orthophoto (in this case the user had to go afterwards into the field with a GPS/palmV device in order to place the insect trap at the previously planned location),
- or by going outdoors in the grove with a remote GPRS unit and placing the insect trap on a tree (close to the location that was suggested by the GIS). Afterwards the GPRS data was imported into the GIS and the system was automatically updated with the new (true) coordinates of the in-situ-placed insect traps.

Next step was to perform a segmentation over the region. This was done by applying a stratification (density classification), where each segment contained 30 insect traps. An additional constraint was that at least one edge of each computed segment should lie on a road, so that good accessibility to each segment was guaranteed.

Every five days the insect traps were inspected and the following data was entered in-situ into a palm device:

- number of insects
- number of males
- number of fertile insects
- total number bigger than 3
- ratio between female and male bigger than 7/3

This palm device was afterwards synchronised with the GIS, so that all data was stored in the database with the corresponding date (Figure 3).

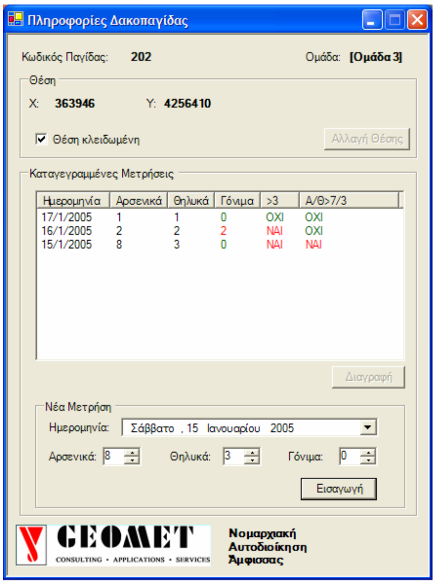

Figure 3: Traps information.

Another important data source for updating the GIS continuously was information about the olive crops. This information was collected every 15 days from 10 trees over the whole project area. The properties entered into the database of the collected olives were:

- fertile
- infertile
- exit (Did any pests exit the olive fruit?)
- ProBe (Is there any indication of the Prolasioptera Berlesiana parasite? This parasite nests close to pest eggs and eats them.)

From this information the percentage of already damaged trees could be derived.

Moreover, every July olives were collected to examine their pip. This was done for one tree per segment. The properties of each kernel could be hard or soft.

After the GIS had been fully updated, the targeted spraying procedures could be concluded (see Figure 2).

In case the system reported that no spraying at all was needed, that is to say that there were no pests, an additional diagnosis was carried out in order to confirm the GIS’ decision. A few randomly chosen trees (that where well distributed over the whole area) where heavily sprayed. Under these trees special reception nets were placed in order to see (1,2 and 3 hours after the spraying) whether any olive pests had existed and thus fallen off the tree. This way it could be verified if the system's decisions was correct or not.

In areas were the system predicted pests, the spraying was carried out on a (segment-wise) tree-by-tree basis. Again all available information (pest situation in traps after the spraying) was imported into the GIS and the decision making-tool provided the end user the information which tree had to be re-sprayed again. The GIS accentuated certain regions with 4 different kinds of ALERTS and marked the trees/areas where the pests persisted. How these ALERTS were concluded can be seen in the following flowchart (Figure 4).

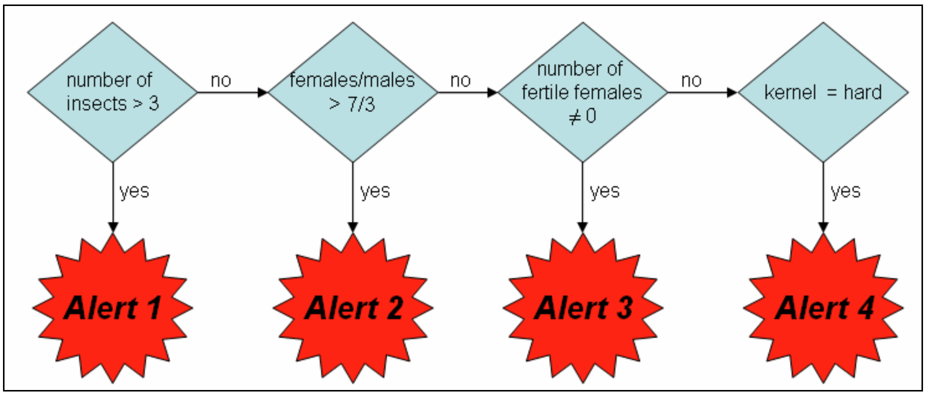


Figure 4: Flowchart for the decision of spraying.

For example, if an area was labelled with alert1, alert2, alert 3 and more than 30% of alert 4, repeated targeted spraying was obligatory. Although most of the alterations of different alerts gave the end-user a hint what to do in the corresponding regions, there existed some cases were still an agronomist's opinion was needed in order to decide whether to spray again or not.

The repeated targeted spraying followed a certain iterative scheme that depended on the number of persisting pests in an area that had been sprayed before. The system computed automatically how big the spraying radius around an insect trap should be, in order to remove all the remaining pests.

For the trained spraying operator who went out into the grove for the spraying it was very difficult or even impossible to know precisely which trees were inside the previously determined spraying radius and which not. Thus an AVL (Automatic Vehicle Location System) named 'GPS-tracker' was designed and developed by the companies Geomet Ltd. and Heletel (Figure 5). Through this system the headquarters could always keep track (online) where the tractors (which were equipped with GPRS units) where and which areas had been sprayed. In case of a mistake (e.g. spraying trees outside the spraying radius etc.) an intervention was very easy.

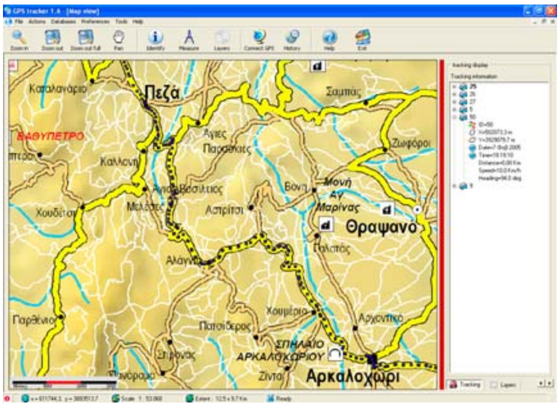


Figure 5: GPS-tracker screenshot

In the future the tractors will also be equipped with PalmV/GPS units, so that the specialized spraying teams are navigated to the spraying locations as fast as possible. Here also the terrain's topography will be considered (e.g. for cases where slopes are too steep for the tractor).

## 4 Results and Conclusions

We described an advanced method for pest control in olive groves. The suggested methodology is based on an expert system (GIS that is trained by getting and more and more information during the procedure and hence is in position to deliver more and more accurate and reliable results). The goal was to minimize the amount of pesticides used for fighting the pests and make the procedures as efficient as possible in order to reduce cost and time.

The pilot project showed that when using modern surveying technologies together with multi-temporal data coming from various sources, the overall time can be reduced up to 20%, the cost up to 18% and most important of all, the amount of used pesticides is 23-25% less.

Since the pilot project covers only a small area (15.000 acres) it can be said that if this procedure is followed also for bigger regions the pesticide reduction will be even higher (more than 25%) and thus the highest possible degree of protection of the environment is guaranteed.