Chapter 2
A Knowledge-Based SDSS for Medfly Area-Wide Control: Development, Validation and Effectiveness Evaluation

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ABSTRACT
The aim of this chapter is to describe the motivation to develop a knowledge-based spatial decision support system (KB-SDSS) for medfly control in citrus in Israel, its development approach and procedure, its validation, and the steps towards its assimilation among the zone-managers. Development of the KB-SDSS for medfly control in Israel, also known as MedCila involved four main phases: 1. acquisition of expert and domain knowledge related to the control decision process; 2. identification of the relevant criteria and modeling each criterion and the overall decision making procedure; 3. its integration into a GIS environment; and 4. its performance evaluation by an expert-panel considering four aspects: verification, validation, acceptance and effectiveness. Comparison with data-mining approach exemplifies the effectiveness of the KB approach in this case. Our results show that the MedCila may reduce spraying actions by at least 8%, which is estimated to save ca. 13.3 ton/year of chemicals. Ceratitis capitata; Medfly control, knowledge-based spatial decision support system, Stanford certain factor algebra, expert panel, verification, validation, acceptance, effectiveness.

INTRODUCTION
The Mediterranean fruit fly (medfly), Ceratitis capitata (Diptera: Tephritidae) is a major pest of fruit crops in the Near East and worldwide (Rossler et al., 2000). Over 250 plant species have been listed as hosts to this pest, including citrus, deciduous subtropical fruits, and various vegetable crops. Among these, 47 species in the Near East...
are known to be hosts. In the absence of control, the Mediterranean fruit fly could damage up to 100% of a crop. Because of its devastating nature, medfly is considered a quarantine pest, especially in countries with suitable climatic conditions such as the Far East, North America and Australia. Strict quarantine measures are imposed on fresh product from ‘infested’ countries. To overcome those restrictions and to ensure access to these important markets, intensive measures must be taken, both pre- and postharvest to ensure that fruit commodities are free of the pest. Medfly control in citrus in Israel is centralized by the Israel Cohen Institute for Biological Control, PPMB (Plant Production and Marketing Board). The control operations are aimed at the adult stage of medfly, mainly because this is the only life stage of the pest that is exposed. One of the main control methods against the medfly in Israel and elsewhere is the use of bait sprays. A wide-spectrum insecticide (Malathion) is sprayed with proteinaceous bait, to enable an effective use of ultra-low volumes, applied in strips or spots, as a selective control method. This procedure, however, affects only the adult flies and, therefore, needs to be repeated every 5 to 10 days throughout the fruiting season. Field operations are directed by monitoring the adult medfly population in the orchard, by using Steiner trimedlure traps (Gruviyas Ltd., Bnei-Brak, Israel), which attract and trap only males.

Approximately 2,700 traps are distributed in the 20,000 ha of citrus blocks all over Israel, at a density of around one trap per 7 ha. The traps are monitored about once a week by six field scouts who count the number of trapped males, record their findings on a portable terminal and e-mail them to three zone-managers. The latter in turn, decide upon the time, space and mode of the control measures (aerial or ground application). During the 50 years of the existence of the medfly threat in Israel the level of infestation of citrus fruit has been negligible. Nevertheless, from the 1970s to the early 2000s the average number of spraying actions is constantly increasing (Figure 1). Moreover, in the last few years there is also a constant increase in medfly population (Figure 2) and consequently in damage events.

The PPMB summarizes list of possible reasons for these two trends:

1. Constant increase in species diversity in Israel enables medfly survival all year long;
2. Deterioration in sanitation level that causes leftovers of ripe fruits on trees and on ground after harvest;
3. Existence of a single or few trees with exceptional ripening period in the orchard which are not treated in time;
4. Species and plots which were not harvested, mainly because of economical reasons;