

## Spatial Analysis for Pest Management in Tuscany

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**Abstract:** Within the META project (Extensive Monitoring System of Tuscan Forests) a monitoring campaign has been carried out since 2000 aimed at producing an historical database and map, gathering knowledge on the updated phytosanitary status of the Tuscan forests of Italy. The aim of the present work was to study both population levels and trends among insect pests, in order to foresee new outbreaks of two very damaging forest pests, i.e., the maritime pine bast scale, *Matsucoccus feytaudi* Duc. (Hom. Coccoidea Margarodidae), and the oak moth processionary, *Thaumetopoea processionea* (L.) (Lep. Thaumetopoeidae). Monitoring the pine bast scale by pheromone traps got data on its diffusion by means of many georeferenced observation points. This data has been spatialized by the "Thiessen Polygons algorithm" and analyzed by the "Least Accumulative Distance method" to obtain a forecasting map. Monitoring of the oak processionary was done by collecting oak twigs with both new and old egg masses; its population dynamics were analysed by a trend index (IT). Data was spatialized by means of "Inverse Distance Weighted Interpolation System" (IDW). The data led to the forecasting of infestation levels. Maps obtained by these spatial analyses are presently used in forest pest management in Tuscany.

**Key words:** *Matsucoccus feytaudi* Ducas; *Thaumetopoea processionea*; monitoring; spatial analysis

### Análise Espacial na Gestão Florestal na Toscânia

**Sumário.** Com base no projeto de monitorização das florestas da Toscânia (META project), uma campanha de monitorização tem sido realizada desde o ano 2000 para formar uma base de dados histórica e um mapeamento regional rigoroso, permitindo obter um conhecimento atualizado do estado fitossanitário das florestas da Toscânia (Itália). O objetivo do presente trabalho foi estudar o nível e a tendência populacional de duas pragas muito importantes na região, a cochonilha do pinheiro bravo *Matsucoccus feytaudi* Duc. (Hom. Coccoidea Margarodidae) e a processionária dos carvalhos *Thaumetopoea processionea* (L.) (Lep. Thaumetopoeidae), de modo a prever novos surtos destas pragas florestais. A monitorização da cochonilha foi feita recorrendo a armadilhas iscadas com feromonas colocadas no terreno em pontos de observação selecionados e geo-referenciados. Os dados obtidos foram usados para construir uma base de dados geo-referenciada através de "Thiessen Polygons algorithm", tendo sido analisados pelo método "Least Accumulative Distance", de modo a obter um mapeamento de previsão de ocorrência. A processionária dos carvalhos foi monitorizada através da recolha

periódica de ramos atacados e com posturas antigas e recentes. A dinâmica populacional desta praga foi analisada por um índice de tendência (trend index). Uma base de dados geo-referenciada foi elaborada através do sistema "Inverse Distance Weighted Interpolation" (IDW). Os resultados obtidos permitiram prever os níveis de infestação. Os mapas obtidos através desta análise espacial são atualmente usados como ferramentas de gestão de pragas florestais na Toscana.

**Palavras-chave:** *Matsucoccus feytaudi*; *Thaumetopoea processionea*; monitorização; análises espaciais

## Introduction

Within studies of spatial ecology aimed at obtaining improved strategies for forest pest management, the spatial distribution of phytophagous insects allows us to check up on those ecological conditions that forewarn environmental risk (AUERNHAMMER, 2001; LIEBHOLD *et al.*, 1993; NANSEN *et al.*, 2003).

Since 2000 a monitoring project named M.ETA (Extensive Monitoring System of Tuscan forests) has been active, aimed to provide an historical database and map in Tuscany, gathering knowledge of the updated phytosanitary status of the Tuscan forests (I) (ROVERSI *et al.*, 2005).

In recent years, two phytosanitary problems have aroused particular attention regarding forest insects living on *Pinus* and *Quercus*: the maritime pine bast scale *Matsucoccus feytaudi* Ducasse (Hom. Coccoidea Margarodidae) and the oak processionary moth, *Thaumetopoea processionea* (L.) (Lep. Thaumetopoeidae).

The maritime pine best scale *M. feytaudi* was introduced from the French Atlantic regions into south-eastern France in the sixties of the last century and since then, up to now, it has reached eastwards to Tuscany, causing the decay and death of many thousands of hectares of pine stands. *M. feytaudi* was located in Tuscany for the first time in 1998 (BINAZZI *et al.*, 2002).

Recent infestations in central Italy by *Thaumetopoea processionea* (L.), a lepidopteran defoliator of deciduous oaks, have caused both direct damage to oaks and serious public health problems because of the aerial diffusion of huge quantities of rash-causing hairs from larvae. Due to recent massive attacks by this moth in the same areas, reliable methods have to be prepared for monitoring oak processionary moth populations and for forecasting their outbreaks (ROVERSI, 2002).

Thorough studies on *T. processionea* population dynamics have been carried out in Tuscany since 1995, using egg-mass parameters as indicators.

## Materials and methods

Monitoring campaigns for each pest have been carried out at geo-referenced observation points spread throughout the Tuscan forests.

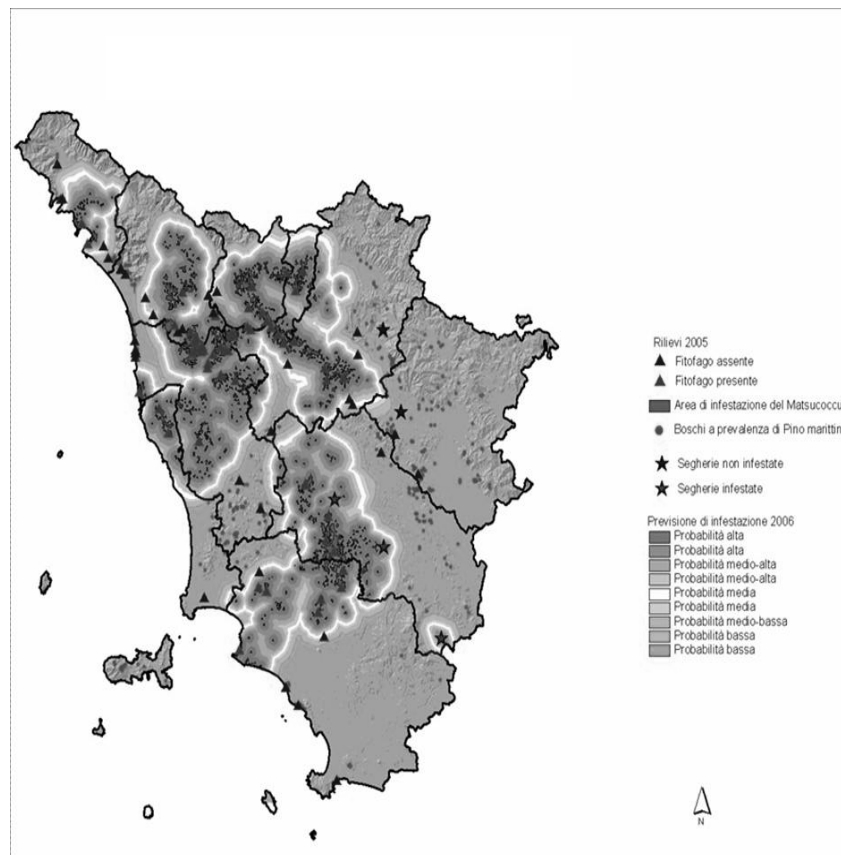
### *Matsucoccus feytaudi* Ducasse

Sticky plate traps (25x25cm) were distributed in 62 geo-referenced monitoring stations, baited with *M. feytaudi* sex-pheromone synthesized by INRA (Unité de Chimie Biologique, Centre de Versailles - Grignon). Traps were kept in the forest throughout the male bast scale's flying period. Data was spatialized by applying the algorithm of

Thiessen polygons. To simulate insect spread in the next year, wind was established as the main cause of the scale insect's diffusion, so the dominant wind was utilized in the cost-distance calculation and the least accumulative distance was calculated for each point of the area investigated. This calculation was carried out by using borders of polygons that symbolize the areas of infestation. The algorithm enabled the insertion of layers by means of which the distance measurement was weighted.

The layer was obtained by subtracting from a grid value 1 (algorithmic neutral value) with the same dimension, using the map calculator of the Arcview 3.2 spatial analysis extension. In this way it was easy to locate, for 2006, the possible areas of the insect's further diffusion (Figure 1) and to evaluate its outbreak probability in terms of cost-distance (BERRY, 1993; MCGREW *et al.*, 1993). Forecast models have been ratified by a bidimensional error matrix (Table 1).

*Thaumetopoea processionea* (L.)



**Figure 1** - Forecast diffusion map of *Matsuococcus feytaudi* for 2006

**Table 1** - Bidimensional error matrix used to ratify forecast model of *Matsucoccus feytaudi* for 2006

		Data 2006		Total		
		no presence	presence			
Forecast	no presence	14	0	14	100,00	<b>user accuracy</b>
	presence	13	19	32	59,38	
Total		27	19	46		
<i>producer accuracy</i> =		51,85	100,00			
<i>overall accuracy</i> =				71,74%		

In the winter of 2005-2006, oak processionary populations were monitored in Tuscany by collecting oak branches, with new egg-masses (laid in summer 2005) and old egg-masses (laid in summer 2004) at 130 geo-referenced points.

At each checkpoint 10 oak branches were cut and then all new egg masses ("TOT\_NEW05") and old egg masses ("TOT\_OLD05") were collected. The trend index (TI) was thereby calculated as the ratio of TOT\_NEW05 to TOT\_OLD05 (ROVERSI, 2002). The moth population increases when the index is greater than 1. In order to avoid indeterminate or indefinite fractions we have added one unit to both the numerator and the denominator. Spatial sorting of data was carried out by an IDW (Inverse Distance Weighted) interpolation system (Figures 2, 3).

In this work the 3 closest sample points have been used to calculate an estimated value for each grid cell (with each side measuring 100m).

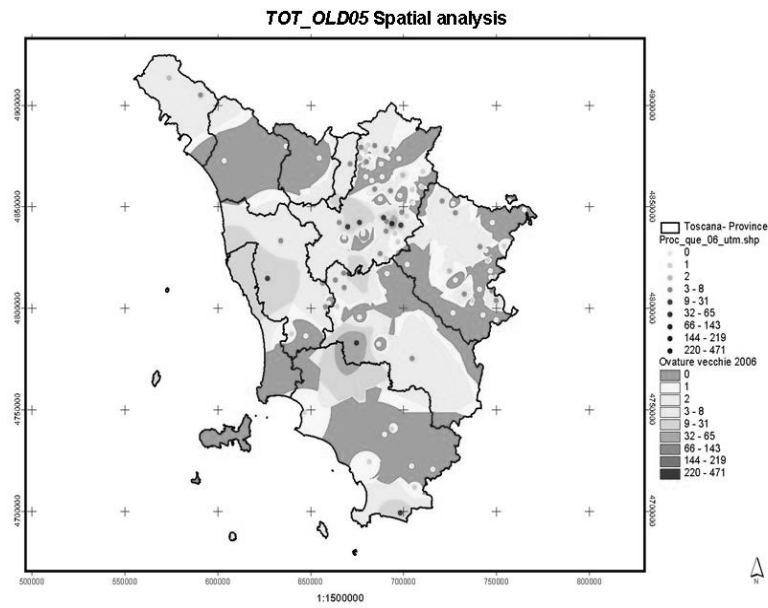
We have also adjusted the relative influence of sample points by adjusting the power setting. In this study we have used the power of 3, so that the nearest sample points to the estimation cell have

higher weight.

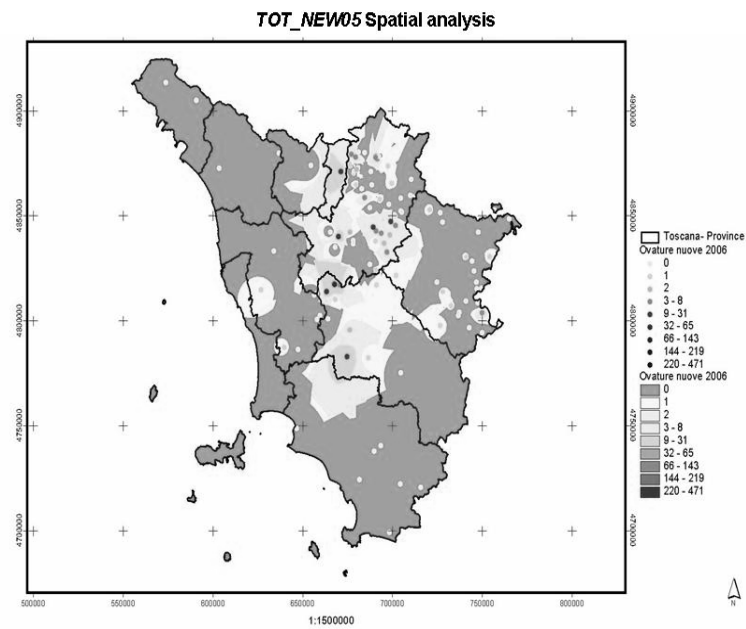
## Results and conclusions

By means of the Thiessen polygons algorithm we obtained a map of *Matsucoccus* presence in Tuscany in 2005. Elaboration of this data by the least accumulative distance method, using the dominant wind direction and the maritime pine stand uniformity as parameters, allowed development of a diffusion forecast map for 2006 (Figure 1). Although the use of a bidimensional error matrix showed that it overestimated *Matsucoccus* diffusion, it was considered to be a valid method for spatial analysis in biological invasions such as the one described for *Matsucoccus feytaudi* in Tuscany.

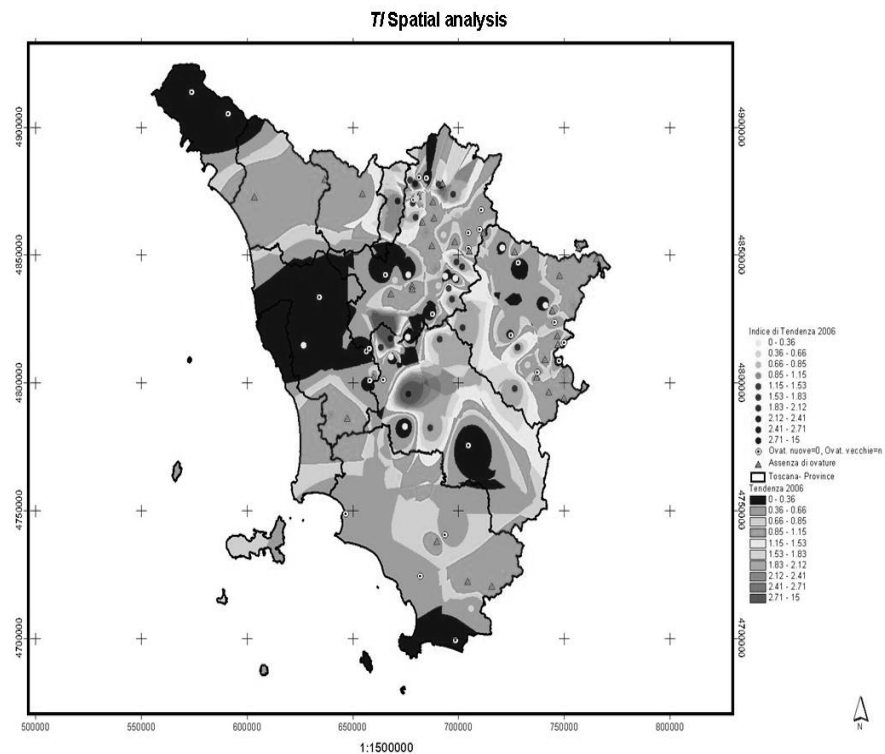
The IDW interpolated system has proven to be a technique that can also be used in studies of population dynamics of *T. processionea*, to make cartography useful for pest management, in order to plan biological control operations. This method used with TI allowed us to check the population levels' range, aiming for a prognosis of possible new outbreak areas (Figure 4).



**Figure 2** - Distribution map of *T. processionea* old egg masses



**Figure 3** - Distribution map of *T. processionea* new egg masses



**Figure 4** - Trend Index map of *Thaumetopoea processionea* for 2006

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