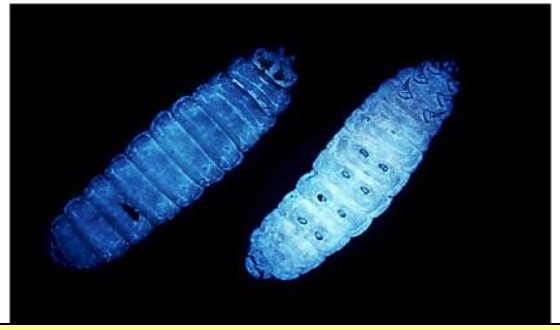
Learning objectives:

1. Biodiversity
2. Invasive species
3. Structure of forest insect communities and ecological guilds
4. Population dynamics of forest insect pests
5. How forest insects respond to abiotic drivers
6. How forest insects respond to biotic drivers: plant quality
7. How forest insects respond to biotic drivers: competition
8. How forest insects respond to biotic drivers: natural enemies
9. Ecological management of insect pest populations

Natural enemies: predators, parasitoids, pathogens



Fluorescent *Photorhabdus* bacteria inside *Galleria* larvae

ANIMALS par pre

FUNGI pat

PLANTS pre

PROTISTS pat

BACTERIA pat

VIRUS pat

Biological control

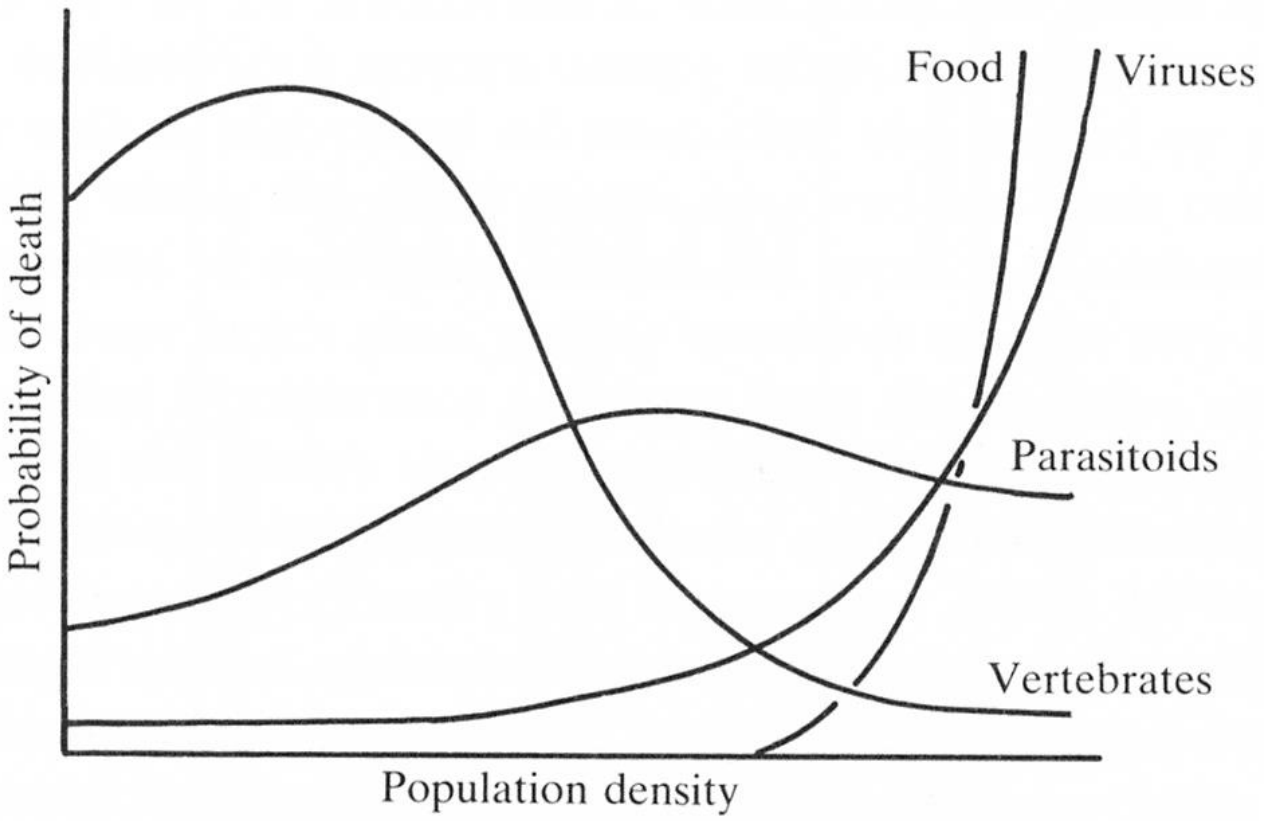


FIG. 7.1. The effect of population density of *Lymantria dispar* on the probability of death from vertebrate predators, insect parasitoids, viral pathogens, and food shortage (from Berryman *et al.* 1987, after Campbell 1975).

Economic threshold and enemy release

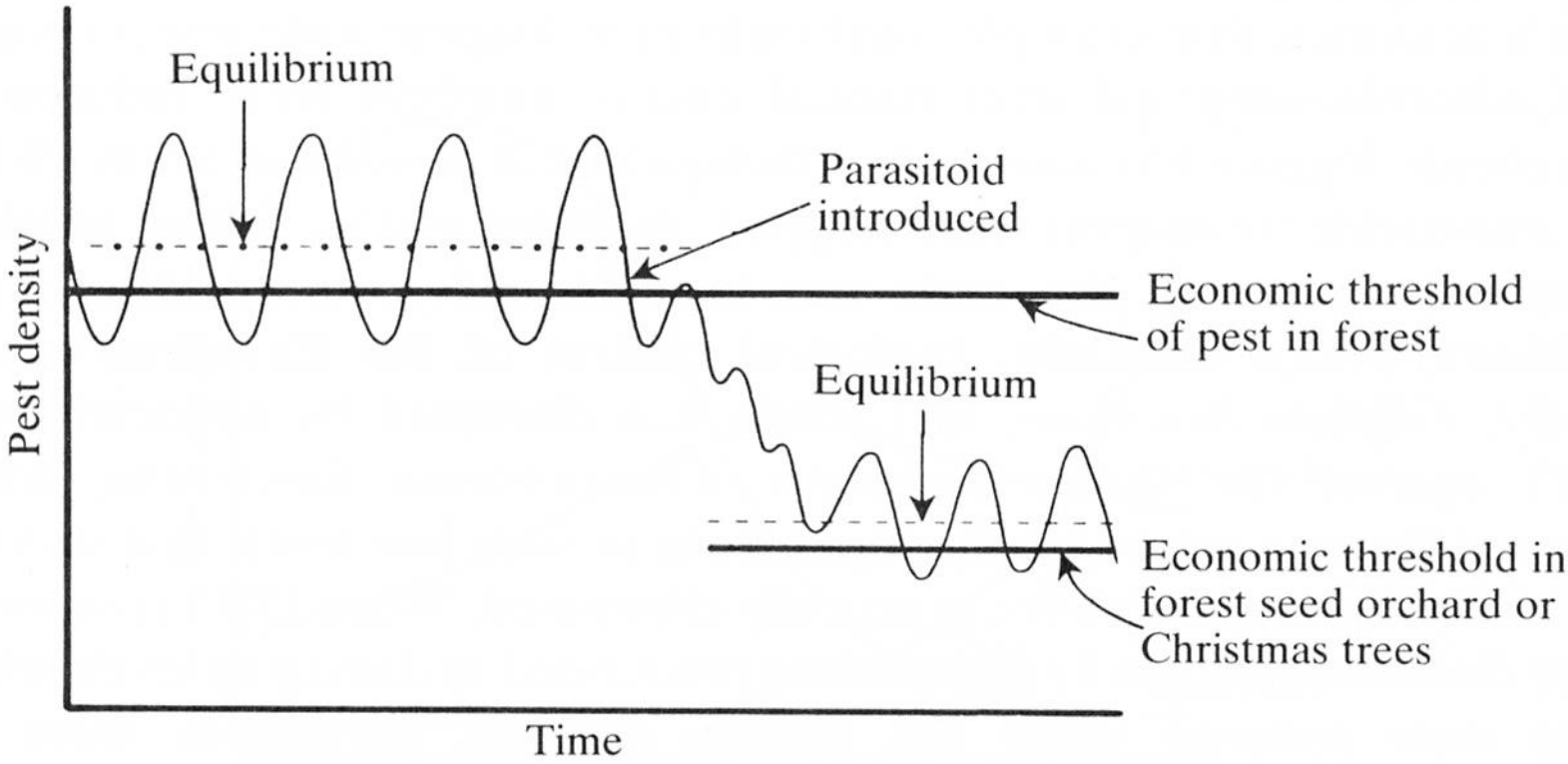


FIG. 7.2. A hypothetical example of biological control in relation to the economic threshold in a forest and in specialized forest crops. Control is achieved in the forest but not in the other crops where the economic threshold is lower (after Smith and van den Bosch 1967).

A case study: the natural enemies of the pine processionary moth *Thaumetopoea pityocampa*

Egg parasitoids: 3 major + 5 minor species
Egg predators: many occasional

Larval parasitoids: 1 major + 4 minor species
Larval predators: many insects, birds and mammals (hairs!)

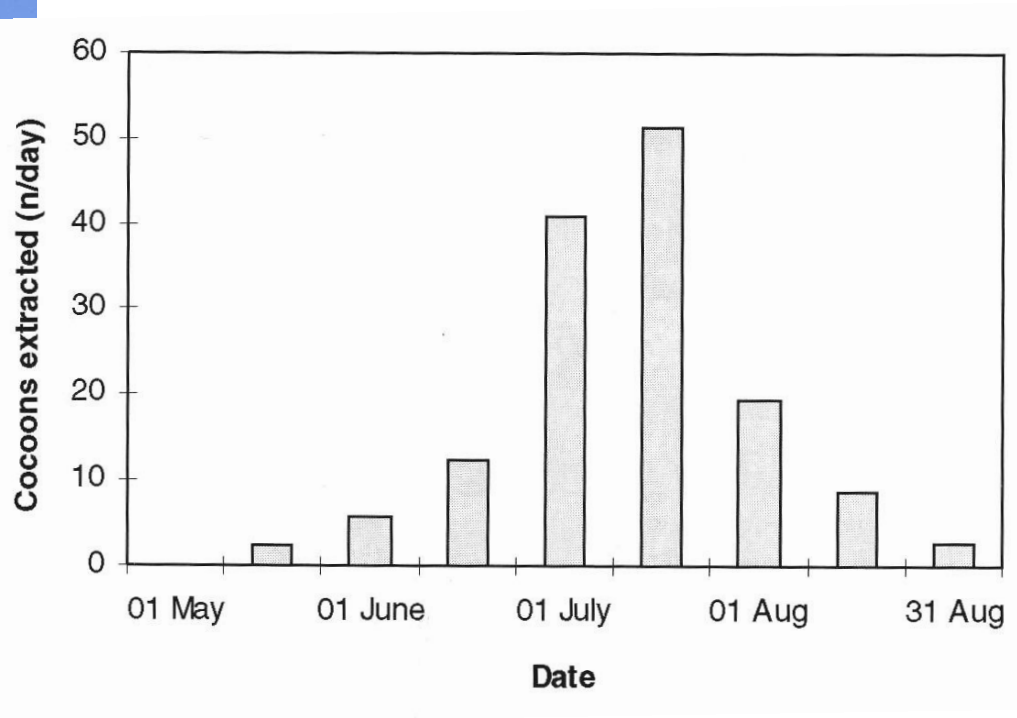
Pupal parasitoids: 1 major + 3 minor species
Pupal predators: 1 major and many occasional

Pathogens of larvae and pupae: 2 major and many occasional

Adult moth: many occasional (birds and mammals)

Experiment of manipulation of the access to predation: the hoopoe Upupa epops and the pine processionary moth Thaumetopoea pityocampa

Pupation site

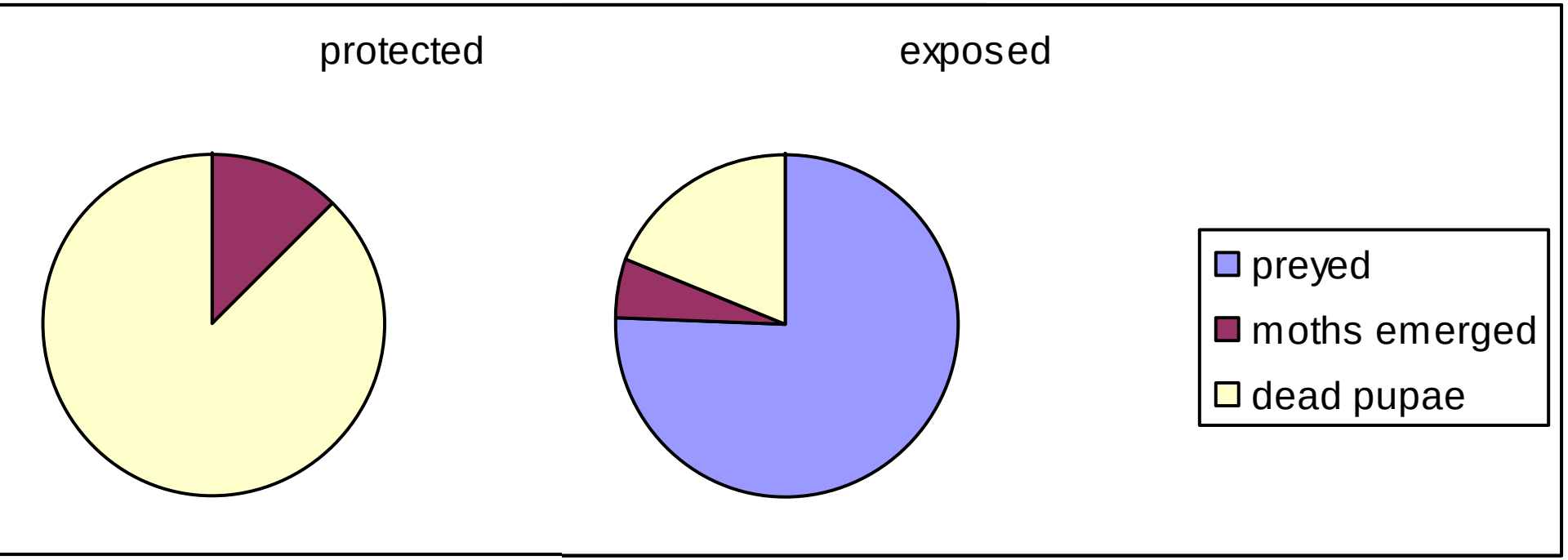


Cocoons extracted

Hoopoe preying on pupae

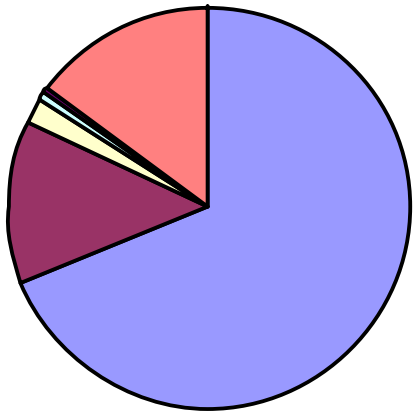
Holes in soil

- 20 sites protected from birds and 20 sites exposed
- counting emerging moths
- counting dead pupae

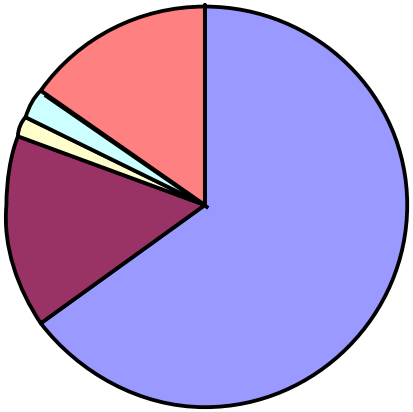


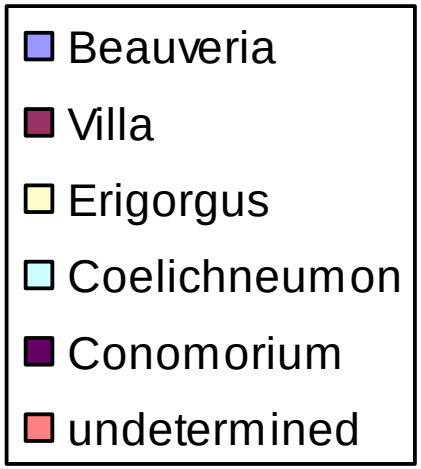
Mortality factors of pupae: fungi, insect parasitoids, insect predators

protected



exposed





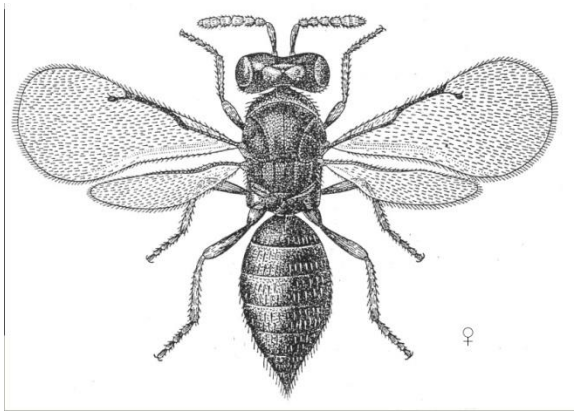
Biological control types

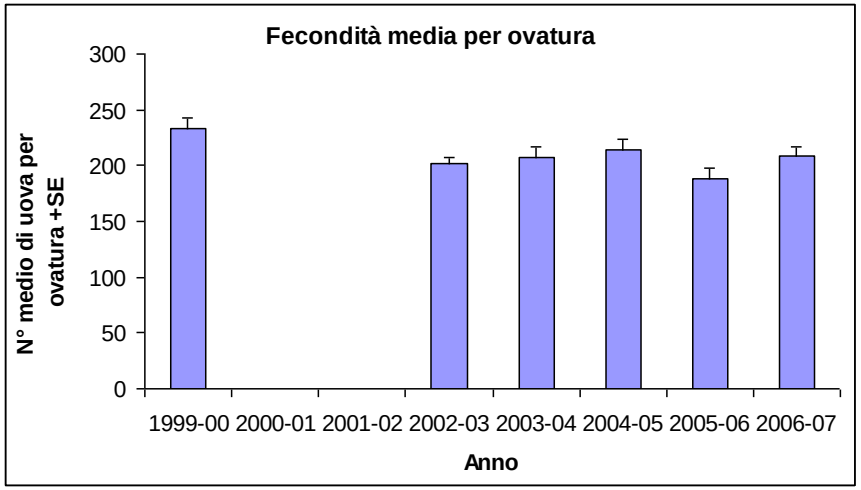
Table 7.2. *The ways in which natural enemies may be used in biological control programmes against insects (see text)*

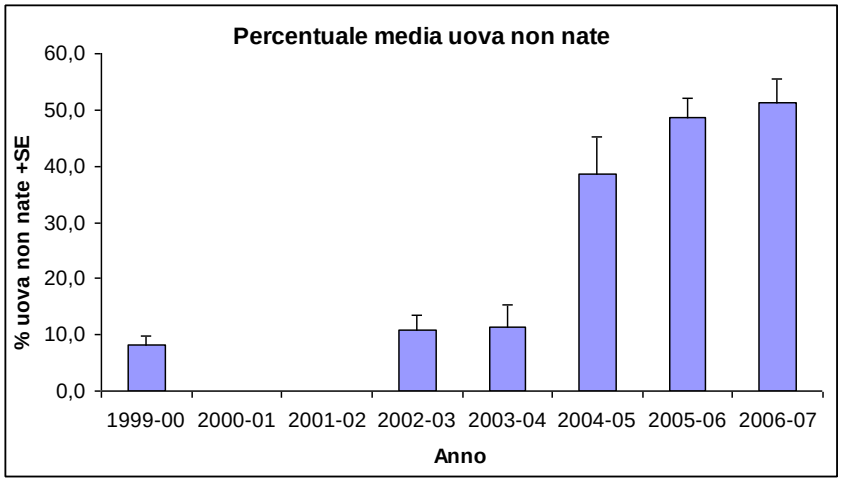
Host or prey	Natural enemy	
	Introduced	Native
Introduced	Classical biological control	Fortuitous control
Native	Fortuitous control From related hosts 'Adaptation importation'	Augmentation Conservation Inundation Intra-areal transfer

A case of augmentation control (native/native) in Italy: pine processionary moth and egg parasitoids in Venosta Valley

Occurrence of the egg parasitoid *Baryscapus servadeii*







Microbial control

Virus: nuclear polyedrosis virus (NPV)

Bacteria: Bacillus thuringiensis kurstaki (BTK)

Fungi: Beauveria bassiana

Nematodes: Steinernema spp.

Microbial control by Btk

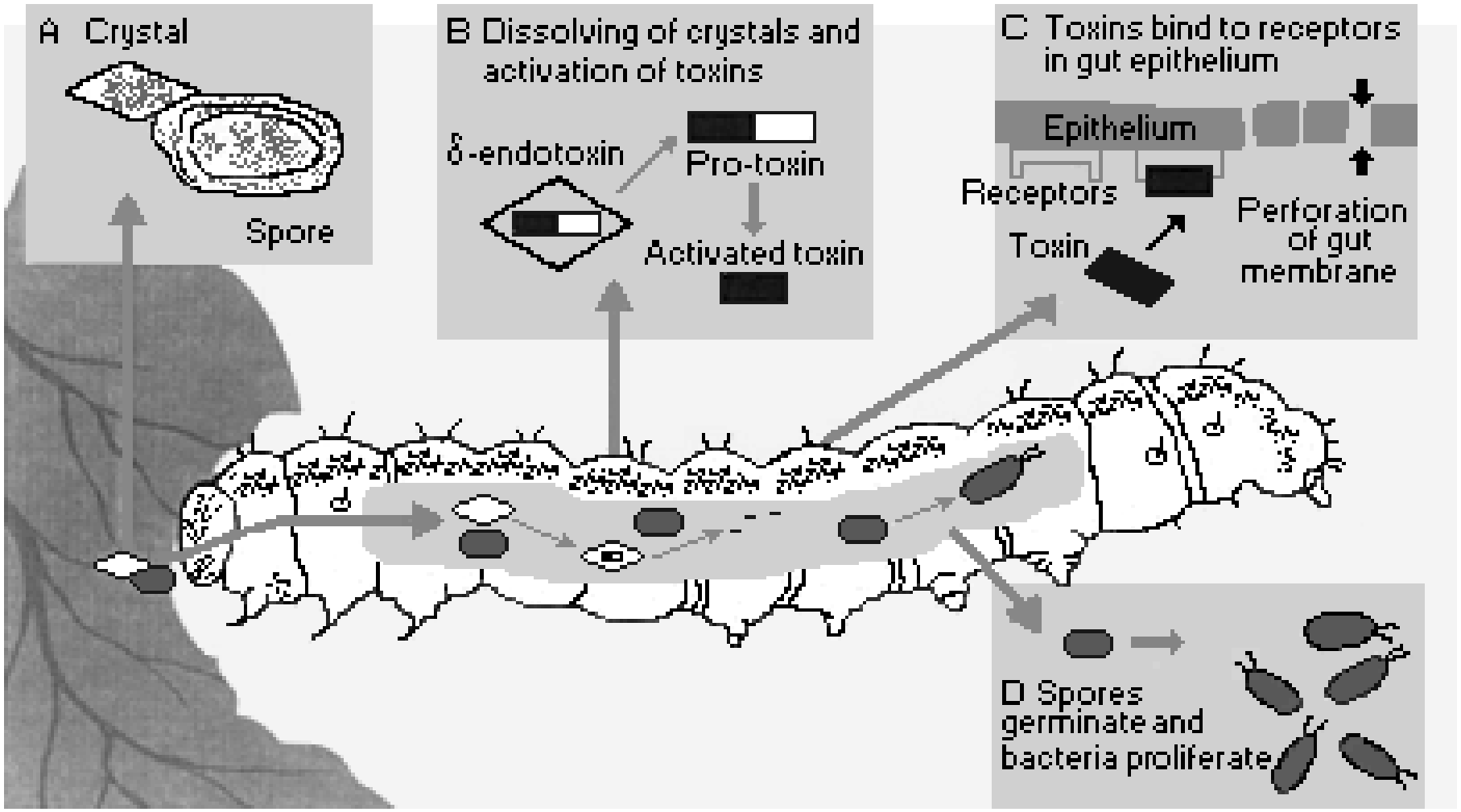


Fig. 1. Mechanism of toxicity of Bt

Examples of microbial control by Btk

Lymantria dispar – Sardinia cork oak stands:

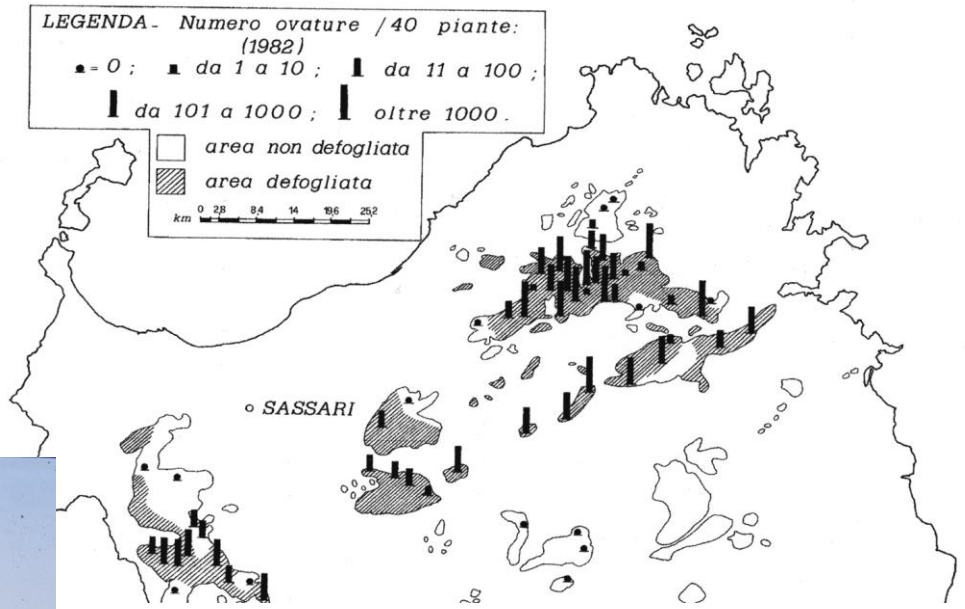
3000 - 14000 ha/year

Thaumetopoea pityocampa in pine stands:

500 – 1200 ha/year

Use of Btk against Lymantria in Sardinia (from Luciano et al. 2002)

Monitoring by assessment of egg density: threshold 100 egg masses / 40 trees

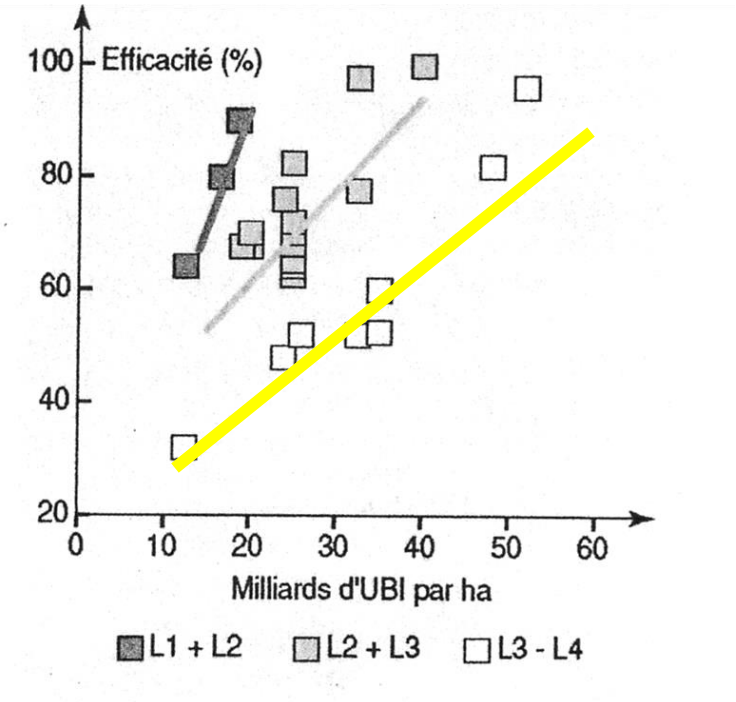


ULV (Ultra Low Volume) spraying from helicopter

Egg masses of Lymantria dispar on cork oak

Commercial products and dosage of Btk

The most commonly used in Europe is Foray, based on Btk strains producing different types of toxins, mainly cry 1A. Registration in Italy: Foray 48B (12 miliardi BIU/litro -Biological International Unit), dose 2 - 4 litre/ha.



Calculation of dose-mortality relationship in T. pityocampa, different larval age (Martin & Mazet, 2001)

The situation in Italy

- **Sprayed areas (see document Foray 48B)**

- **Limitations**

- **Cost/benefit**

- **Risks**

Cost Benefit Analysis of an insect outbreak in relation to climate change

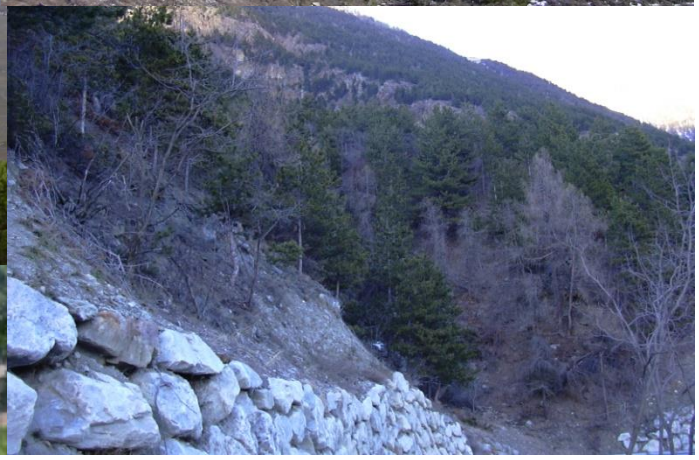
The Processionary Moth in the Venosta/Vinschau Valley (Northern Italy)

Main questions

1. Are strategies of Integrated Pest Management in pine forests sustainable from the financial and social point of views?

2. Does financial/social sustainability change if we take into account the possible effects of climate change and to what extent ?

Val Venosta/Vinschgau, Northern Italy



- Total area: 940 ha of Pine forests aged around 60-70
- none or very scarce importance for timber production
- planted with the main purpose of preventing soil erosion
- today important for tourism and landscape

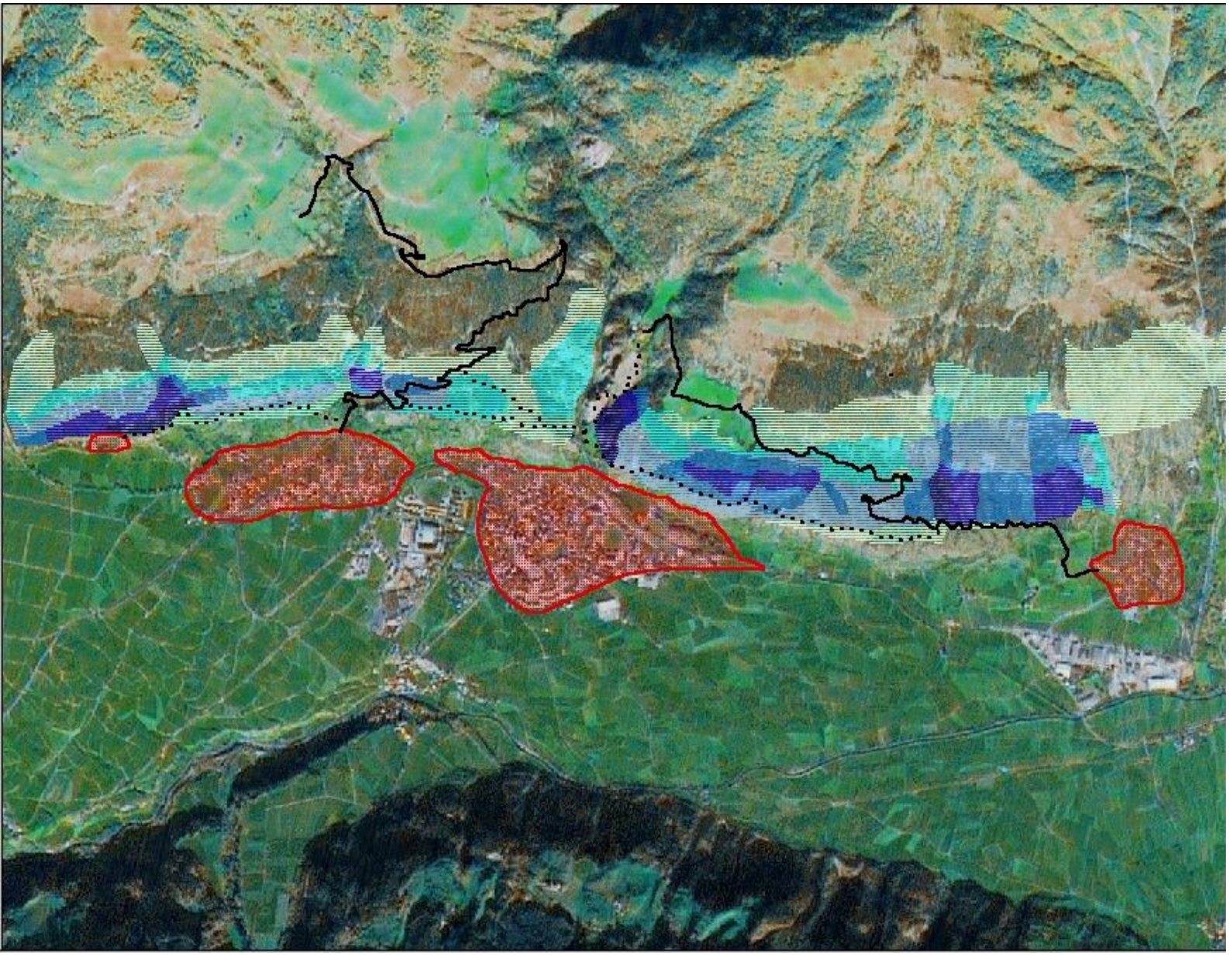
- From 1958 to 1995 nests were collected from tree using shears, then burned.

- From 1995 to 1998 nothing was done.

- Since 1999 the Forest Service has regularly carried out pest control using Btk sprayed by an helicopter.

- Everything is recorded: area treated and costs.

Area treated with Btk 1999 - 2007



Btk treatment

Relation-ship with human activity

Items considered in Cost-Benefit Analysis

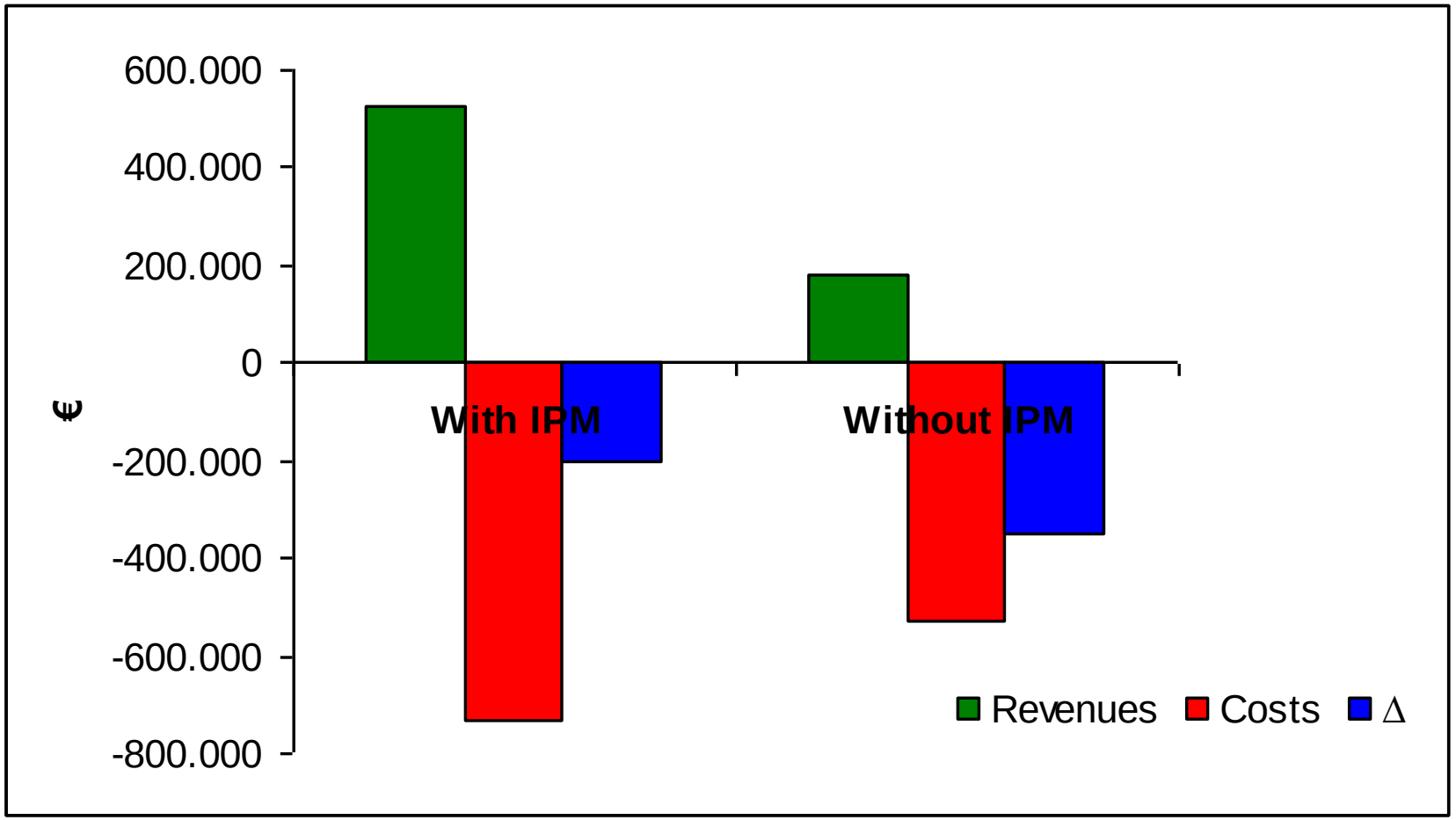
Financial sustainability

- Market revenues
  - Timber sold through thinnings
  - Maintenance of estate value
- Market costs
  - Forest management costs
  - Btk treatment costs

Alternatives compared under financial sustainability

- With IPM - the situation with the investment, Btk treatments
- Without – the situation without the investment

Time-span of the analysis 15 years, discount rate 2%



Items considered in Cost-Benefit Analysis

Financial sustainability

- Market revenues
  - Timber sold through thinnings
  - Maintenance of estate value
- Market costs
  - Forest management costs
  - Btk treatment costs

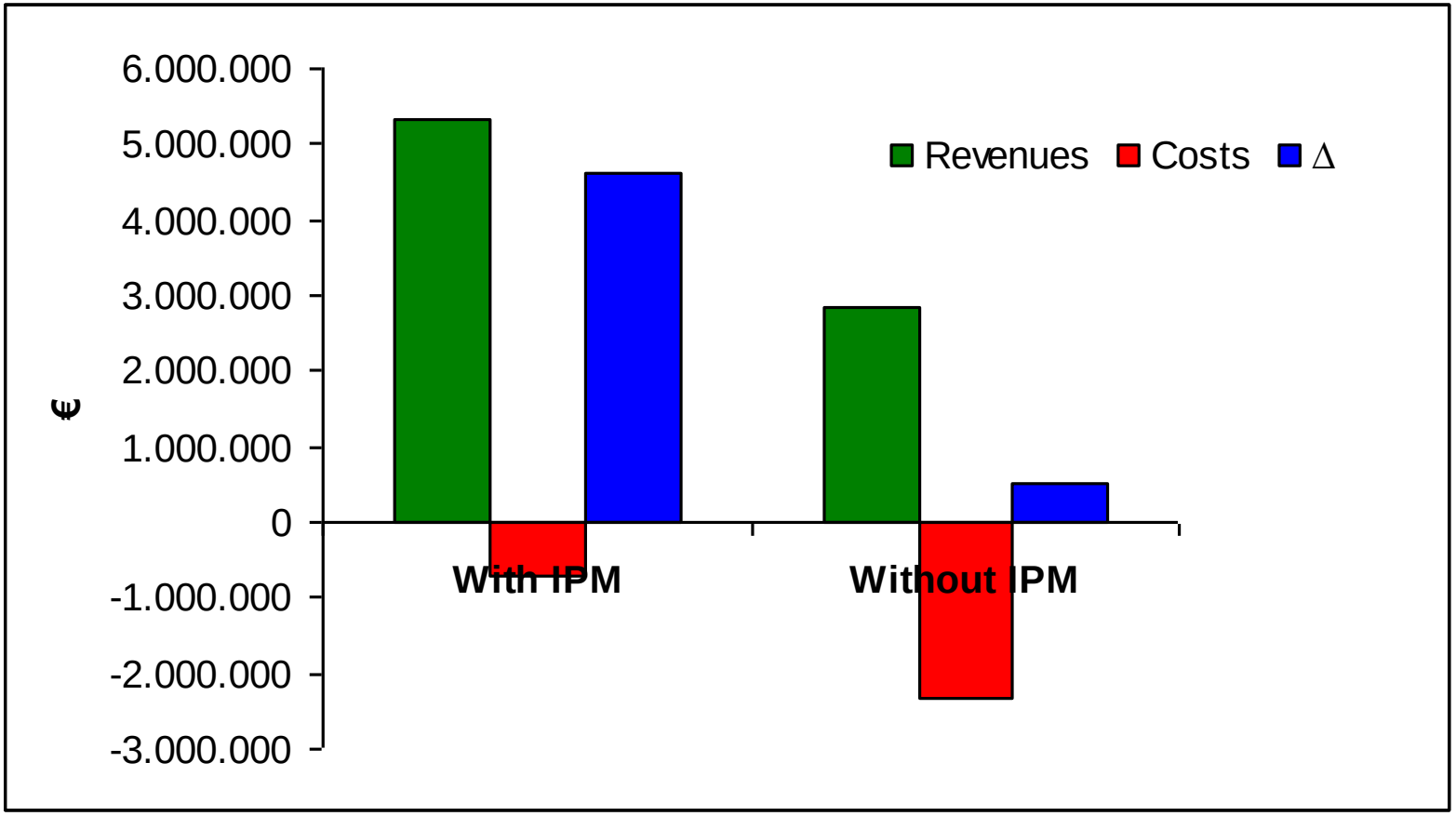
Social sustainability

- Social benefits
  - Hydrogeological protection
  - Carbon fixation
  - Recreational and landscape values
- Social costs
  - Risks to human health caused by larvae

Alternatives compared under financial and social sust.

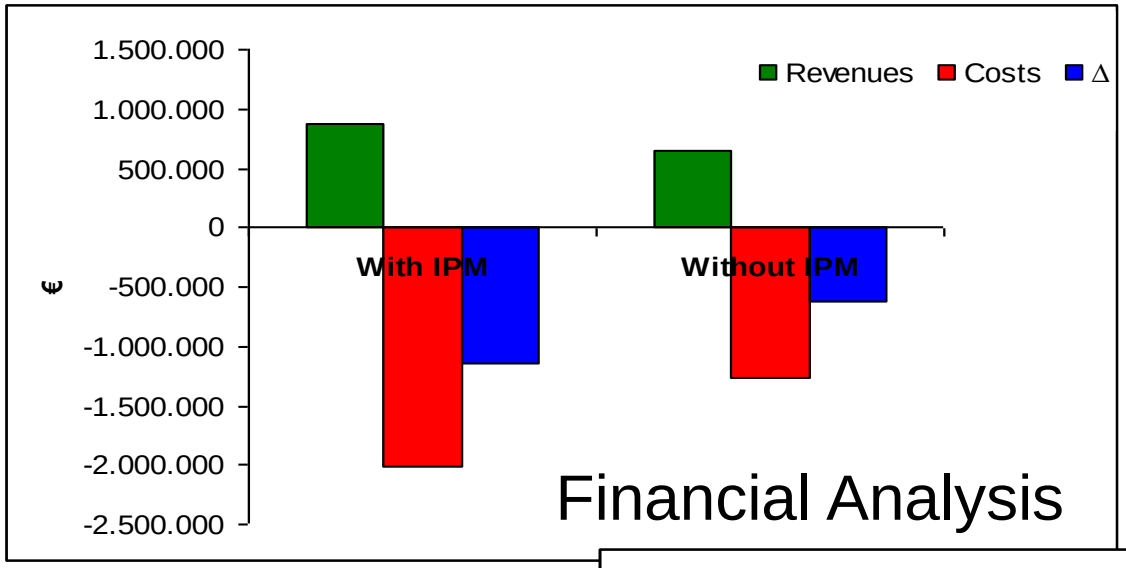
- With IPM - the situation with the investment, Btk treatments
- Without – the situation without the investment

Time-span of the analysis 15 years, discount rate 2%

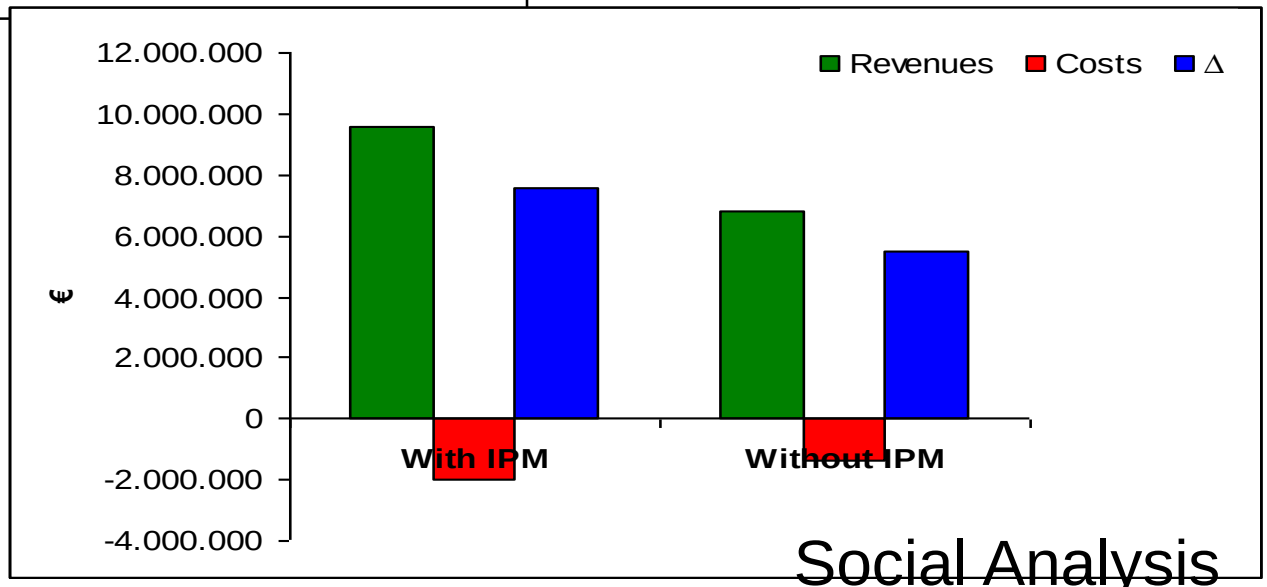


Alternatives compared under climate change scenario

The temperature increase of 1°C in the future will imply the expansion of both pine forest and processionary moth



Financial Analysis



Social Analysis

Conclusions

- with respect to the ‘business as usual’ situation, it appears that the increase of the pine area and of the area attacked by pine moth will be more costly to treat and therefore not financially sustainable

- there is a need of new cost-effective treatment systems

- pest control is always justified from the social point of view