BCPC Pests & Beneficials Review , 29 January 2020

Thresholds, risks and realities – lessons from the past to inform the future?

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AHDB

I P M

Integrated Pest Management

Monitoring Identify Sanitation

Exclusion Treatment Strategy Evaluation

Where are we with IPM implementation?

- To carry out research on pest management methods is one thing, to get the results **applied in the field by commercial growers** is quite another.
  - **Just doing the research is not enough**

- This is illustrated by the **relatively low number of pest management methods actually used by growers** in their regular cropping practice when compared with the number of pest management methods which are potentially useful.
  - **Much research has been done, relatively little of it has been applied in practice.**

This was 1985

J Theunissen & H van Ouden, 1985. ***Progress on Pest Management in Field Vegetables.*** Edited by R. Cavallo.

Can we measure if we have moved on?

2000: Finch & Collier – QUALITATIVE?

- Improvements in **insecticide application**, **supervised control**, and **pest forecasting systems** have helped to reduce the amount of insecticides **required** to control vegetable pests.
- By growing **plants that are partially resistant** to certain major pests, it is now **possible** to apply even less insecticide than the dose recommended for the crop.
- In crops where only small amounts of insecticides are applied, natural predators **should** prevent large increases in pest insect populations.

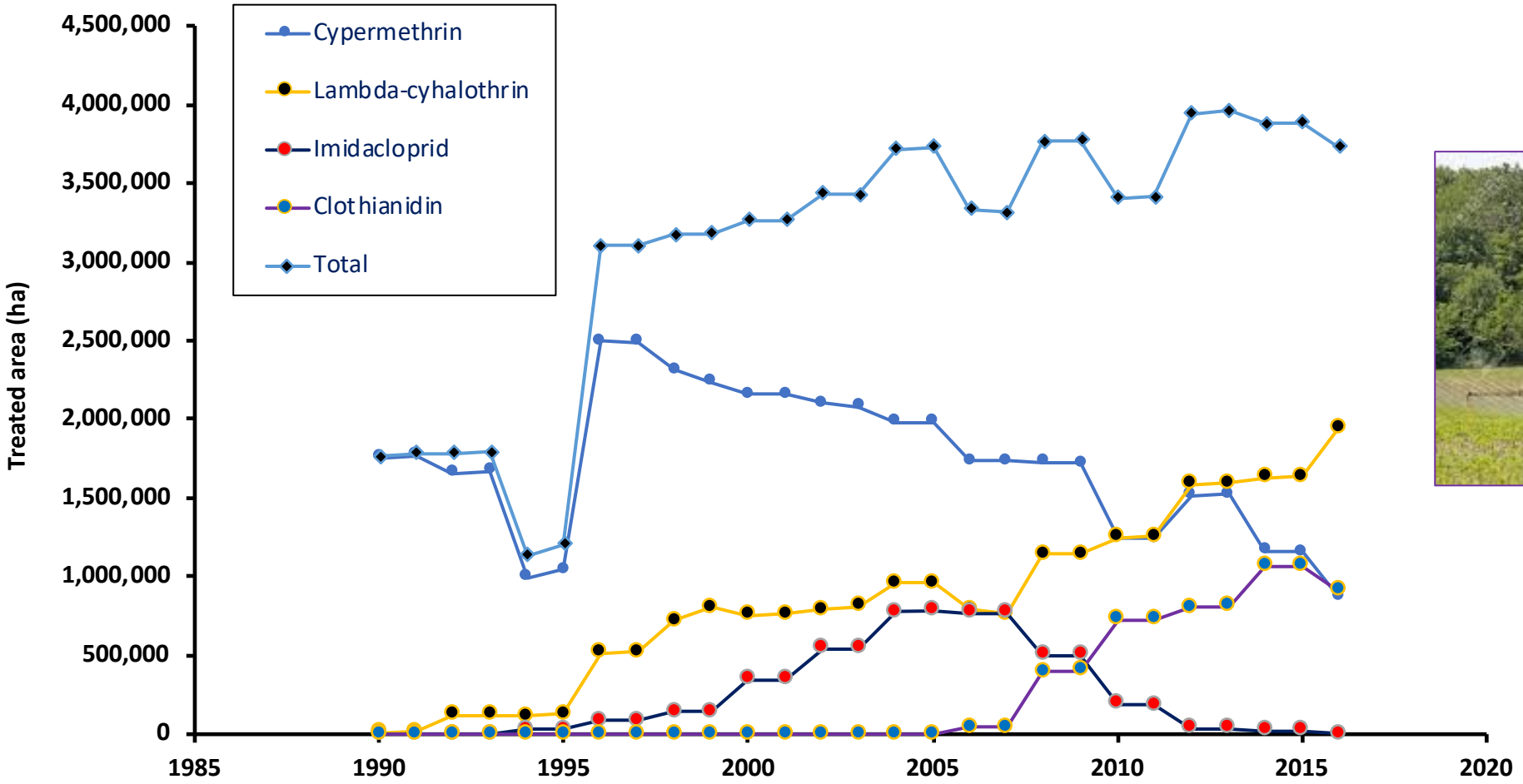
Finch, S & Collier, R 2000. Integrated pest management in field vegetable crops in northern Europe – with focus on two key pests. *Crop Protection* **19:** 817-824

2019: Creissen *et al*. - QUANTITATIVE

- A **significant deficit exists in the ability to practically monitor and measure IPM adoption** across arable farms.
- Established a **universal metric** for quantifying adoption of IPM in temperate arable farming.
- Survey results: all farmers had adopted IPM to **some extent** (mean score of 65/100), but only 13 of 225 farmers (**5.8%)** had adopted more than 85% of what is theoretically possible.

Creissen *et al*., 2019 Measuring the unmeasurable? A method to quantify adoption of integrated pest management practices in temperate arable farming systems**.** *Pest Management Science* **75:** 3144-3152.

UK Insecticide usage: 1990 – 2016 (all crops)

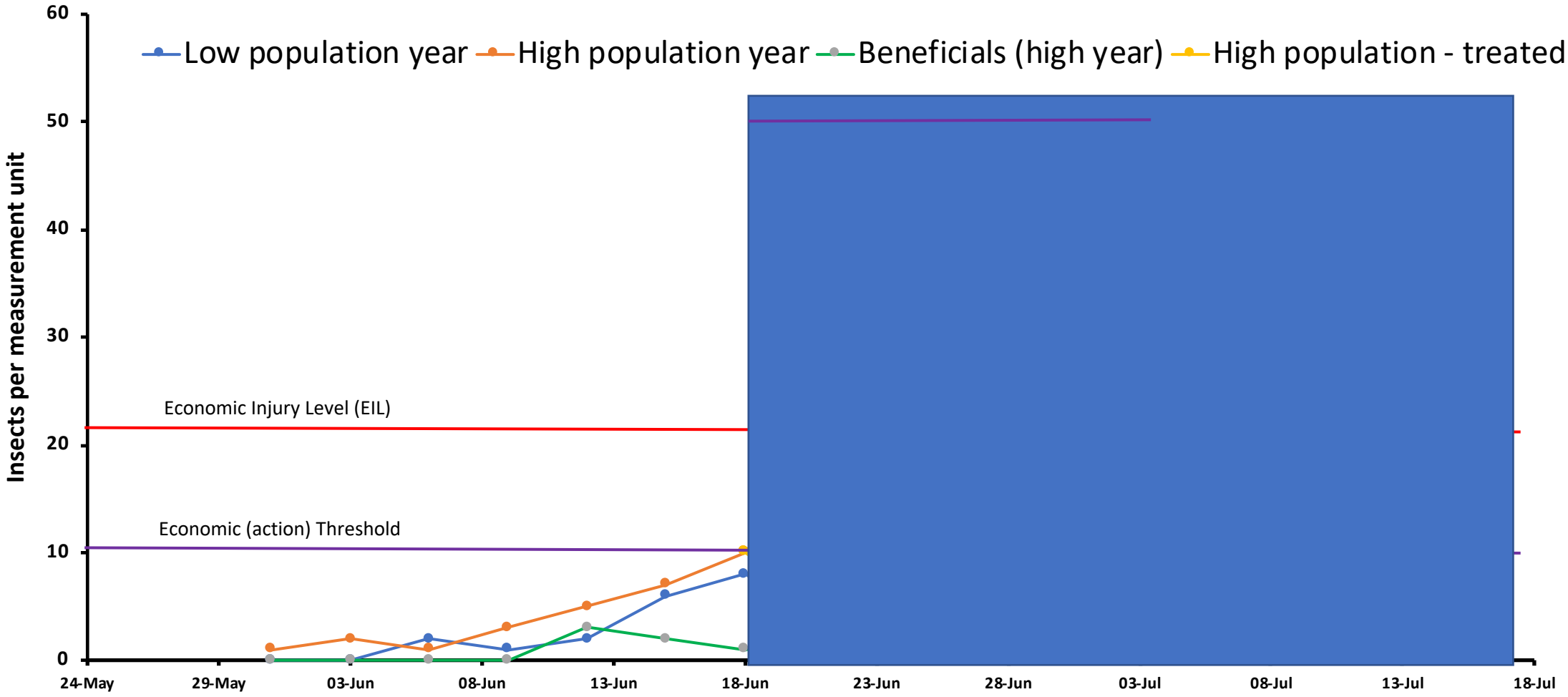


Source: Official Pesticide Usage Survey data

Thresholds – a key tool that needs metrics

- **Economic Injury Level (EIL):**
  - The smallest number of pests (amount of injury) that will cause yield losses **equal to** the pest management costs.
- **Economic (action) threshold (ET):**
  - The pest density at which management action should be taken **to prevent** an **increasing** pest population from reaching the EIL.
- **Establishing an ET is hard work:**
  - It incorporates the EIL.
  - Need to understand pest population dynamics & relationship with yield loss & crop phenology in the specific crop.
  - Practical aspects of management tactics all have to be considered when establishing ETs

Threshold concepts in practice

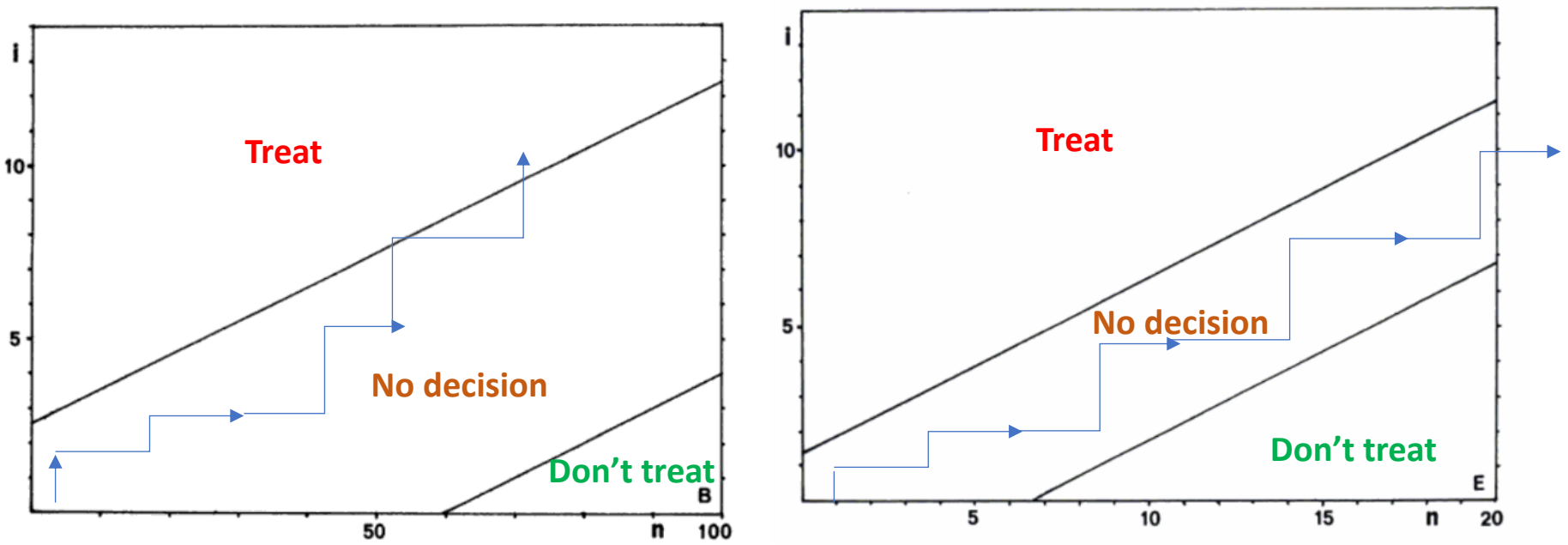


Fixed-precision sequential sampling plans: Supervised Control of Brussels sprouts pests

Threshold: 10% plants infested

Threshold: 50% plants infested

Accumulated number of infested plants

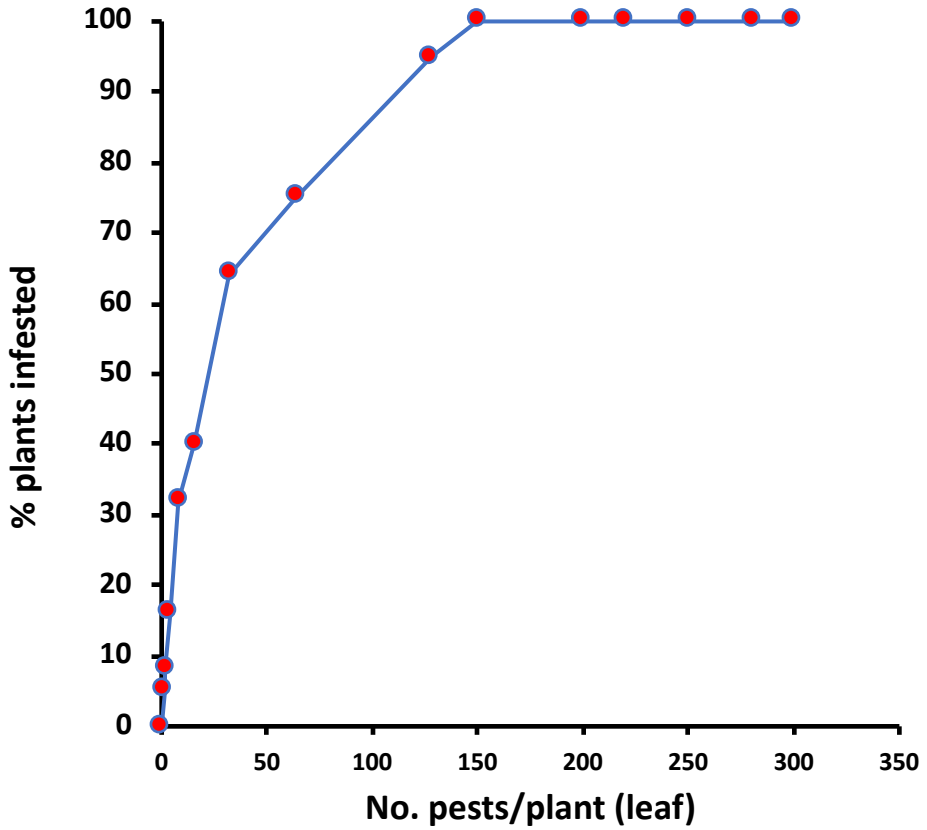


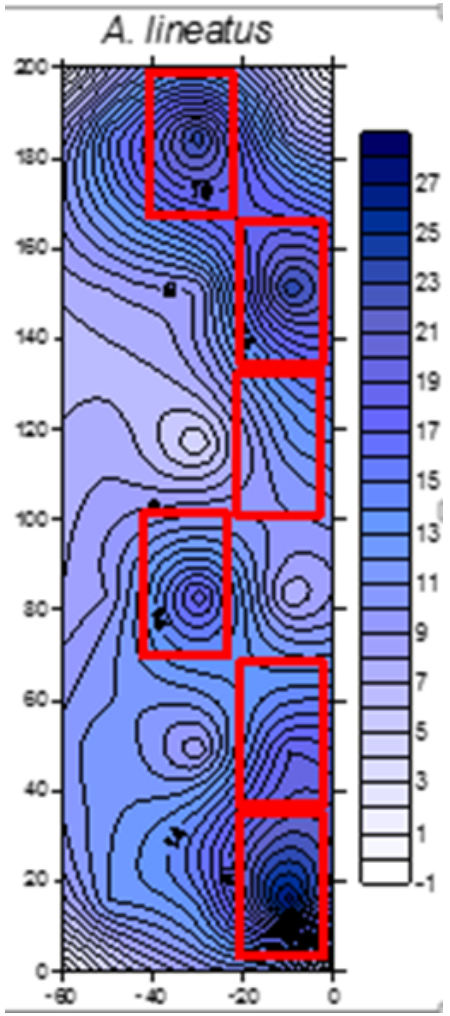
Accumulated number of plants sampled

NB: You can't eliminate mistakes entirely: Type I error: False positive; **Type II error:** False negative

..and the ‘where’ - spatial distribution?

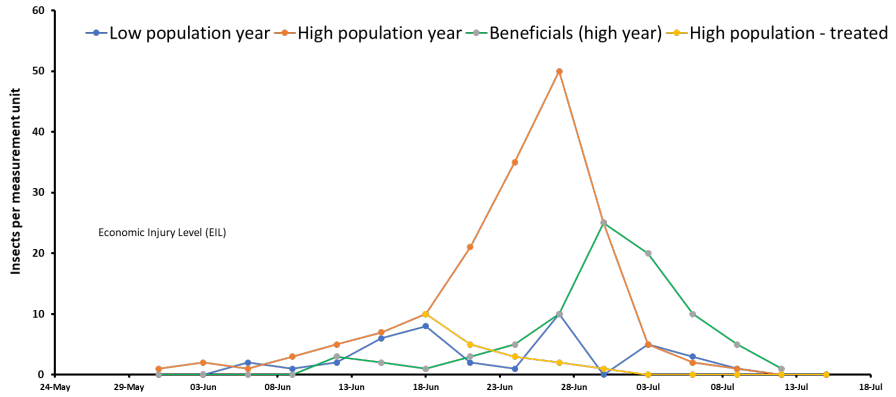
- How are the pests distributed and does this change with time?
  - Aggregated/random?
  - Edge effects?
- Taylor’s Power Law
- SADIE
- Other geostats

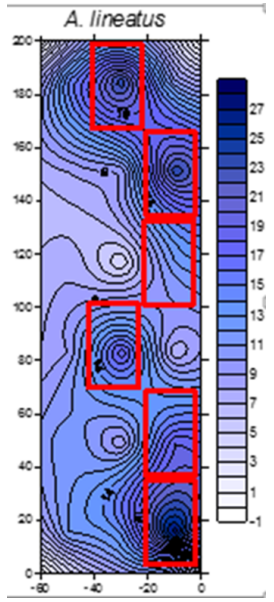


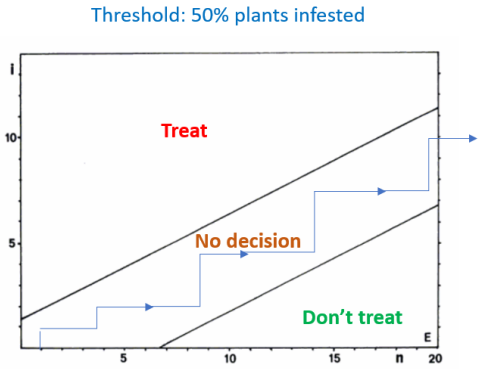


Thresholds – a complex & risky business

- **Are thresholds always appropriate?**
  - Yield vs quality?
  - Crop survival vs acceptable/recoverable damage
  - Virus transmission vs direct damage
- **Do we know <u>what</u> we are looking for and <u>why</u>?**
  - Eggs, larvae, adults?
  - Economic damage vs population level relationship (ET/EIL)
  - Crop compensation effects?
- **Do we know <u>when</u> to look for it?**
  - Pre-cropping, in the crop (growth stage?) or post-crop?
- **Do we know <u>where</u> to look for it?**
  - On the plant, in the soil, in the air?
  - Which part of the field?
- **Do we know <u>how</u> best to look/assess?**
  - What are the practicalities & economics of sampling and do they stack up?
- **Do we understand the <u>risks</u> & <u>trade-offs</u>?**
  - What else is affected by controlling this pest (in this way)
  - Effects on beneficials
  - Cost:benefit analysis







Yield loss caused by cereal aphids

- **The 'accepted' wisdom – a simple action threshold:**
  - 5 aphids/ear at flowering (GS 61) *and increasing* (Ken George, 1975/1979).
  - Subsequently adjusted to 66% tillers infested.
  - *Thought* to cause around 20% yield loss….
  - Any relevance to today's wheat varieties?
- **Was/is this good enough?**
  - Large differences between potential and achieved profits
  - Value of insecticide treatment varies with time course of infestation
  - Value of forecast depends on its timing & accuracy, the size of the aphid outbreak & its probability of occurrence.
  - …and BYDV?

Watt, A D, Vickerman, G P & Wratten, S D (1984). The effect of the grain aphid, *Sitobion avenae*, on winter wheat in England: an analysis of the economics of control practice and forecasting systems. *Crop Protection* **3** 209-222.

Yield loss caused by cabbage stem flea beetle

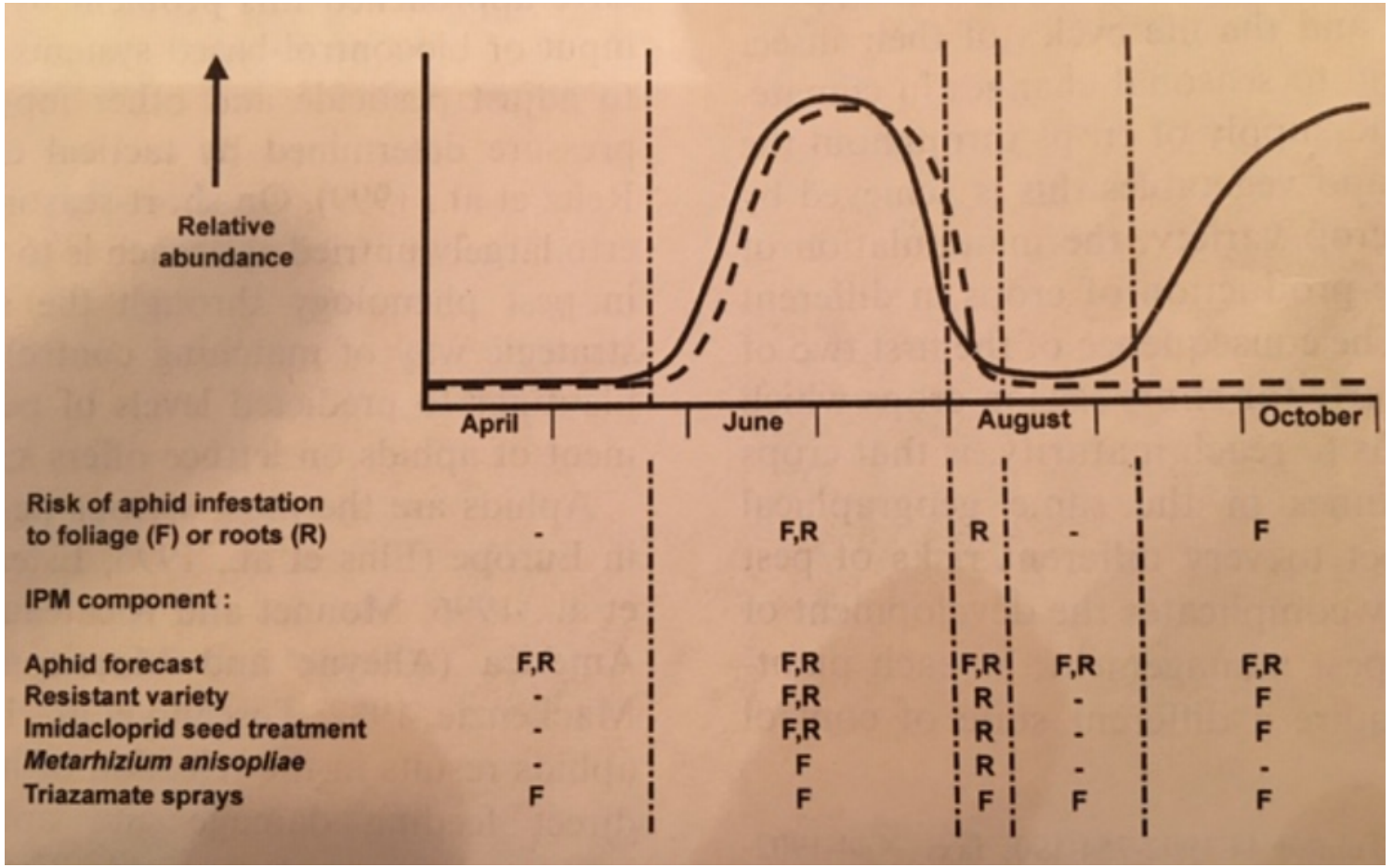
- **The accepted wisdom – a simple action threshold:**
  - NB – there is/was a model for predicting egg hatch
  - 3-5 larvae plant in the late autumn – plant dissection
  - Subsequently adjusted to a measure of petiole scarring - visual
  - *Any relevance to today?*

- **Larval damage? We should be so lucky!**
  - NIAB/TAG Survey: 13% crop failure in 2018, 29% in 2019.
  - The timing of adult invasion varies considerably from year to year, being influenced mainly by temperature.
  - Early-germinating crops tend to be invaded earlier than later-germinating ones.

Alford, D V 1979. Observations on the cabbage stem flea *beetle, Psylliodes chrysocephala*, on winter oilseed rape in Cambridgeshire. *Annals of Applied Biology* **93:** 117-123

Currant-lettuce aphid & Lettuce root aphid

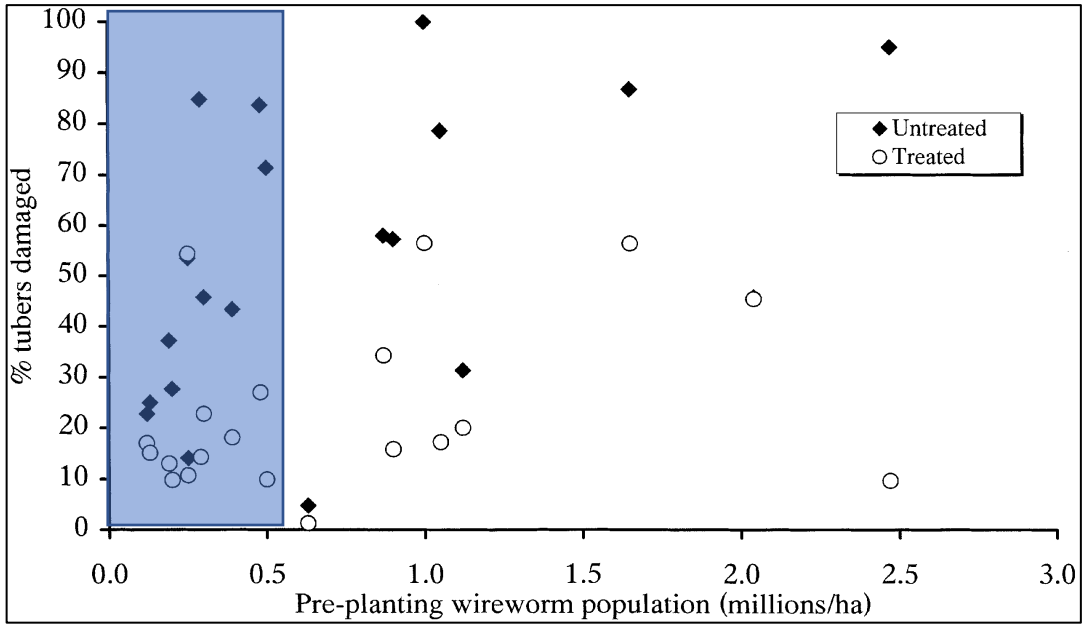
- Quality & yield….but zero tolerance of contamination
- Aphid risk varies through the year
  - Different plantings have different risk levels
  - Different control measures could be applied based on risk
- Forecasting more important than thresholds



Parker, W. E., Collier, R. H., Ellis, P. R., Mead, A., Chandler, D., Blood Smyth, J. A., Tatchell, G. M. (2002). Matching control options to a pest complex: the integrated pest management of aphids in sequentially-planted crops of outdoor lettuce. *Crop Protection* **21** pp 235-248.

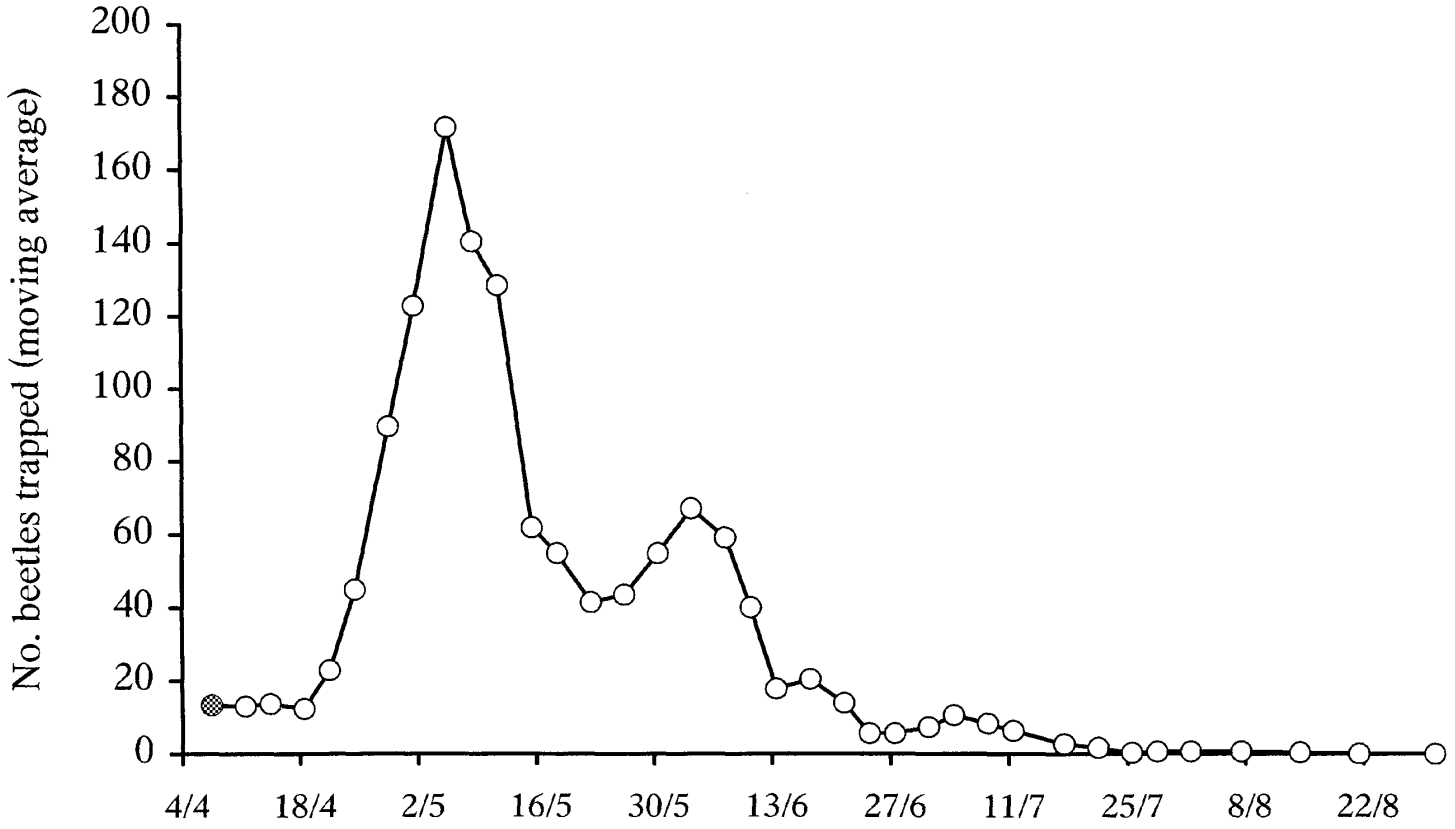
Soil sampling for wireworms (on potato)

- Developed in 1940s
  - OK for high populations
  - Very unreliable for low populations
- There is a lot of soil out there!
  - Big sampling issue
  - Ideally needs lab processing
- Reality check!
  - Poor correlation between what you find and subsequent damage levels
- Risks
  - You can miss damaging populations
  - There is no in-crop control
  - Risk assessment requires everything we've got



Seasonal click beetle pheromone catch profile

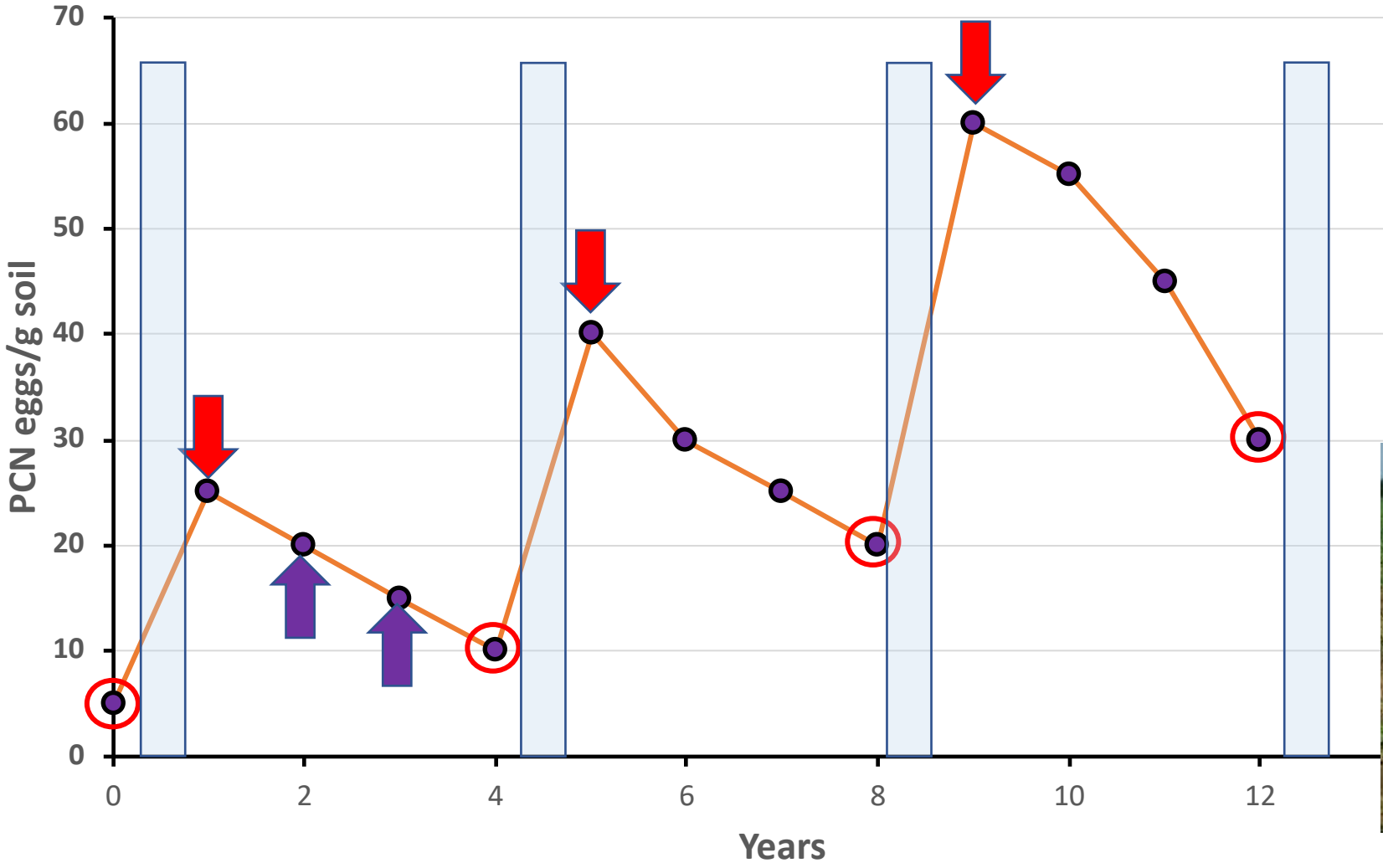
Llanafan (2000)



Season-long trapping is NOT the best way of doing it

Parker, W E & Howard, J J 2001. The biology and management of wireworms (*Agriotes* spp.) on potato with particular reference to the United Kingdom. *Agricultural & Forest Entomology* **3** pp 85-98.

Potato cyst nematodes – timescale, tactics & strategy!



Thresholds – so what have we learned?

- **Are thresholds always appropriate?** → **No:** depends on the type of pest/crop relationship, what level of control is required etc etc.
  - Yield vs quality?
  - Crop survival vs acceptable/recoverable damage
  - Virus transmission vs direct damage
- **Do we know <u>what</u> we are looking for and <u>why</u>?** → **Yes - but:** practicalities may mean that you need to measure a 'proxy'; hard to figure out the ET/EIL.
  - Eggs, larvae, adults?
  - Economic damage vs population level relationship (ET/EIL)
- **Do we know <u>when</u> to look for it?** → **Yes:** but could be improved a lot for some pest/crop combinations
  - Growth stage?
  - Pre-cropping, in the crop or post-crop?
- **Do we know <u>where</u> to look for it**? → **Depends:** on the plant – generally yes. In the field – sometimes not obvious, particularly soil pests.
  - On the plant, in the soil, in the air?
  - Which part of the field?
- **Do we know <u>how</u> best to look/assess?** → **No:** much work done on sampling strategies but remain a fundamental practical stumbling block.
  - What are the practicalities & economics of sampling and do they stack up?
- **Do we understand the <u>risks</u> & <u>trade-offs</u>?** → **Up to a point:** this is the 'I' in IPM but the complete integration of pest, disease and weed control requires much more attention.
  - What else is affected by controlling this pest (in this way)
  - Effects on beneficials?

So do we have decent thresholds for UK arable pests?

- **1986: Internal review by ADAS Entomology**
  - Most thresholds either have no published scientific evidence to support them or are based on old, unpublished data.

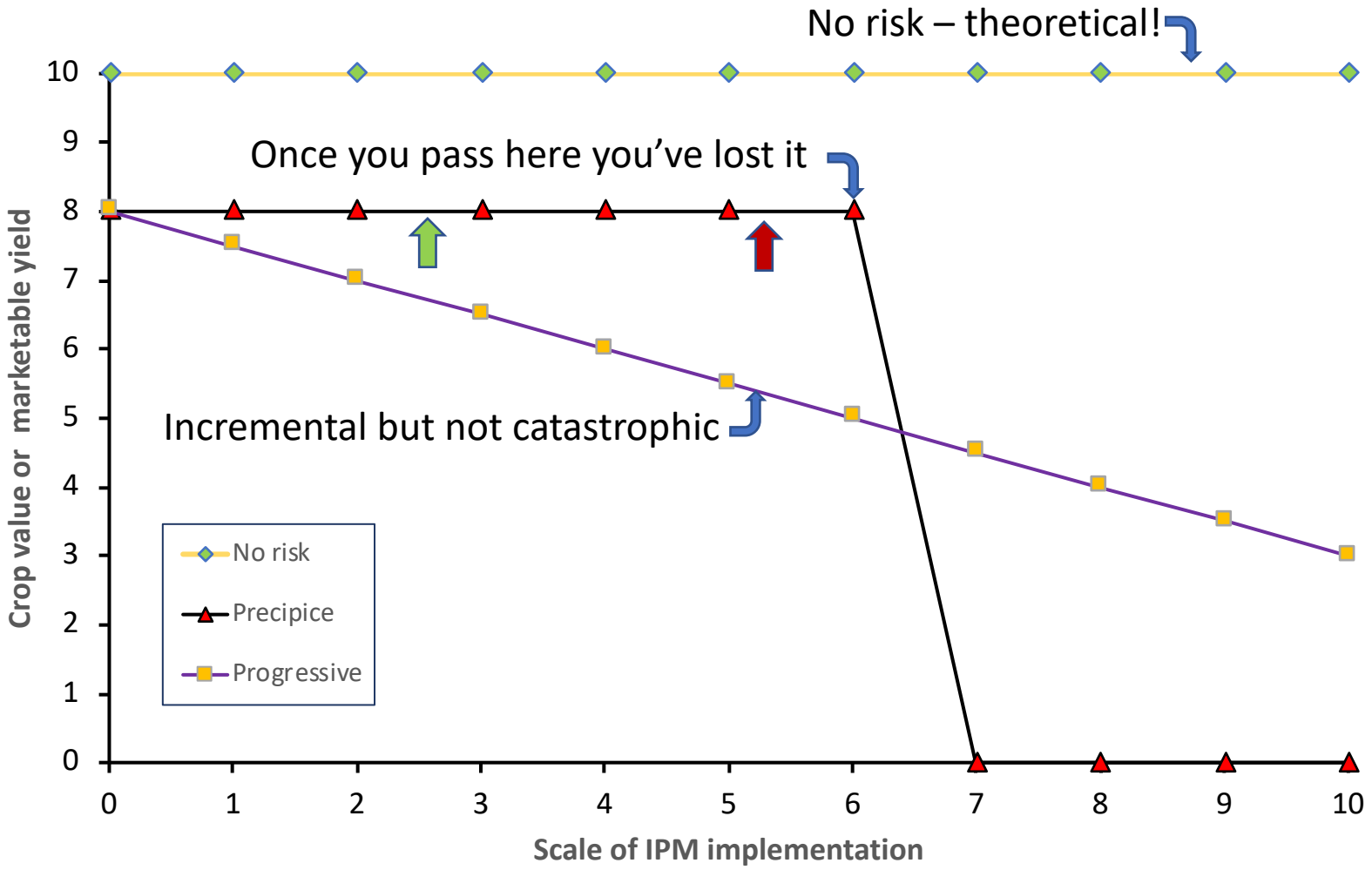
- **2017 (30 years on): Ramsden *et al*., (2017)**
  - Most current economic thresholds for pests of arable crops are not based on published evidence.
  - Few account for the ability of crops to tolerate pest damage, or the amount, or type of crop damage that pests can cause.
  - Many of the methods of pest assessment are impractical and do not guarantee sufficiently accurate estimates of pest abundance.

Ramsden, M, Kendall, S, Ellis, SA, Berry, PM 2017. A review of economic thresholds for invertebrate pests in UK arable crops**.** *Crop Protection* **96: *30-43***

Realities

- Control of foliar insect pests on major arable crops has been too cheap to justify the use of thresholds as a decision-making tool.
  - A low-risk approach has been widespread though not universal
  - The consequences have been serious – but have taken time to show.
- Soil pests are a somewhat different story, but problems remain
  - The higher cost of control has justified more focus on risk assessment.
- Sampling time/cost has been (and probably remains) the biggest single barrier.
  - The practicality/accuracy of traditional sampling methods has not been good enough.
- Developing robust, dynamic thresholds that reflect a genuine cost:benefit analysis is difficult and complex.
  - This has been under-researched and under-funded over many years – but largely because the pests were (until recently) easily & cheaply controlled.

Risk: how much would you take?



Risk 'appetite' will vary with:

- Crop type – yield or quality
- Likely value of crop
- Perceptions of farmer/grower
- Perceptions of agronomist
- 'Efficacy or otherwise of control options
- The extent to which controls are curative
- Everyone will be different

How do we mitigate the risk?

So where is the future?

- **Need to take what we have learned**
  - But apply it differently
- **Judging risk is a combination of experience and data**
  - On-farm 'experience' needs to be measured, pooled and analysed
  - 'Big data' analytics will be required
- **Data, data everywhere but what is really useful?**
  - Where are we data poor where being data rich would enable a better decision/risk calculation?
- **Farmers, growers & agronomists must have confidence**
  - Data sharing is the way forward but issues of ownership, trust and commercial sensitivity need to be resolved.
  - Who does the analysis?

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Another lesson from history?

- Implementation of almost everything in commercial growing depends on cooperation between the researcher, the agronomist and the progressive farmer/grower.
- The researcher must respect the risks taken by the agronomist –– the agronomist carries the risk of failure after all.
- New methods must be technically sound and feasible for the farmer/grower i.e. as simple and short as possible. Possibly less critical if benefits are large.
- Cost:benefit analysis is required
- Growers/Farmers will be increasingly seen as ‘progressive’ if they reduce pesticide use

J Theunissen & H van Ouden, 1985. P*rogress on Pest Management in Field Vegetables.* Edited by R. Cavallo.