Quantitative analysis tools for phytosanitary measures: a perspective from South America

Ricardo B. Sgrillo

CEPLAC/CEPEC
Brazil

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- Phytosanitary Measures
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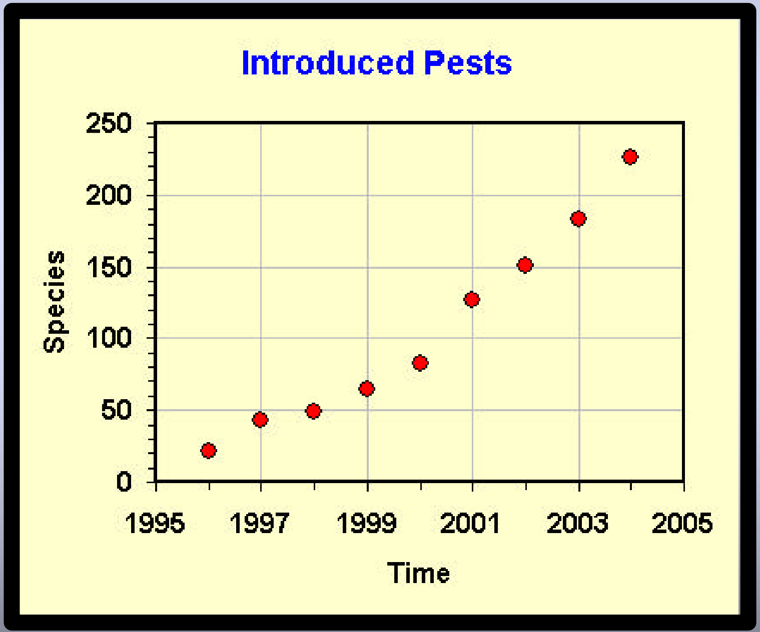
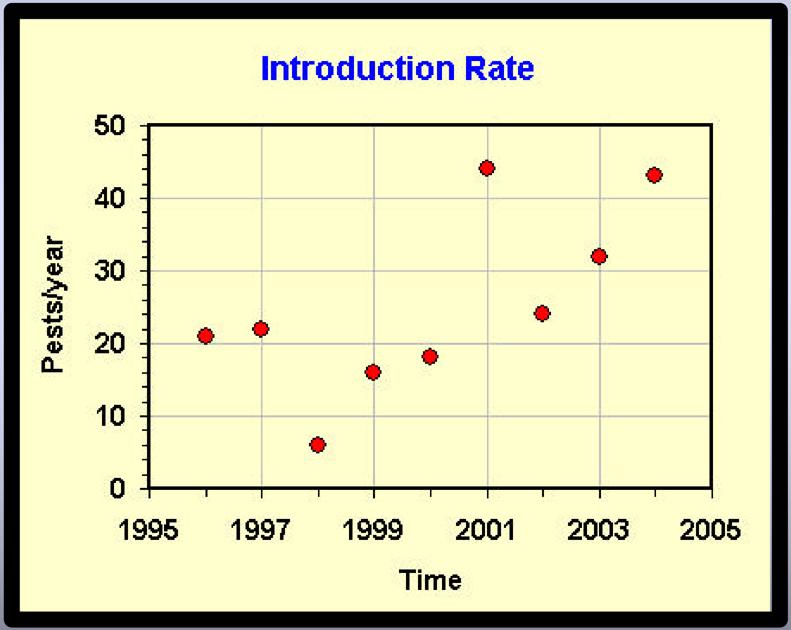
  - Detection

A Global Model

In spite of efforts done by IPPC and by many countries the rate of introduction of quarantine pests is increasing.

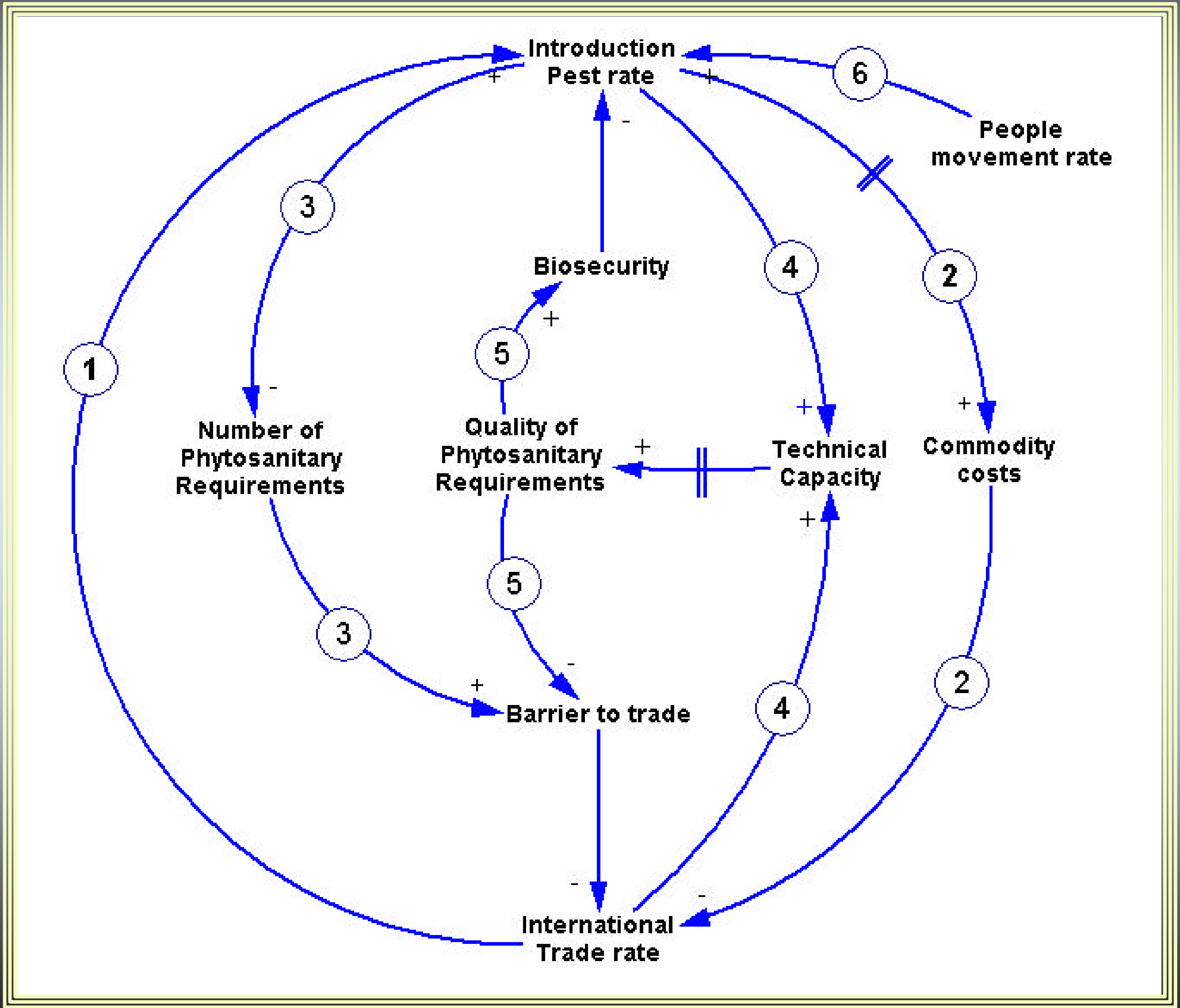




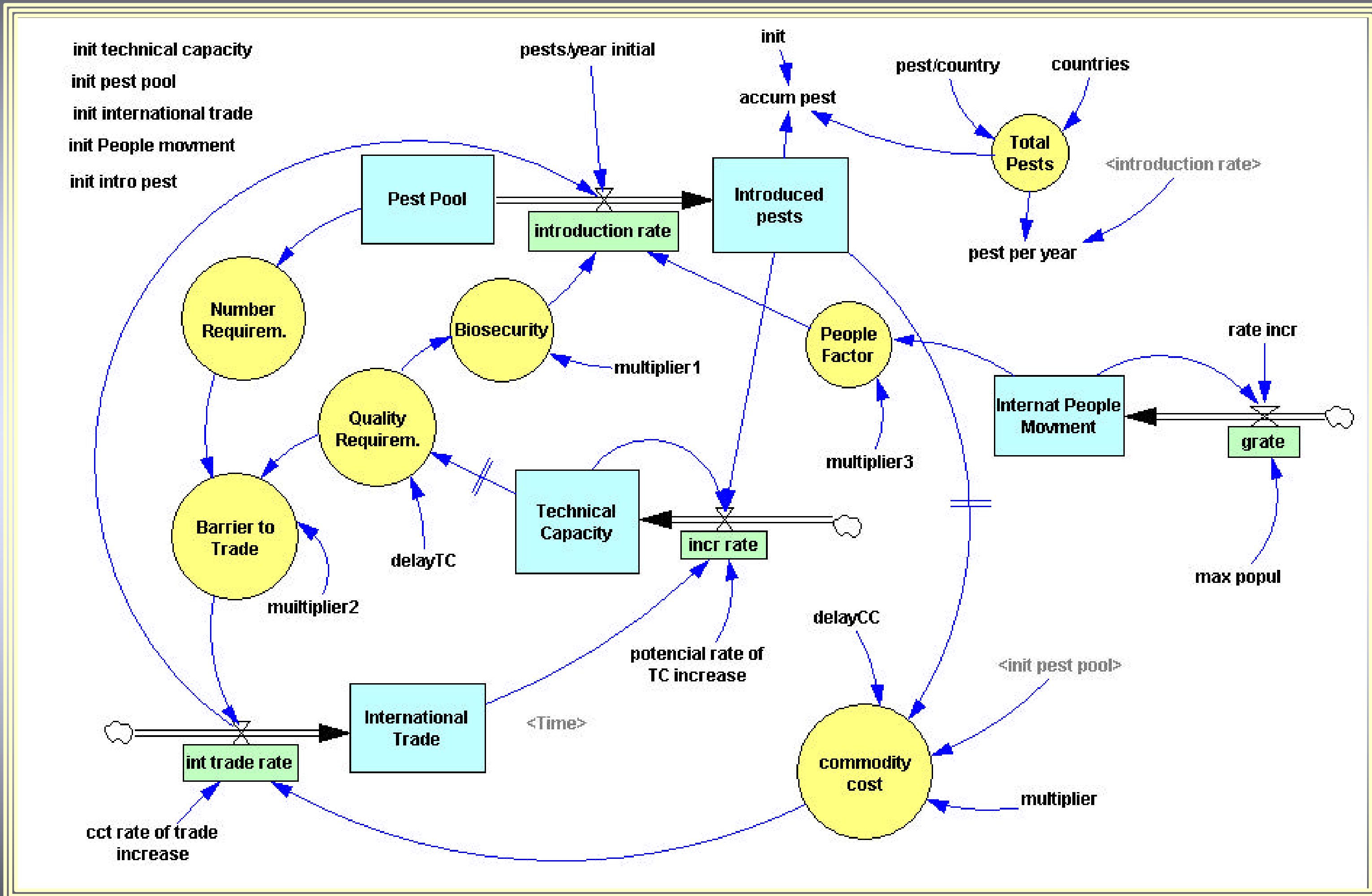
EPPO Service Reporting publication from 1996 to 2004

Why ?

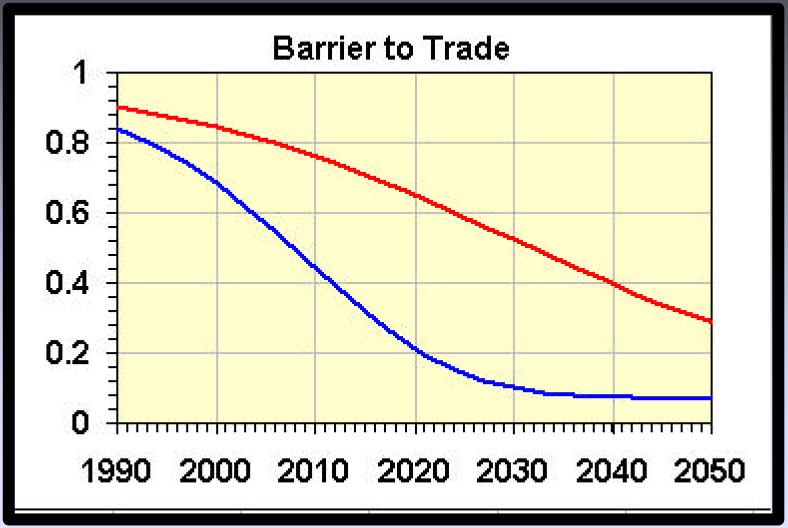
The Conceptual Model

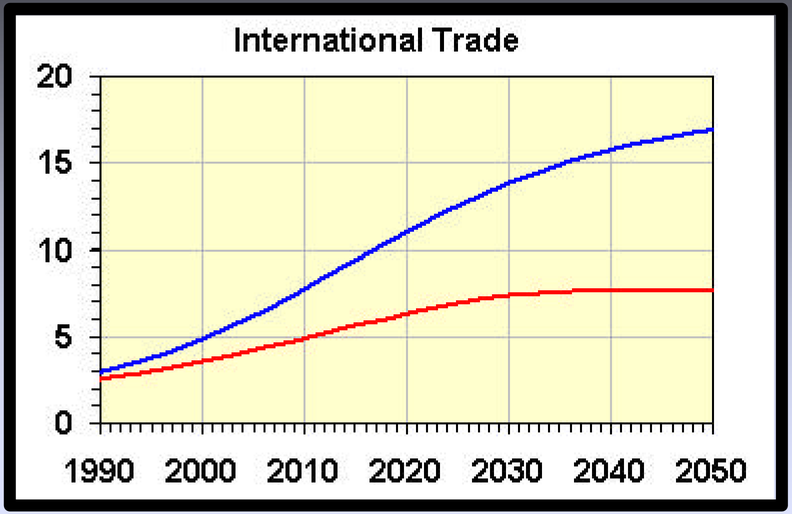


The Simulation Model (Vensim©)



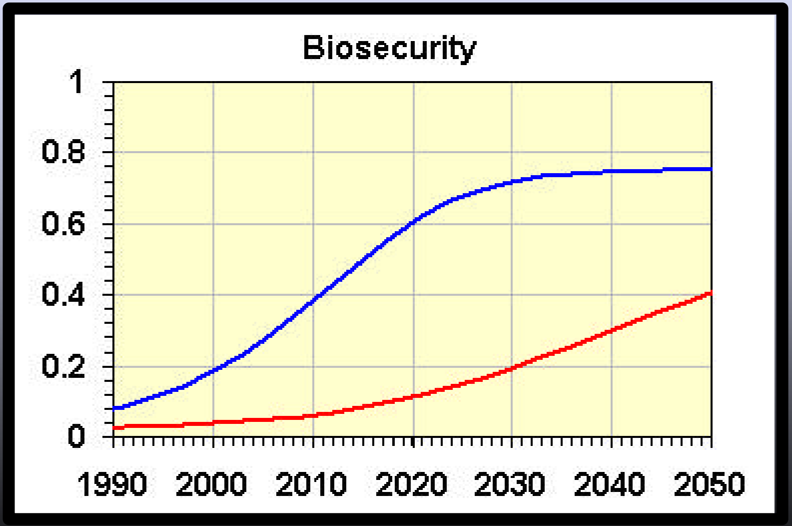
Model Outputs

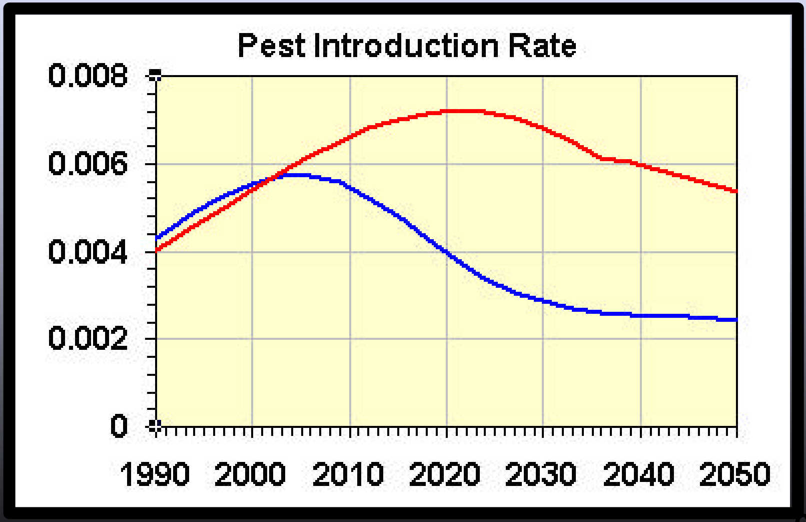




Potential build of the technical capacity: 90%

Potential build of the technical capacity: 10%





Acceptable Level of Risk

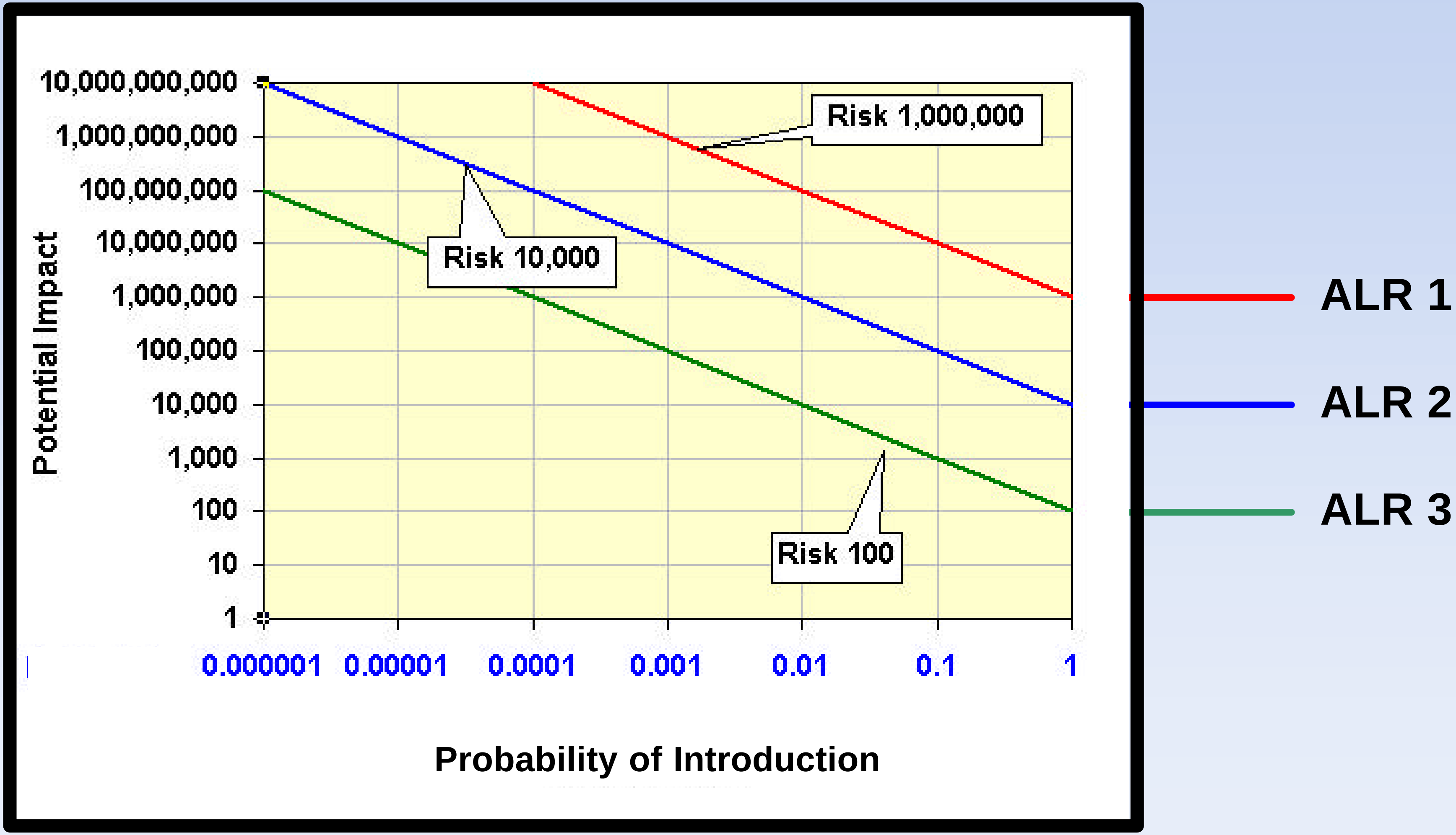
Risk Definition

*Risk = Consequences * Probability of occurrence*

*Risk = Potential Economic Impact * Probability of Introduction*

Acceptable Level of Risk

Iso-Risk Frame Work (Bigsby and Whyte (2001)



Acceptable Level of Risk

*Risk = Potential Economic Impact * Probability of Introduction*

If a pest presents a risk greater then the *ALR*, there are two ways to decrease it:

- **the *Potential Impact* is decreased or**
- **the *Introduction Probability* is decreased (or both)**

Although there are ways to decrease the potential economical impact, as to crop resistant varieties or to develop and apply contention plans, for instance, we will keep the focus in the reduction of the *Introduction Probability*.

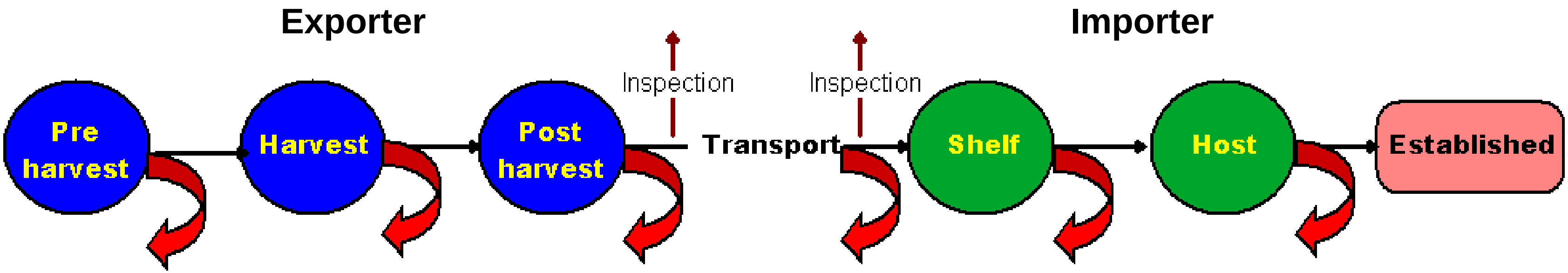
Acceptable Level of Risk

If a country choose an ALR and have an estimate of the Potential Economic Impact then, for each pest, an threshold Introduction Probability can be calculated, as shown in equation below.

$$Probability\ of\ Introduction = \frac{ALR}{Potential\ Economic\ Impact}$$

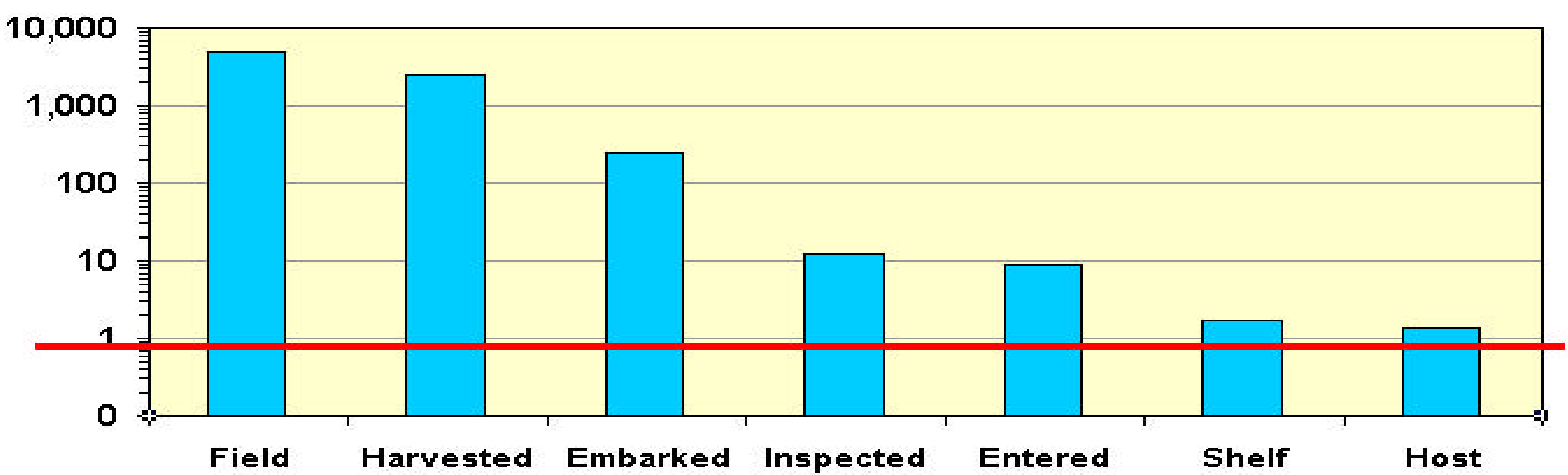
This is essential to support the choice of a risk management strategy.

Probability of Introduction



Consig. size x Prevalence x (1-M.Efficacy) x Prob. Inspec Failure = Entered

Entered x Probability Establishment = Established



Probability of Introduction

$$\text{Probability of Introduction} = \frac{ALR}{\text{Potential Economic Impact}}$$

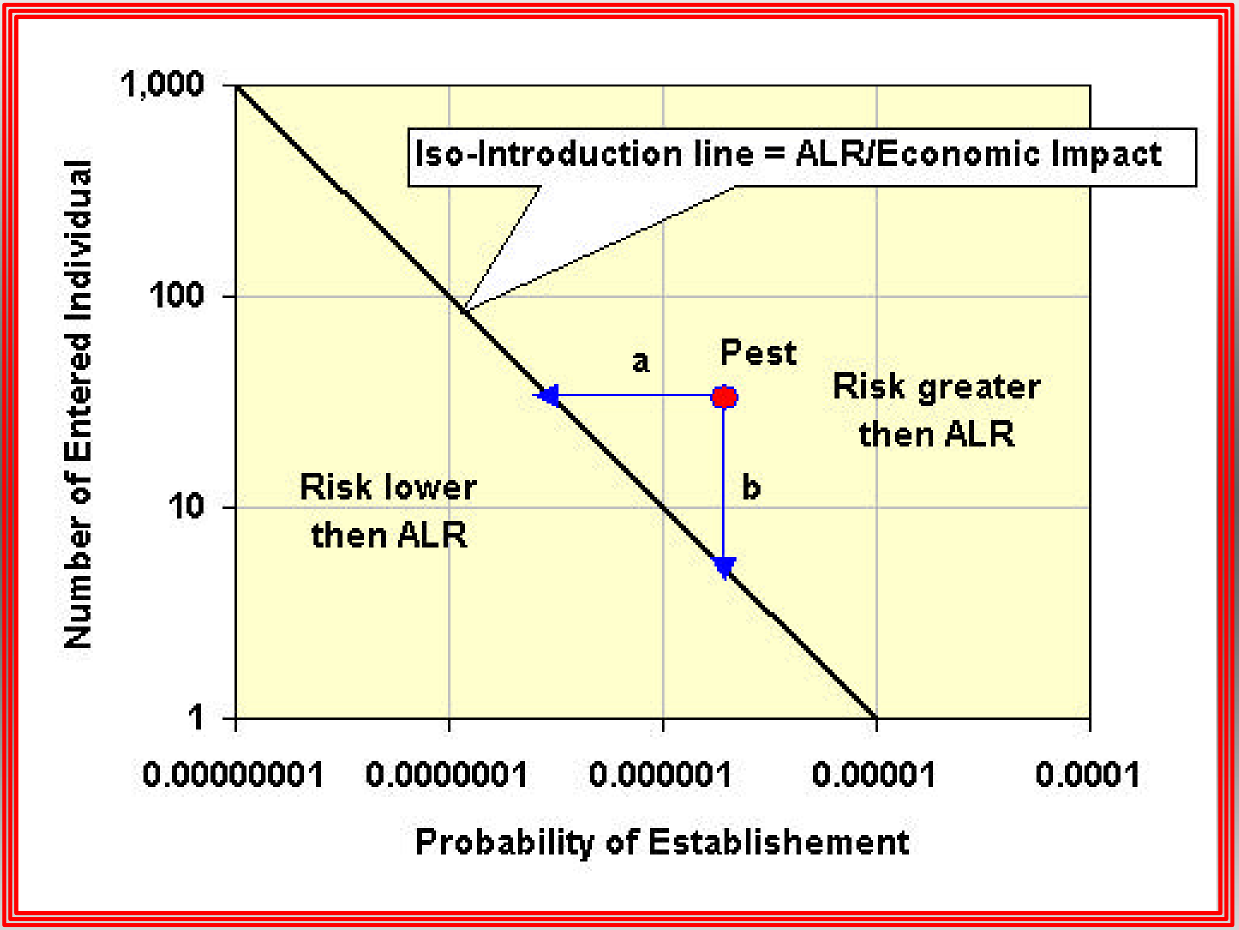
$$\text{Prob. Introduction} = 1 - (1 - \text{Prevalence} * \text{Prob. Establish.})^{\text{Entered}}$$

Baker,1993

$$\text{Expected Introductions} = \text{Entered} * \text{Probability of Establishment}$$

$$\text{Entered} * \text{Probability of Establishment} =< \frac{ALR}{\text{Potential Economic Impact}}$$

Probability of Introduction



$$Entered * Probability\ of\ Establishment = \frac{ALR}{Potential\ Economic\ Impact}$$

Example

Data:

Acceptable Level of Risk:	**US$ 1,000**
Potential Economic Impact:	**US$ 10,000,000**
Consignment size:	**10,000 units**
Expected Infestation Level in the consignment:	**0.005 (0.5%)**
Pest Establishment Probability:	**0.00001**

Results:

Acceptable Prob. of Introduction	=	**1,000 / 10,000,000**	=	**0.0001**
Acceptable entered individuals	=	**0.0001 / 0.00001**	=	**10**
Expected entered individuals	=	**10,000 * .005**	=	**50 ind.**

Conclusions: Consignments of the product could be accepted if:

1. **It is feasible to apply an inspection plan to detect 0.1% prevalence**
2. **The prevalence in the consignment could be decreased to less than 0.1%**
3. **The pest establishment probability could be decreased to less than 0.000002**

Phytosanitary Measures

Group 1. Reduction of the pest population in the consignment (prevalence)

- Pre Harvest (treatment in the field, place or site of production, testing, etc)
- Harvest (removal of infested products, inspection for selection, stage of ripeness/maturity, etc)
- Post Harvest (handling, chemical/physical treatment, etc)
- Shipping and distribution (volume, transport environment, in transit or on arrival treatment, etc.)
- Pest Free Areas (sites and places of production)

Phytosanitary Measures

Group 2. Reduction of the probability of establishment

- Frequency of importation
- Season timing
- Port of entry
- Restriction on the end use

Group 3. Detection of infested consignments

- Inspection
- Testing
- Post-entry quarantine

1. Reduction of the prevalence in the consignment

The main quantitative application <u>widely</u> used by the phytosanitary community in the past is the probit 9 approach.

It was proposed more than 65 years ago as the basis for measuring the efficacy of treatments for fruit flies

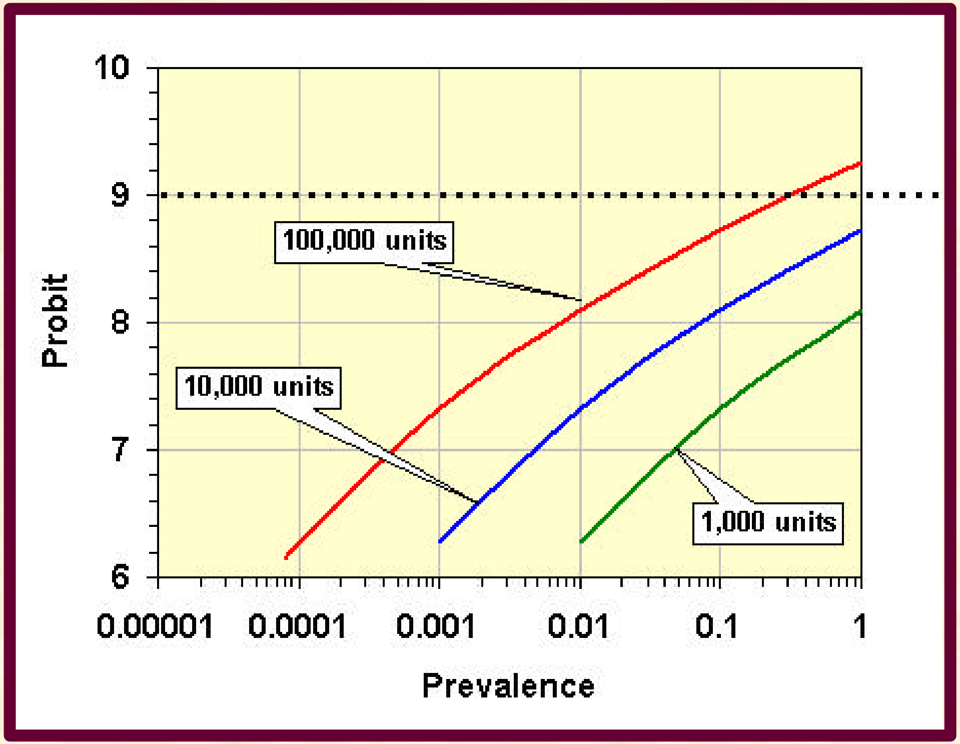
The general rationale behind the probit 9 approach is very simple and straightforward: *if you kill a very high percentage (99.9968 %) of the pest population then you will decrease the chance of pest establishment to zero (or very close to zero)*.

This rationale assumes a worst-case scenario and results in a high-kill treatment requirement that may not be technically justified based on pest prevalence.

1.Reduction of the prevalence in the consignment

Probit

Which would be the necessary probit to reduce the number of individuals to less than one?

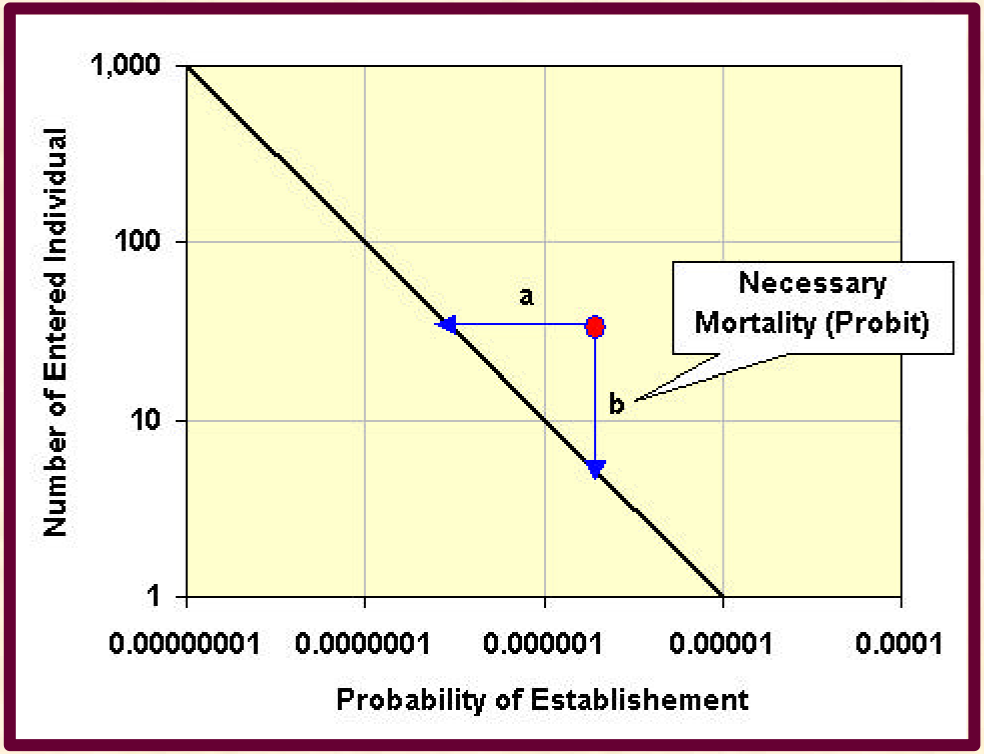


The excess mortality rate that would be attained with probit 9 is expensive, could reduce the shelf-life of the product and increase the residuals concentration.

1.Reduction of the prevalence in the consignment

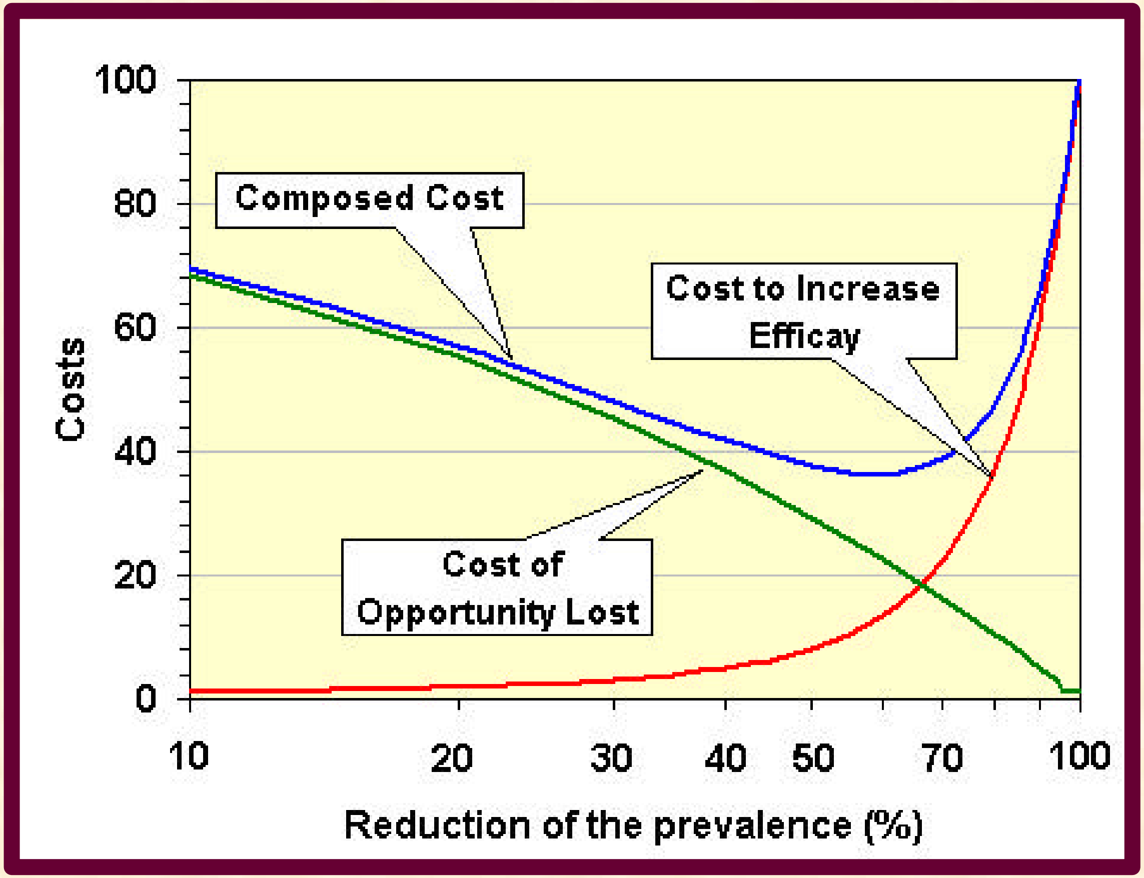
Probit

$$Necessary\ Mortality = 1 - \frac{ALR}{Consig.\ Size \times Prob.\ Estab. \times Pot.Econ.Impact \times Initial\ Prevalence}$$



1.Reduction of the prevalence in the consignment

Cost Considerations



2. Reduction of the probability of establishment

- Population size
- Reproductive strategy
- Genetic adaptability
- Survival at the disposal site
- Transmission to host
- Availability of host or vectors
- Survival on the host
- Suitability of the climate
- Suitability of soil
- ...

2. Reduction of the probability of establishment

Population Size

- *Founder populations are typically small and consequently are at great risk of extinction;*

- *Generally, the smaller the founder population, the less likely is establishment;*

- *It is realistic to consider the probability of establishment as being a continuous function of the initial population size;*

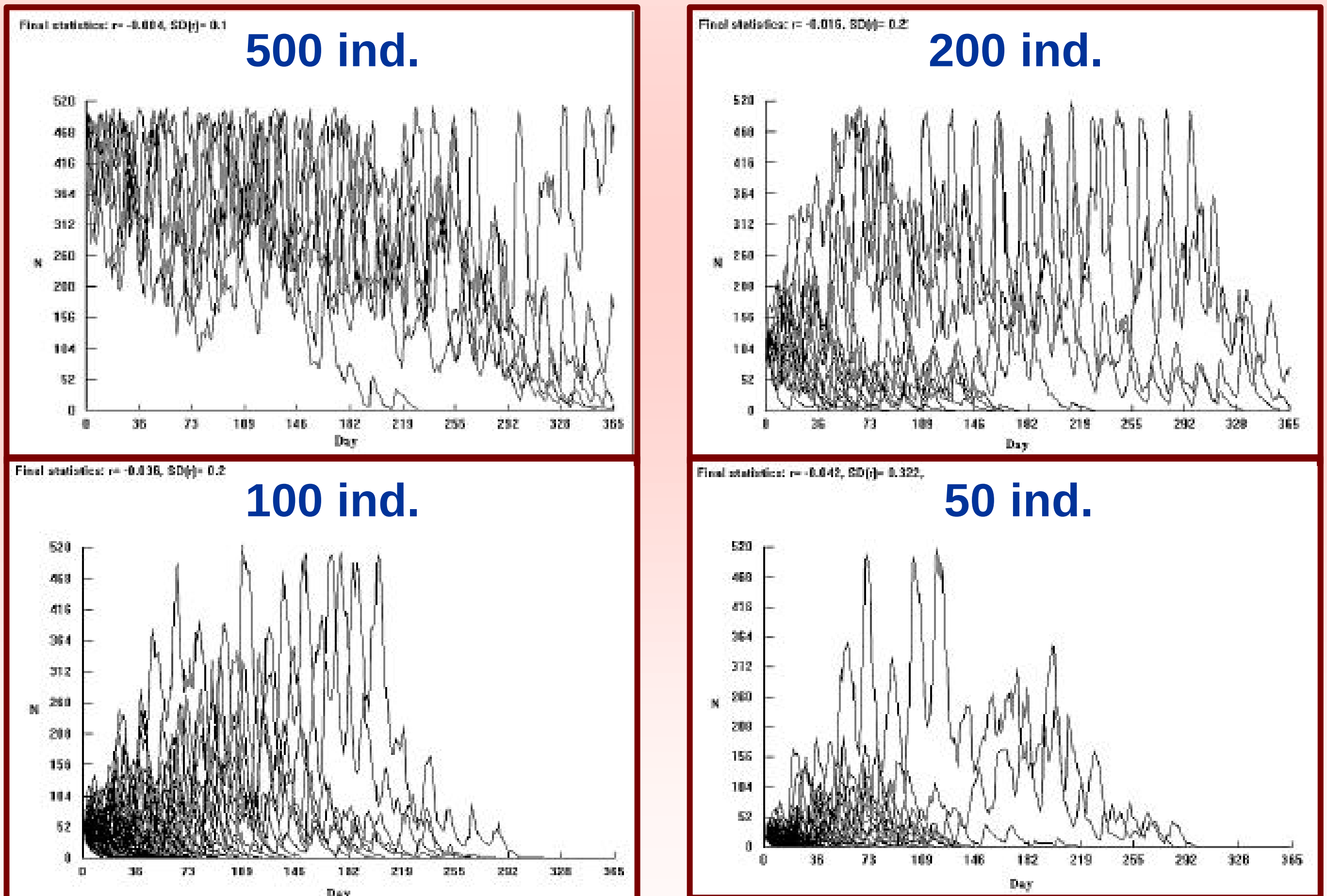
- *This function reflects many characteristics of the species, such as its intrinsic rate of reproduction, mate location abilities, and genetic diversity*.

(Liebhold, 1995)

2. Reduction of the probability of establishment

Population Size

Population Viability Analysis (PVA) is a methodology that consists of estimating the probability of a population of a specified size that will persist for a specified length of time

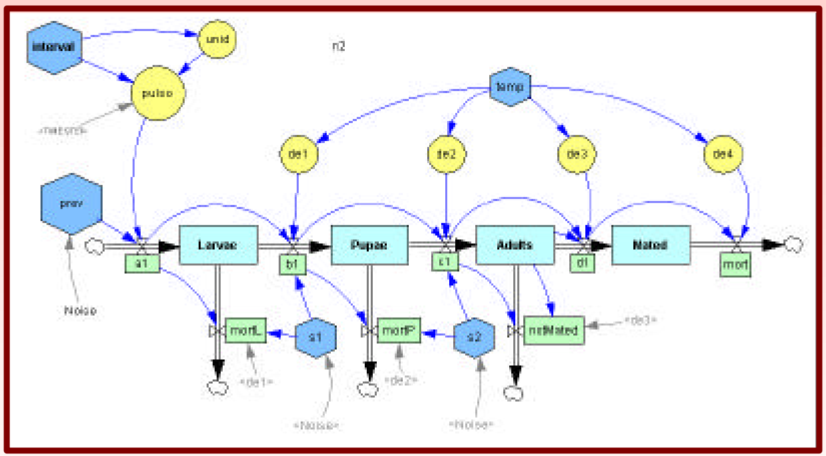


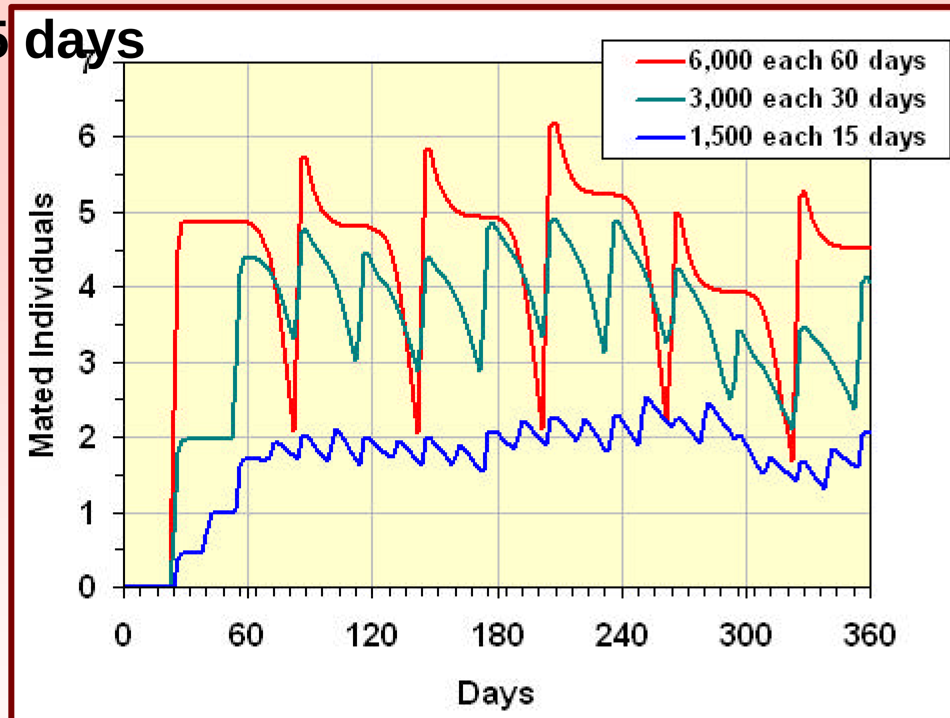
Vortex

2. Reduction of the probability of establishment

Consignment Size x Frequency of Importations

- Consignments size and frequency equivalent to 100 units per day
- Delivery prevalence of 1% (larvae)
- Larvae mortality is 60%
- Pupae mortality is 50%
- 50% of the adults mate
- Mated adult longevity is 55 days

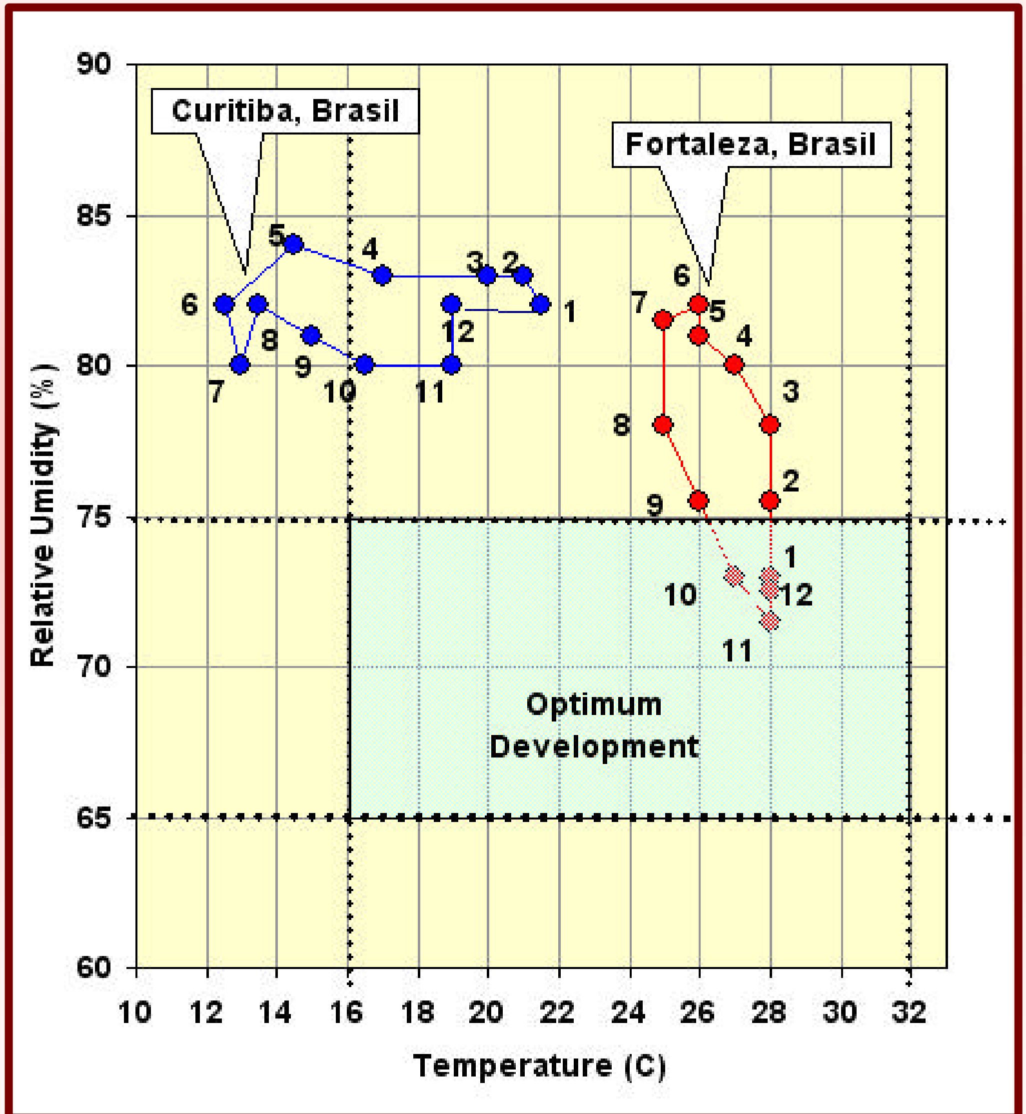




2. Reduction of the probability of establishment
Port of Entry

Climogram

There are commercial software, like *CLIMEX*, for modeling species responses to climate that are (or could be) used for quarantine purposes.

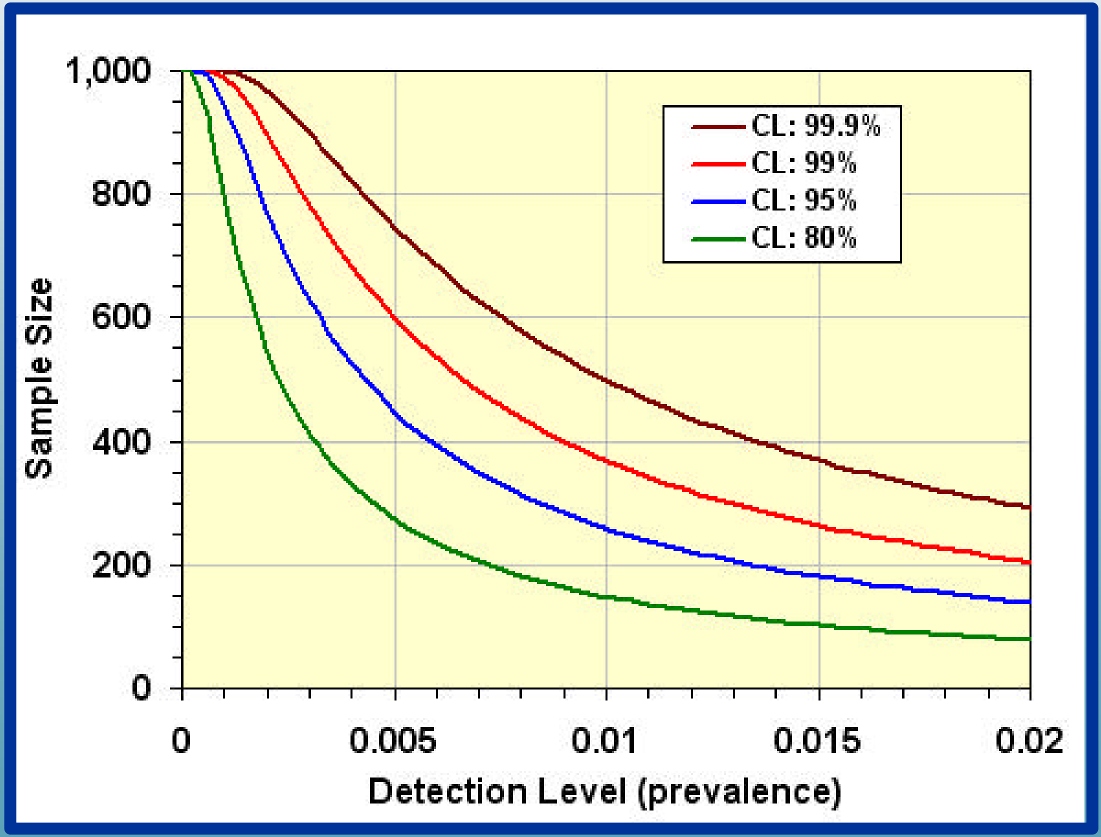


3. Detection of non-compliant consignments

Hypergeometric distribution

$$Sample\ size = Consignment\ size \times \left(1 - (1 - CL)^{\frac{1}{Consignmet\ size \times Detection\ level}} \right)$$

Consig. Size = 1,000

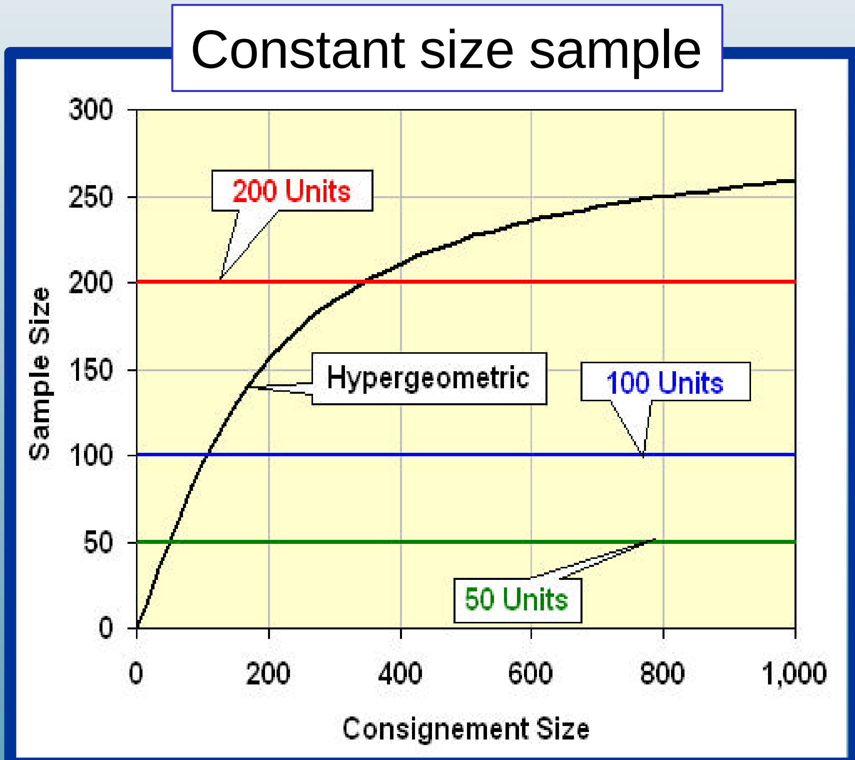


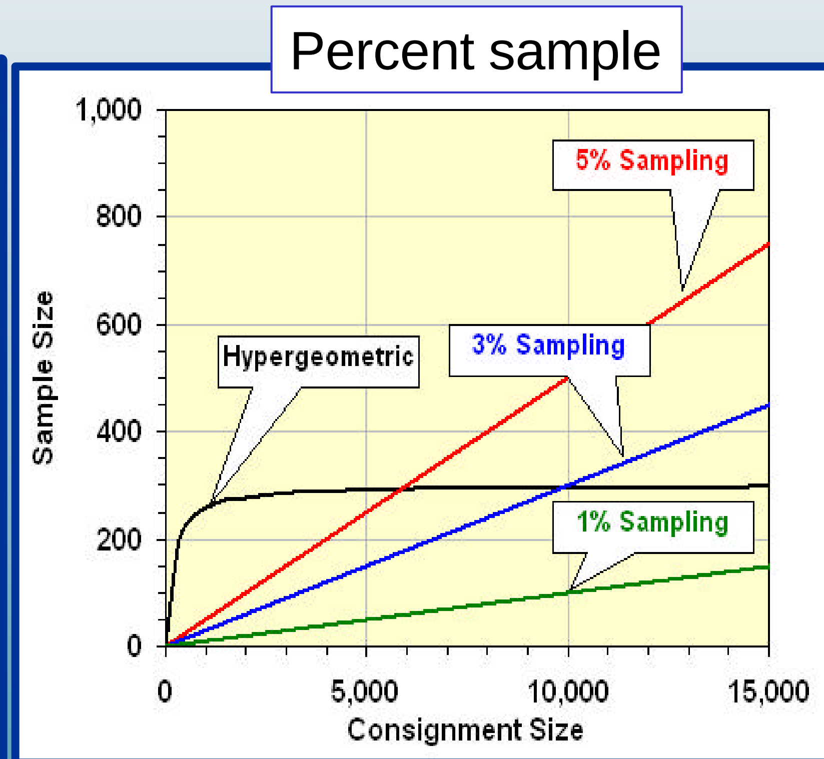
3. Detection of non-compliant consignments

Hypergeometric x Regular Sampling

Confid. Level = 95%

Detection Level = 0.1%

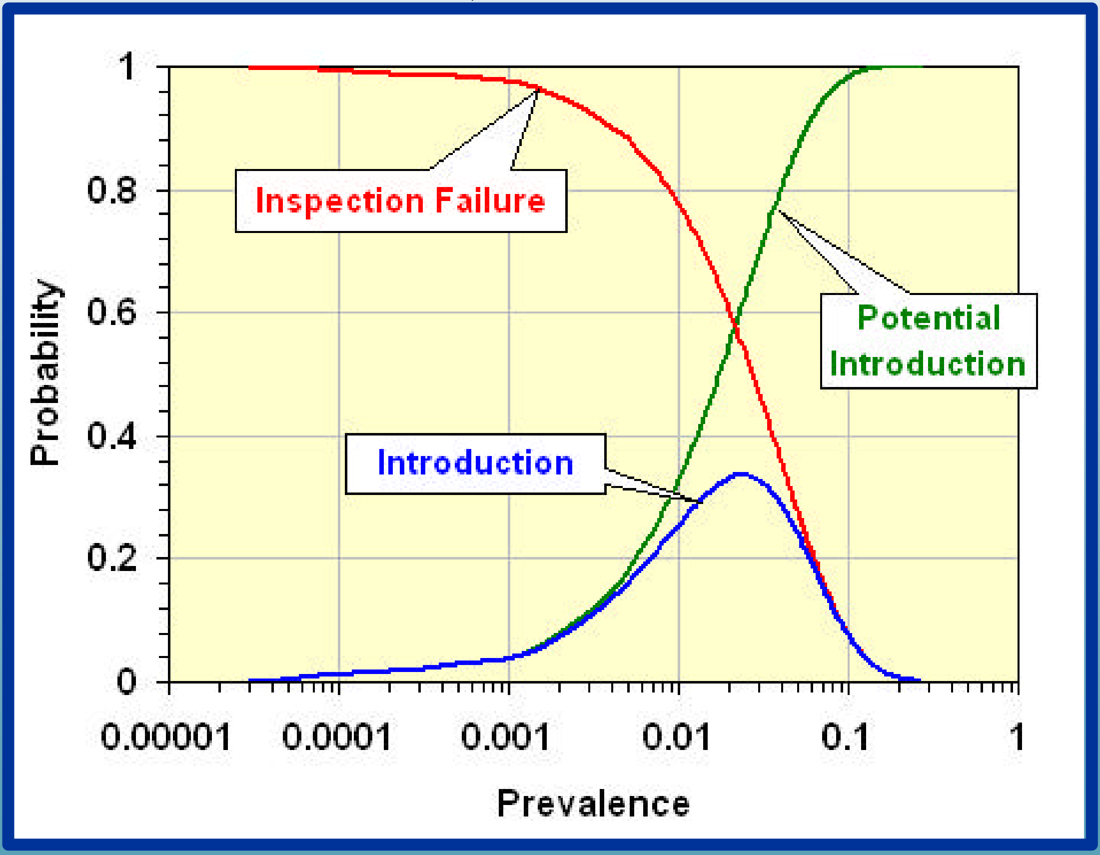




3. Detection of non-compliant consignments

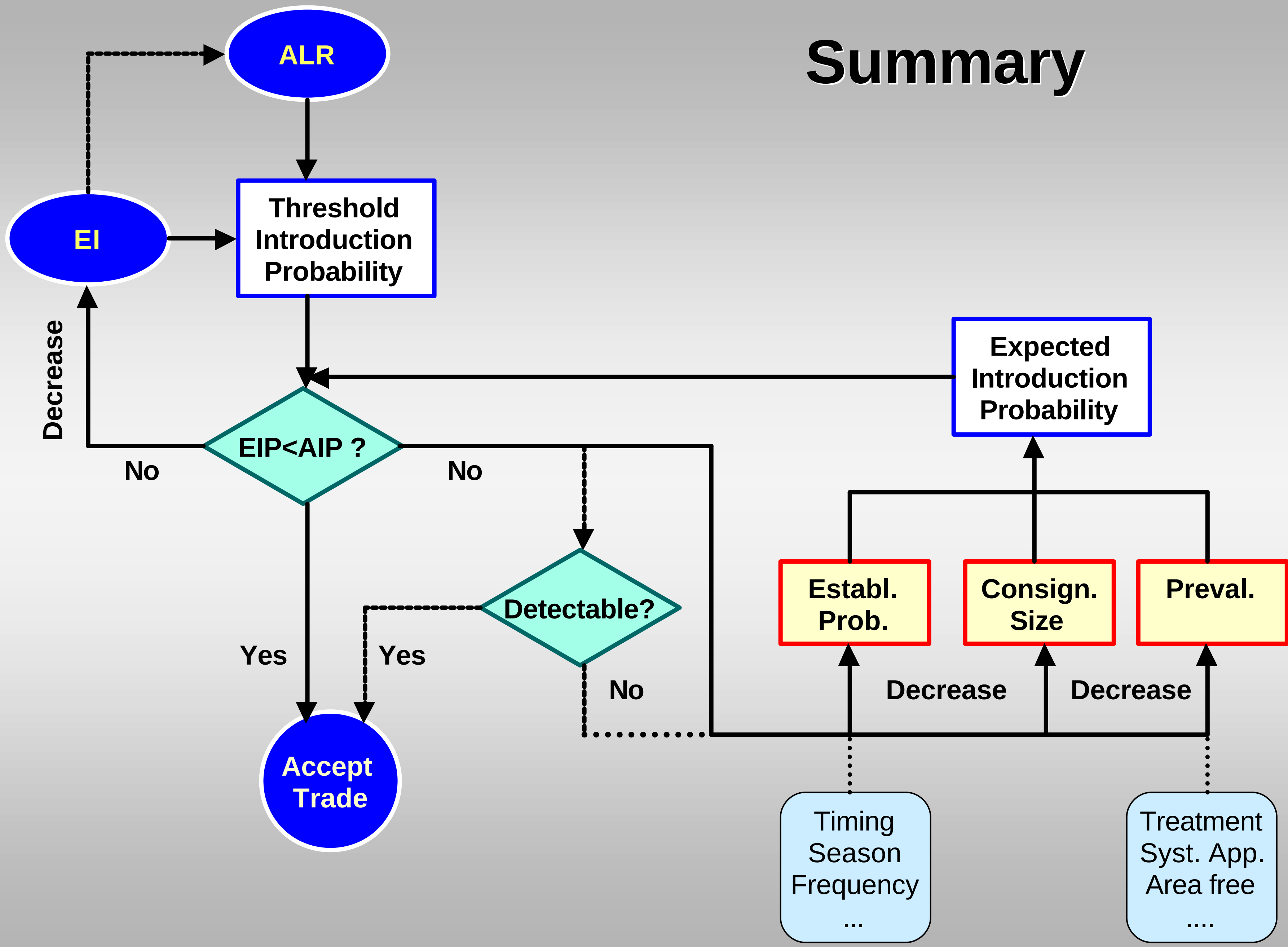
$$Probability\ Inspection\ Failure = \left(1 - \frac{Sample\ size}{Consig.\ size}\right)^{Consig.\ size \times Prevalence}$$

$$Prob.\ of\ Introduction = 1 - \left(1 - Prevalence \times Prob.\ Establish\right)^{Consig.size\ x\ Prevalence}$$



Consignment size = 1000
Sample size = 25
Prob. Establish. = 0.04)

Summary


ALR
EI
Threshold Introduction Probability
Decrease
EIP<AIP ?
No
No
Expected Introduction Probability
Detectable?
Yes
Yes
No
Establ. Prob.
Consign. Size
Preval.
Decrease
Decrease
Accept Trade
Timing
Season
Frequency
...
Treatment
Syst. App.
Area free
....

Thank you