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Plant & Food RESEARCH
RANGAHAU AHUMĀRA KAI

The New Zealand Institute for Plant & Food Research Limited

Bayesian Network model for risk analysis of fresh produce imports

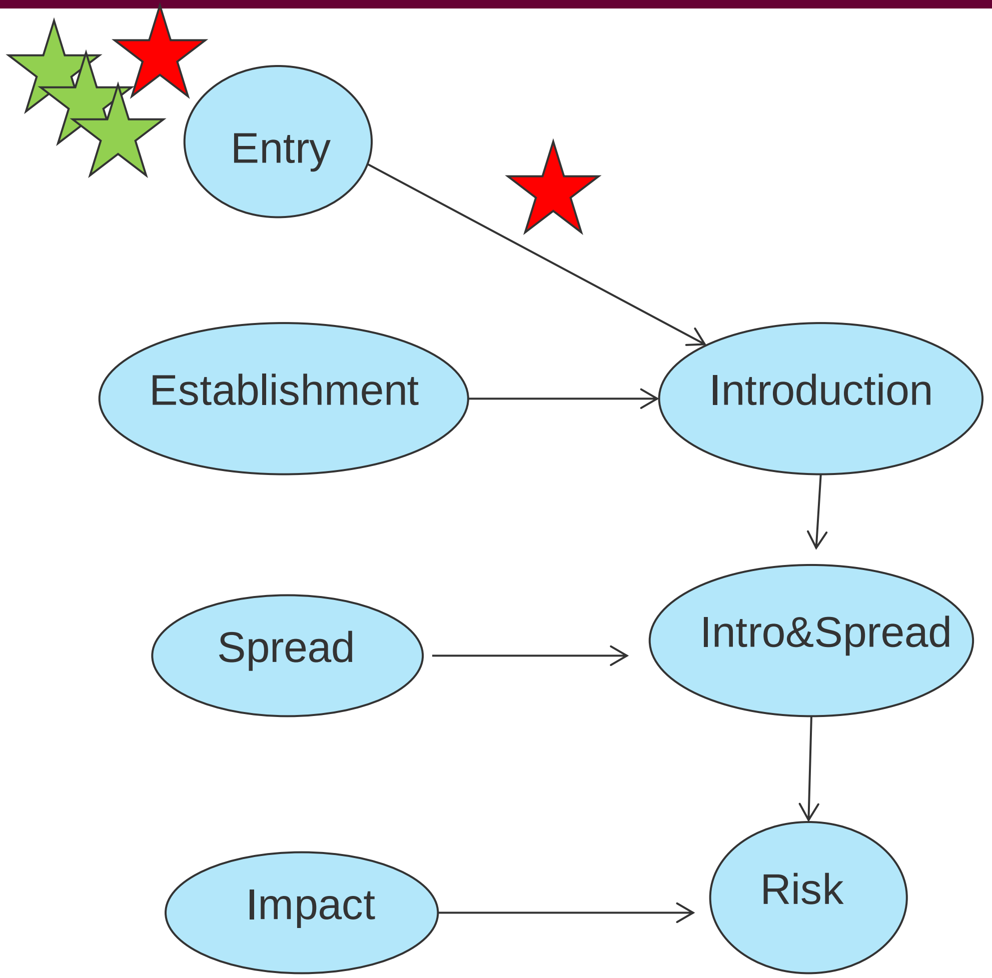
Lisa Jamieson, Nihal De Silva, Alastair Hall

Tools to analyse risk and impact of control measures

- Countries cannot eliminate all threats
  - needs to allocate resources to manage biosecurity risk
  - ensure trade and travel are maintained
- Export sectors aim to
  - reduce non-tariff costs (e.g. on-shore compliance, consignment rejection, destruction or fumigation)
- Science-based transparent framework
  - for pest risk analysis
  - using integrated control measures in a systems approach
  - consistent with the WTO's requirement for justifiable measures.

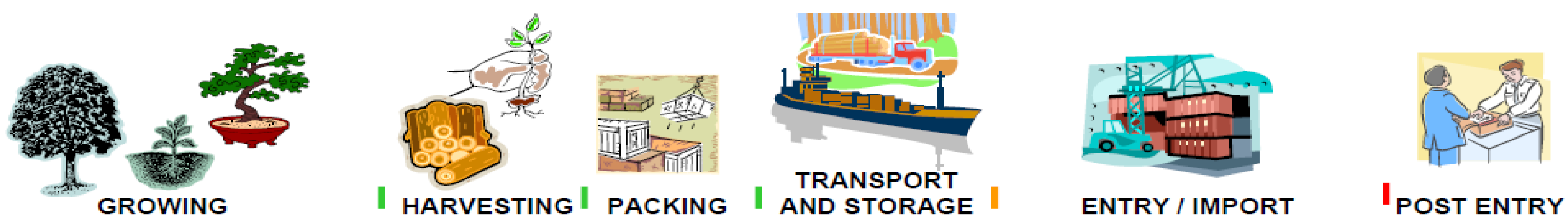
Pest Risk Analysis

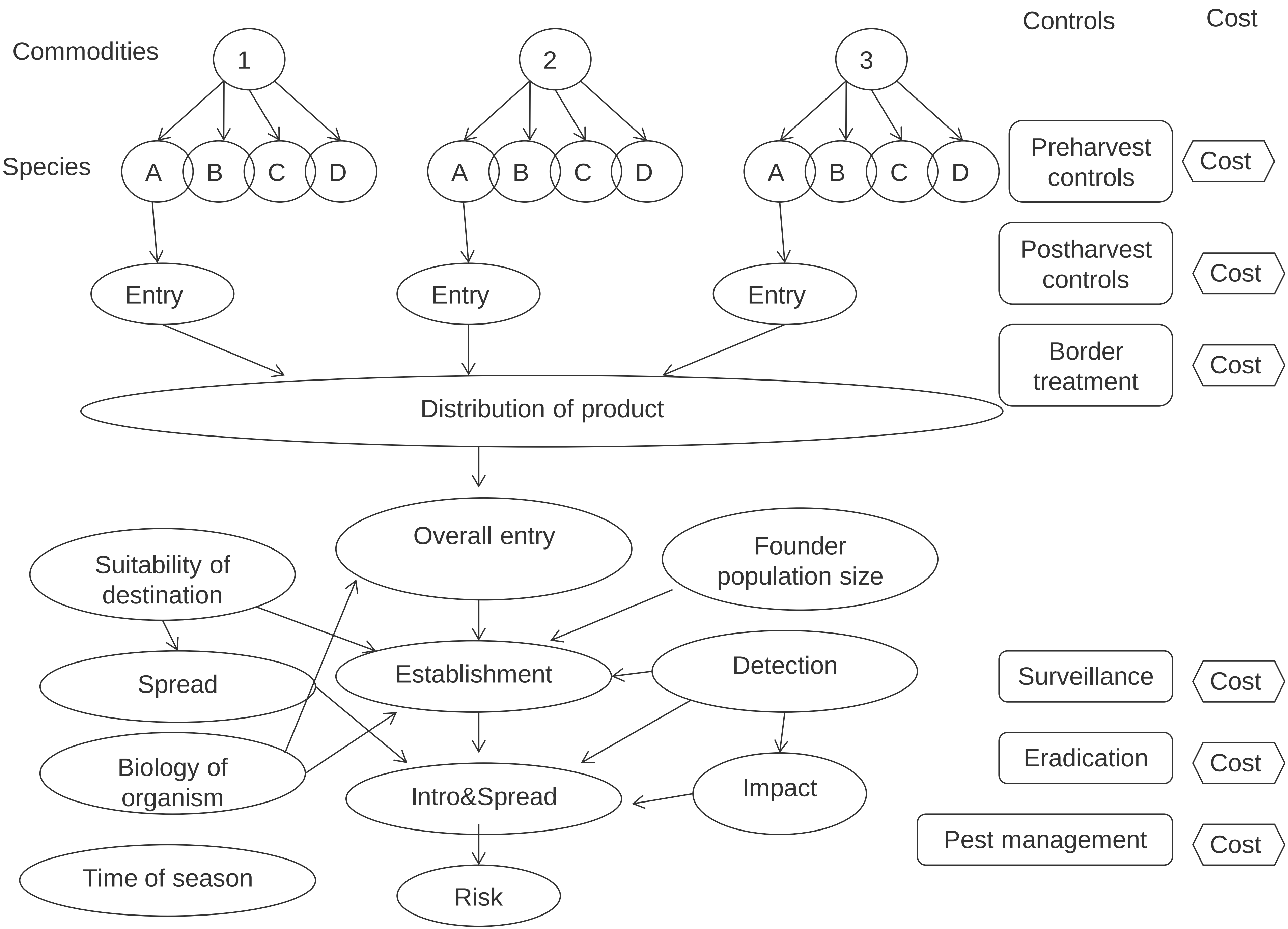
- Hazard ID (257)
  - Associated with commodity
  - Present in exporting country
  - Not recorded from NZ
  - Can potentially establish in NZ
- Risk Assessment (35)
  - Likelihood of:
    - Entry
    - Establishment
    - Spread
    - Consequences
- Risk Management (18)
  - Single treatment
  - System approaches



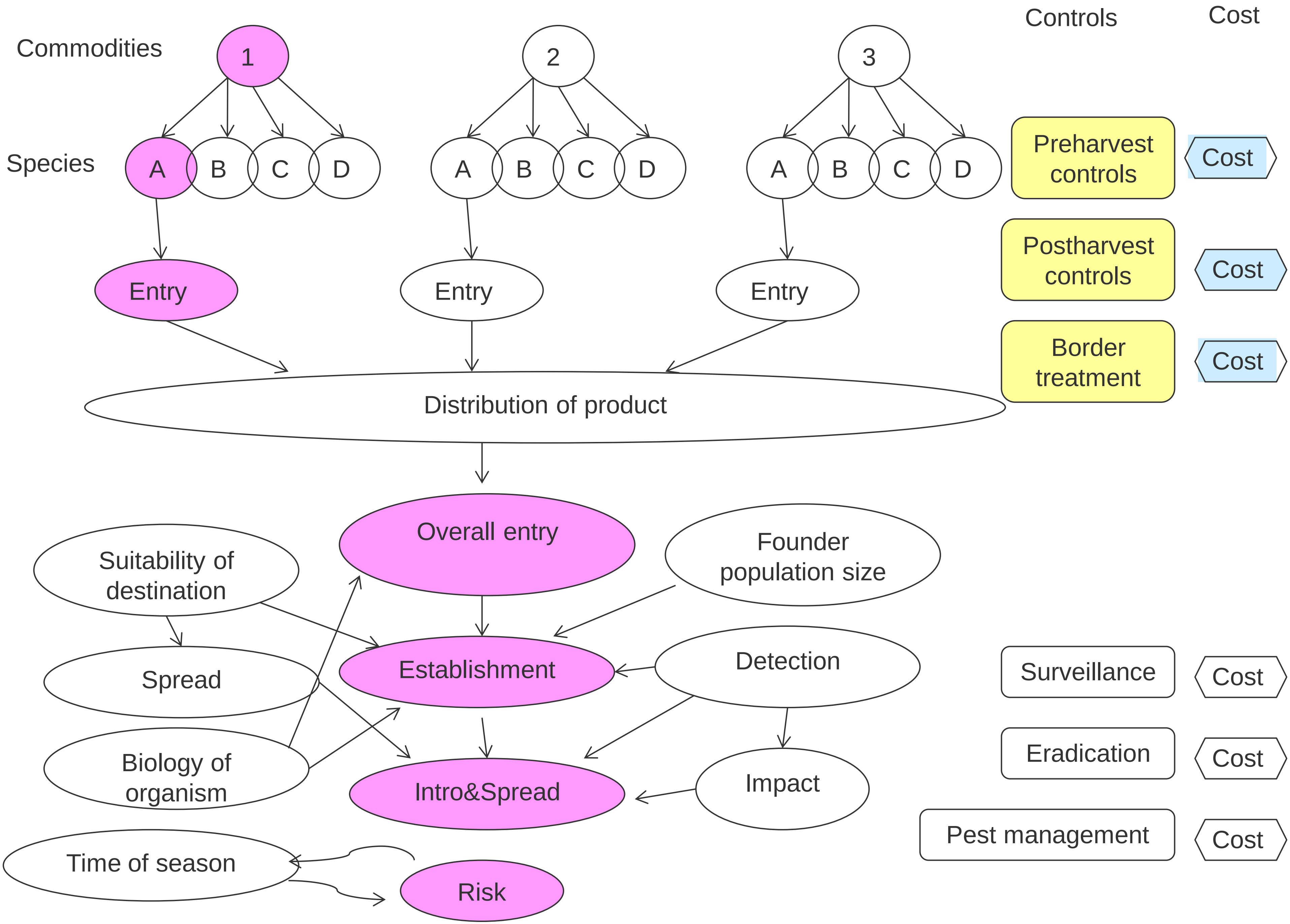
Systems approaches (SAs)

- SA defined as "*The integration of at least **two** measures which act **independently**, and which **cumulatively** achieve the **appropriate level of protection** against regulated pests*"
- As opposed to a dependent measure (e.g. monitoring)
  - does not reduce the risk directly
  - may be required to verify efficacy of an independent measure
- SA increasing as alternatives to single-point risk management treatments applied at the border
- SAs considered when individual measures are:
  - not adequate to meet phytosanitary import requirements
  - detrimental to a commodity, human health or environment
  - not available or likely to become unavailable or cost effective
  - overly trade restrictive; and/or not feasible





Controls
Cost
Commodities
1
2
3
Species
A
B
C
D
A
B
C
D
A
B
C
D
Preharvest controls
Cost
Postharvest controls
Cost
Entry
Entry
Entry
Border treatment
Cost
Distribution of product
Overall entry
Founder population size
Suitability of destination
Spread
Establishment
Detection
Surveillance
Cost
Biology of organism
Intro&Spread
Impact
Eradication
Cost
Pest management
Cost
Time of season
Risk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Preharvest controls
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Distribution of product
Overall entry
Suitability of destination
Founder population size
Establishment
Detection
Spread
Surveillance
Cost
Biology of organism
Intro&Spread
Impact
Eradication
Cost
Pest management
Cost
Time of season
Risk

Pesticide application once a threshold is reached

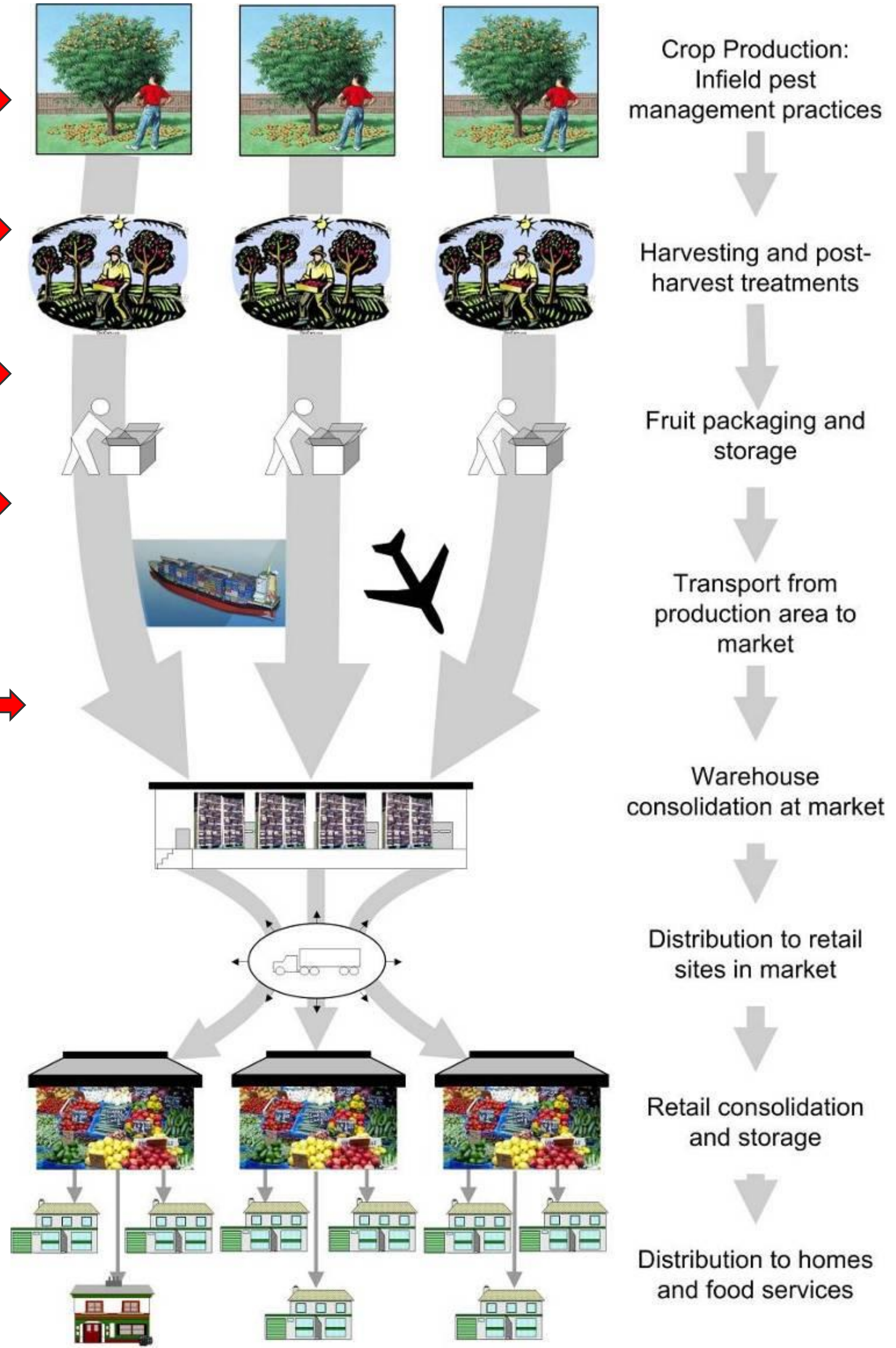
Mating disruption or Sterile insect technique

High pressure washing or grading

Coolstorage

Disinfestation treatment e.g. heat, fumigation

Sps 1 *Sps 2* ……→ *Sps 18*



Picture developed by MPI

Systems approach to managing risks

- Standards - guidelines
  - ISPM 11 – pest risk analysis for quarantine pests
  - ISPM 14 – integrated measures in a systems approach for pest risk management
- Involves the following processes:
  - determining the **risks** at each stage of the pathway
  - determining the points in a pathway where risks can be **reduced**, monitored and controlled
  - establishing criteria or limits for the **acceptance/failure** of each independent procedure
  - implementing the system, with monitoring as required for the desired degree of **confidence**
  - taking **corrective action** when monitoring results indicate that criteria are not met
  - reviewing or testing to **validate** system efficacy and confidence on a regular basis
  - maintaining adequate **records** and documentation

Review of methods for assessing biosecurity risks

- What are the methodologies that have the potential to be used for
  - assessing biosecurity risks on import pathways
  - impact of systems approach measures on reducing risks
- Conceptual models and flow charts
- Bayesian networks
- Monte Carlo simulations
- Influence diagrams, logic trees and decision trees
- Data mining and machine learning
- Eliciting expert opinion

A review of methods for assessing and managing market access and biosecurity risks using systems approaches

L.E. Jamieson[1], H.N. DeSilva[1], S.P. Worner[2], D.J. Rogers[3], M.G. Hill[4] and J.T.S. Walker[3]

New Zealand Plant Protection 66: 1-9 (2013) *www.nzpps.org*

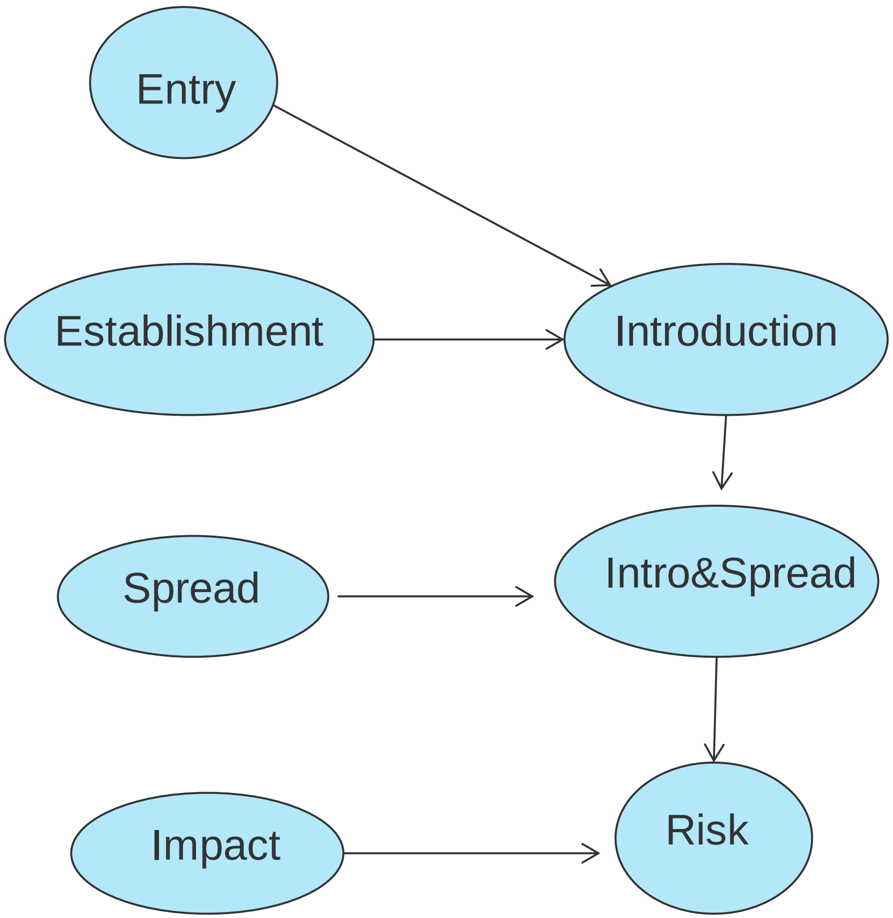
Important processes - developing a systems approach to managing risks

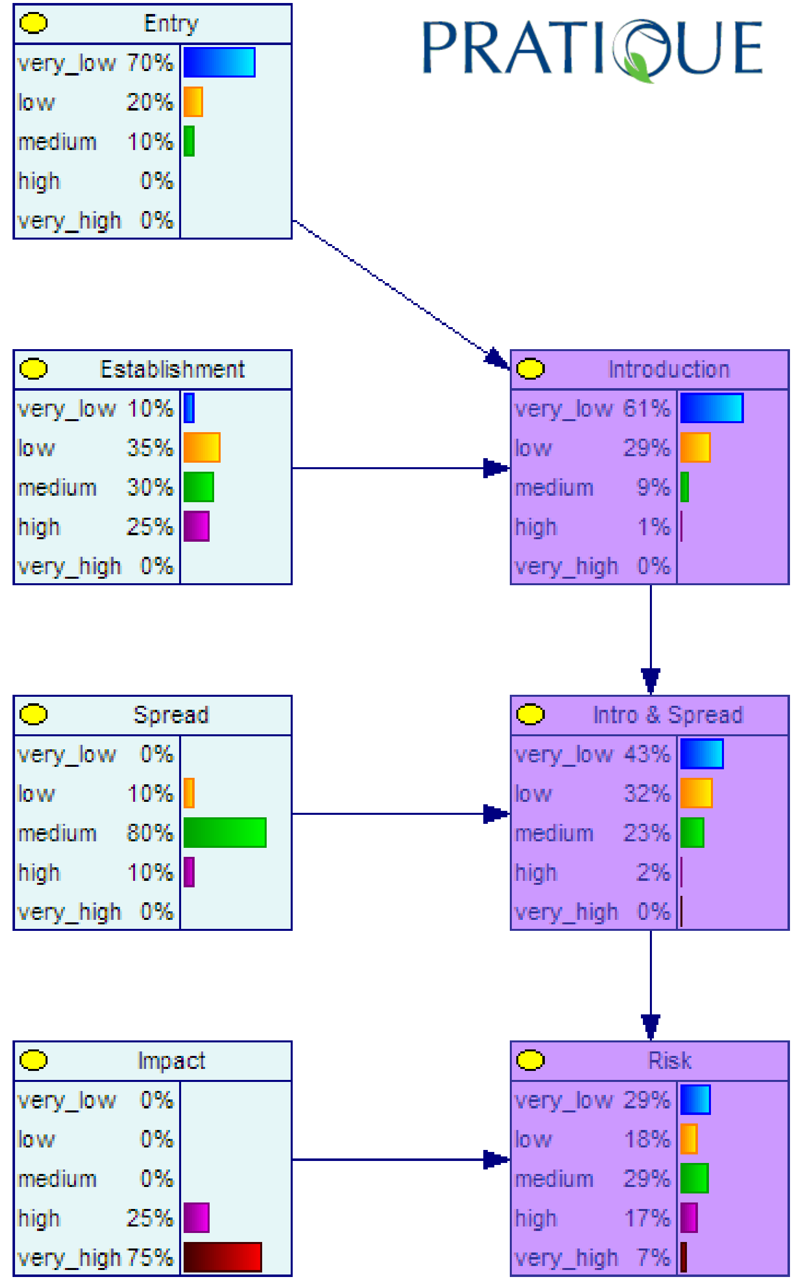
- Conceptual & flow diagrams
  - input from a range of pathway users, stakeholders, regulators and researchers
  - provide a structure to facilitate discussion, exchange ideas and information, identify knowledge gaps, reduce linguistic uncertainty
  - Collective view of the problem
- Break down complex risk analysis system
  - smaller sub-models
  - multiple risk factors on a small part of, or point, in the pathway
- Data availability to verify each sub-model
  - absence of data
  - eliciting expert opinion

Important processes - developing a systems approach to managing risks

- Develop framework
  - combine information in a coherent probabilistic logical way
    - empirical observations
    - system sub-models
    - expert opinion
  - readily updated and validated
  - cause-and-effect models
- Evaluation of uncertainty and validation procedures of a complex system

Conceptual model





EPPO PRA Scheme

PRATIQUE

- Series of questions:
  - Categorisation (19)
  - Entry (14)
  - Establishment (15)
  - Spread (3)
  - Impacts (16)
  - Risk management (44)
- Explanatory Notes
- Responses required:
  - 5 level risk rating
  - 3 level uncertainty score
  - Written justification

1.12. How likely is the pest to be able to transfer from the pathway to a suitable host or habitat?
Note: consider innate dispersal mechanisms or the need for vectors, and how close the pathway on arrival is to suitable hosts or habitats.

very unlikely, unlikely, moderately likely, likely, very likely.

Level of uncertainty:	**Low**	**Medium**	**High**

Go to 1.13

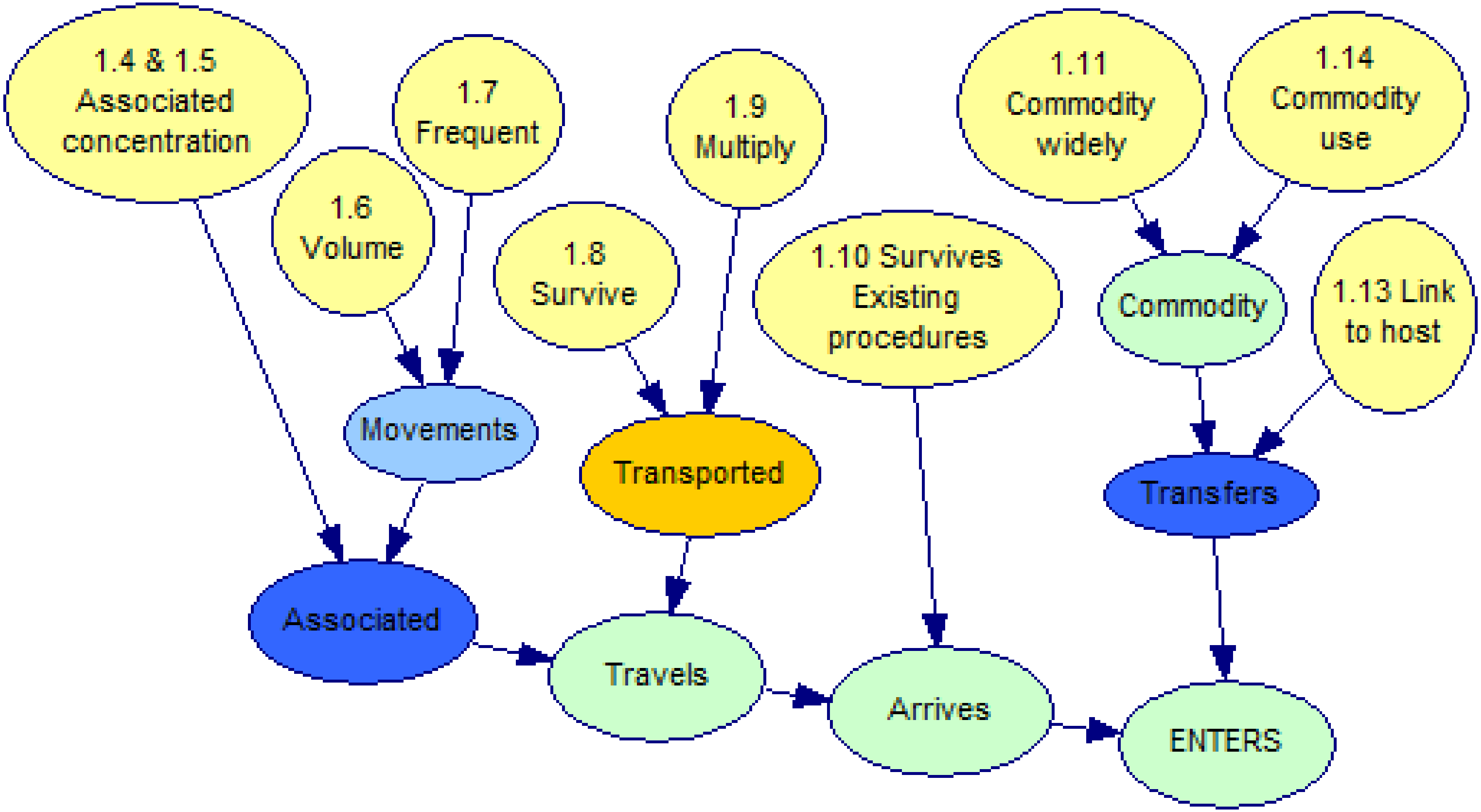
1.13. In the case of a commodity pathway, how likely is the intended use of the commodity (e.g. processing, consumption, planting, disposal of waste, by-products) to aid transfer to a suitable host or habitat?
Note: Some uses are associated with much higher probability of introduction (e.g. planting) than others (e.g. processing). Consider whether the intended use of the commodity would destroy the pest or whether the processing, planting or disposal might be done in the vicinity of suitable hosts or habitats.

N/A, very unlikely, unlikely, moderately likely, likely, very likely.

Level of uncertainty:	**Low**	**Medium**	**High**

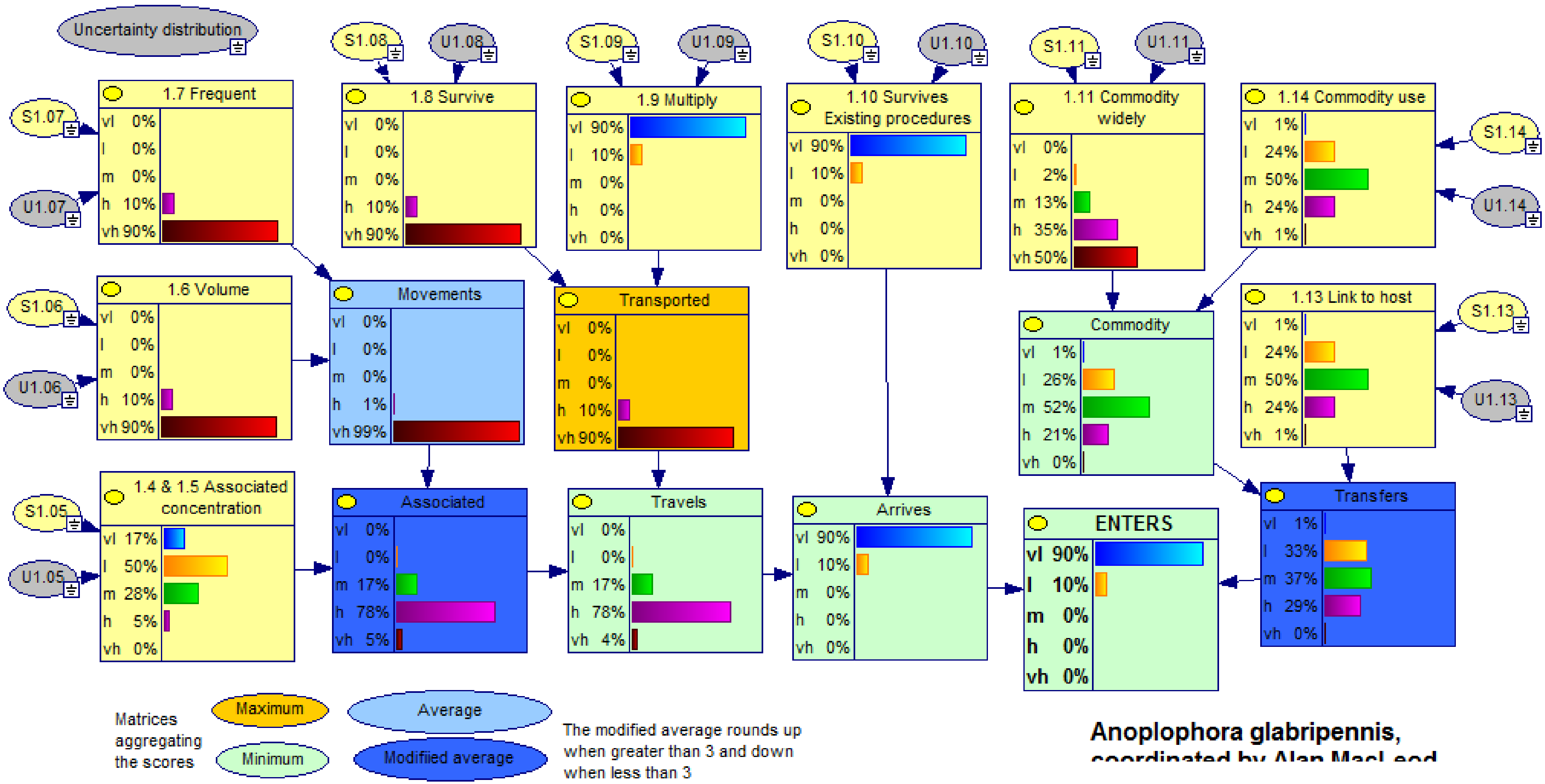
Available here: http://capra.eppo.org/download.php

Conceptual model: Entry

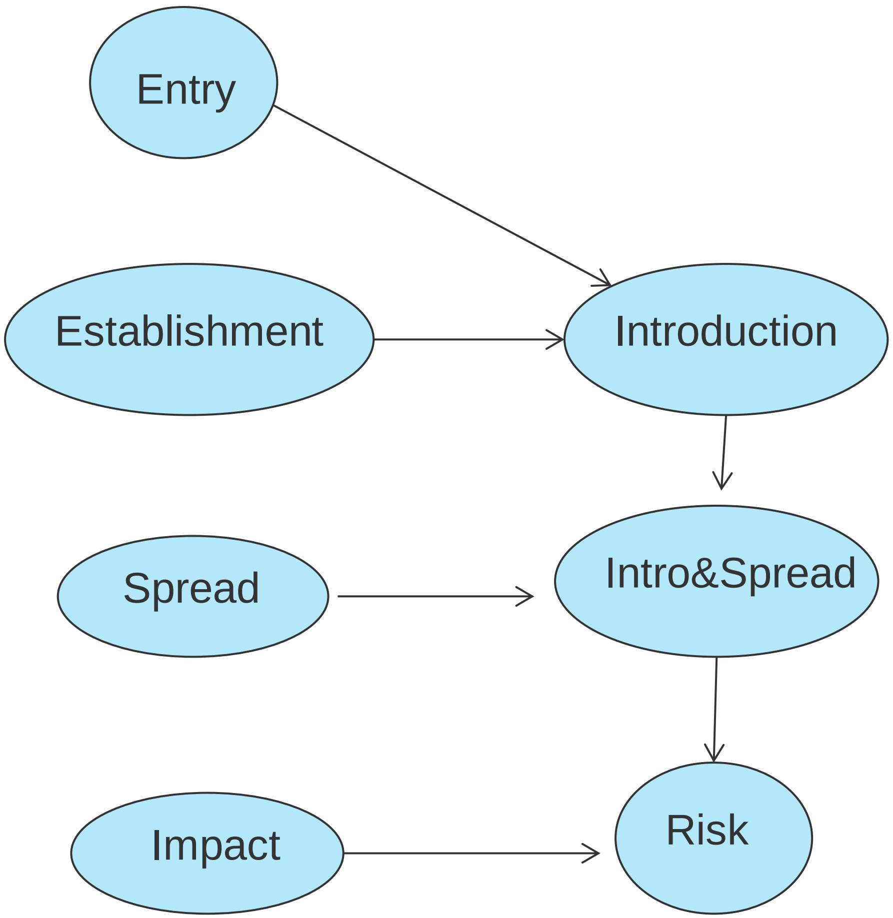


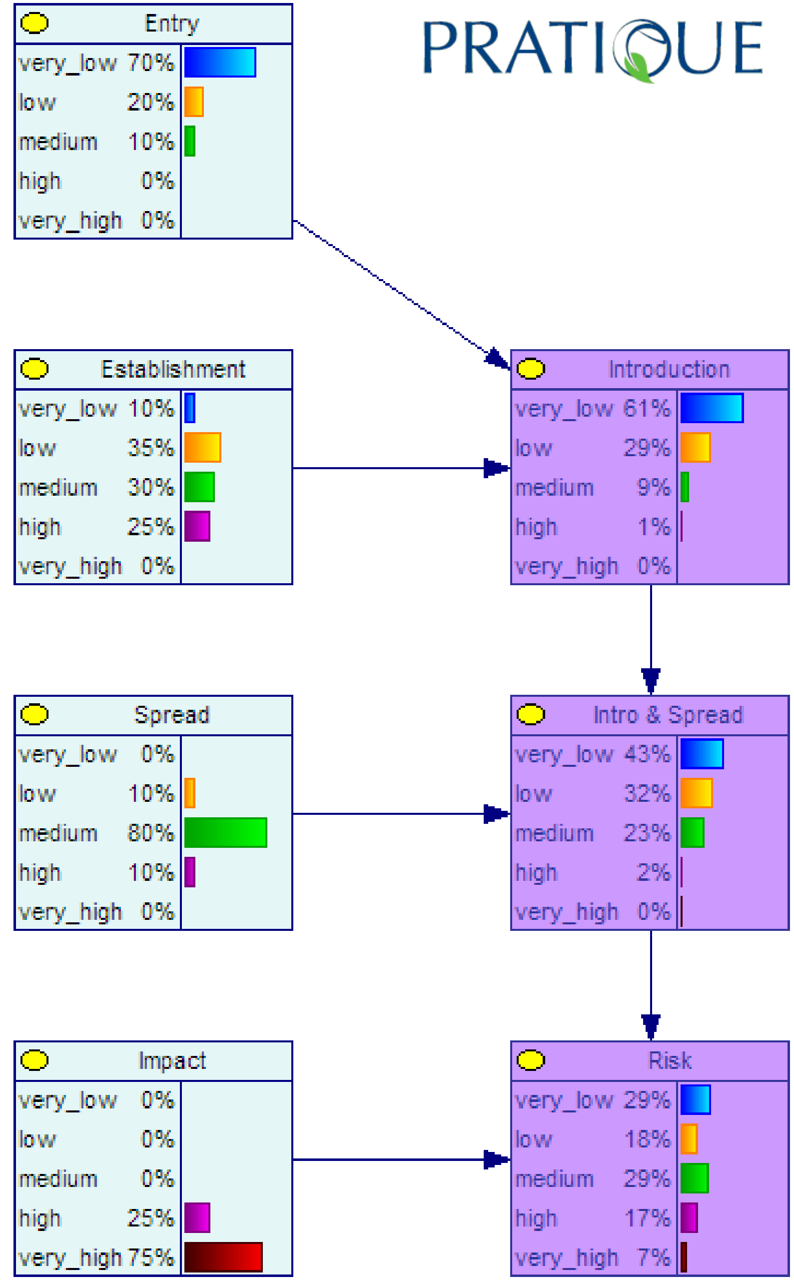
Conceptual model: Entry converted to a BN

Draft matrix model structure for Entry - modification 4 (inputs from Dirkjan, this version gives the closest corrspondence to assessors for test 16 data sets)



Conceptual model





Insecticide application once a threshold is reached

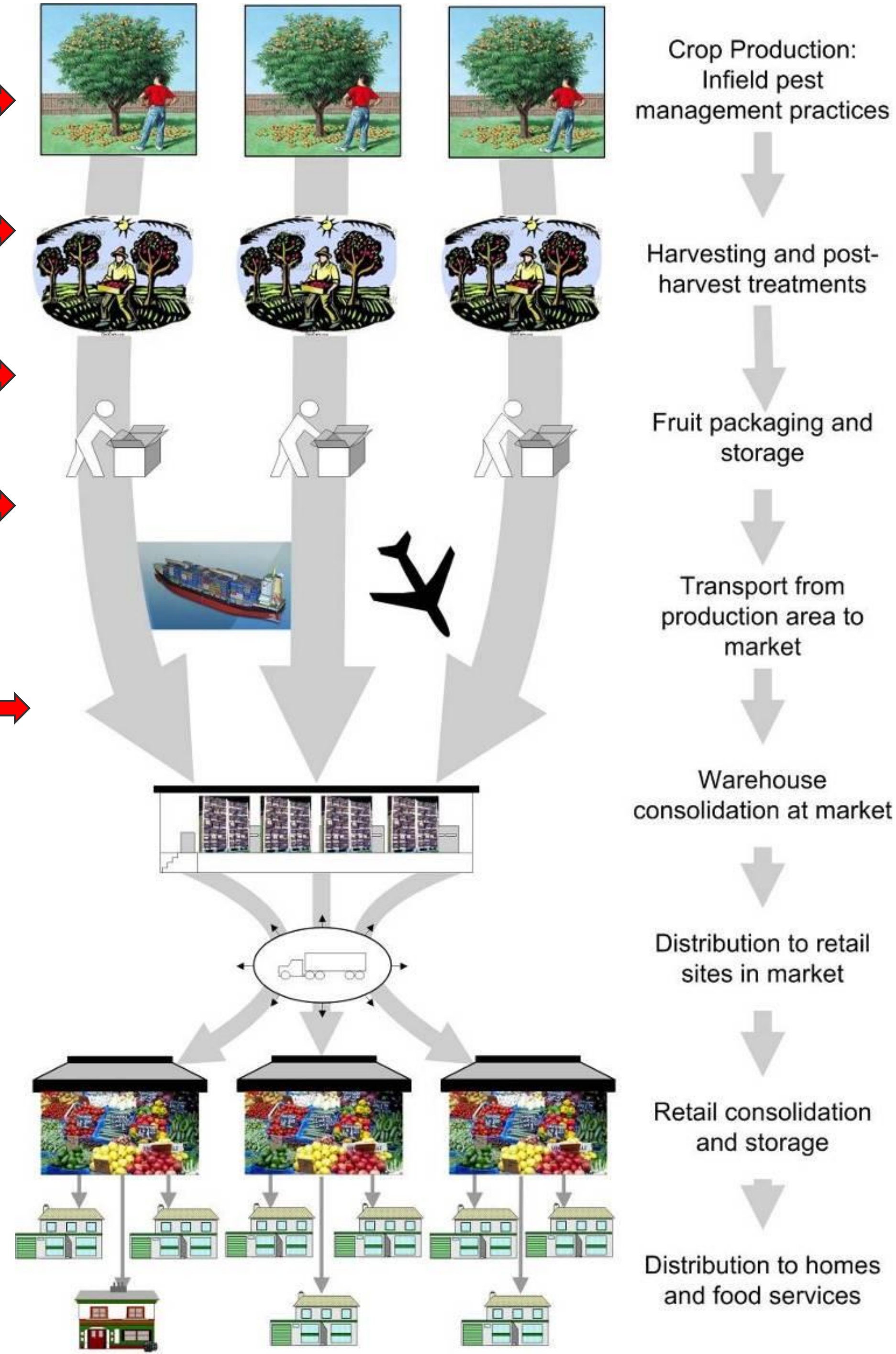
Mating disruption or Sterile insect technique

High pressure washing or grading

Coolstorage

Disinfestation treatment e.g. heat, fumigation

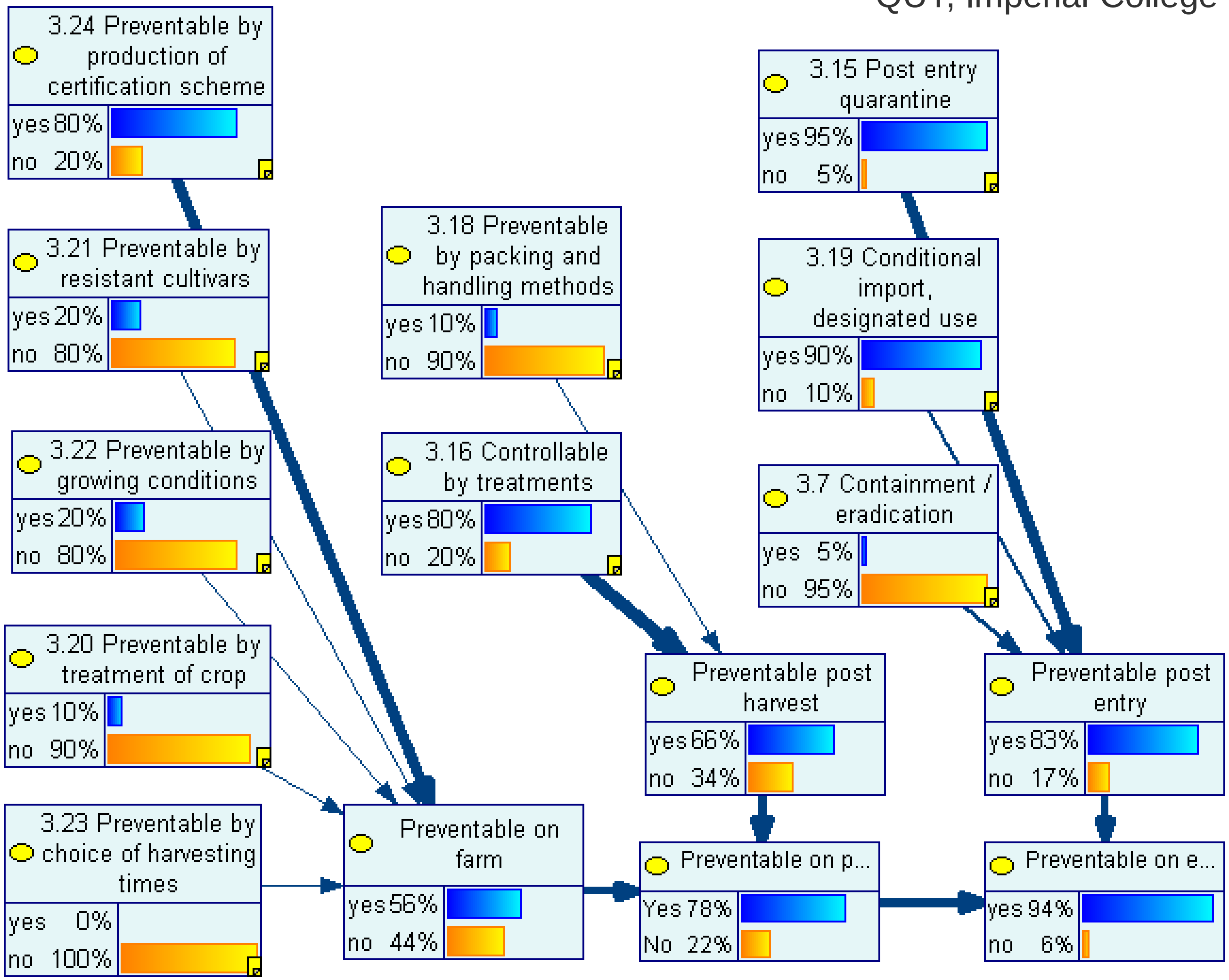
Sps 1 *Sps 2* ……→ *Sps 18*



Picture developed by MPI

BEYOND COMPLIANCE - A *Bayesian Network approach to develop confidence and competence in a Systems Approach to Pest Risk Management*

Whittle et al. 2012 ABNMS
QUT, Imperial College



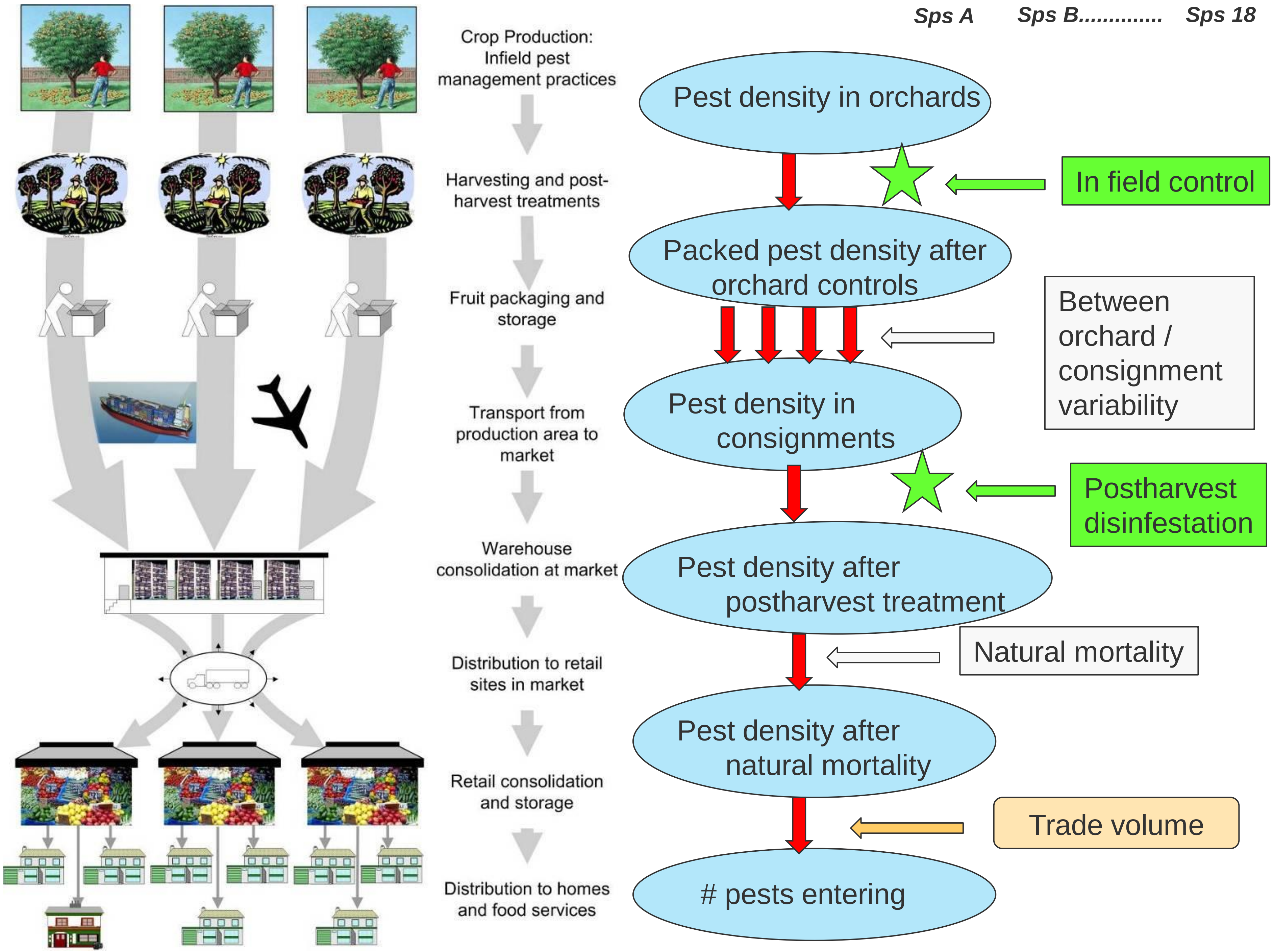
Aim

- Develop models as decision support for import pest risk analysis (PRA)
- PRA aims to objectively evaluate biosecurity risks
  - decisions about importation of an agricultural commodity
  - decisions about risk mitigation

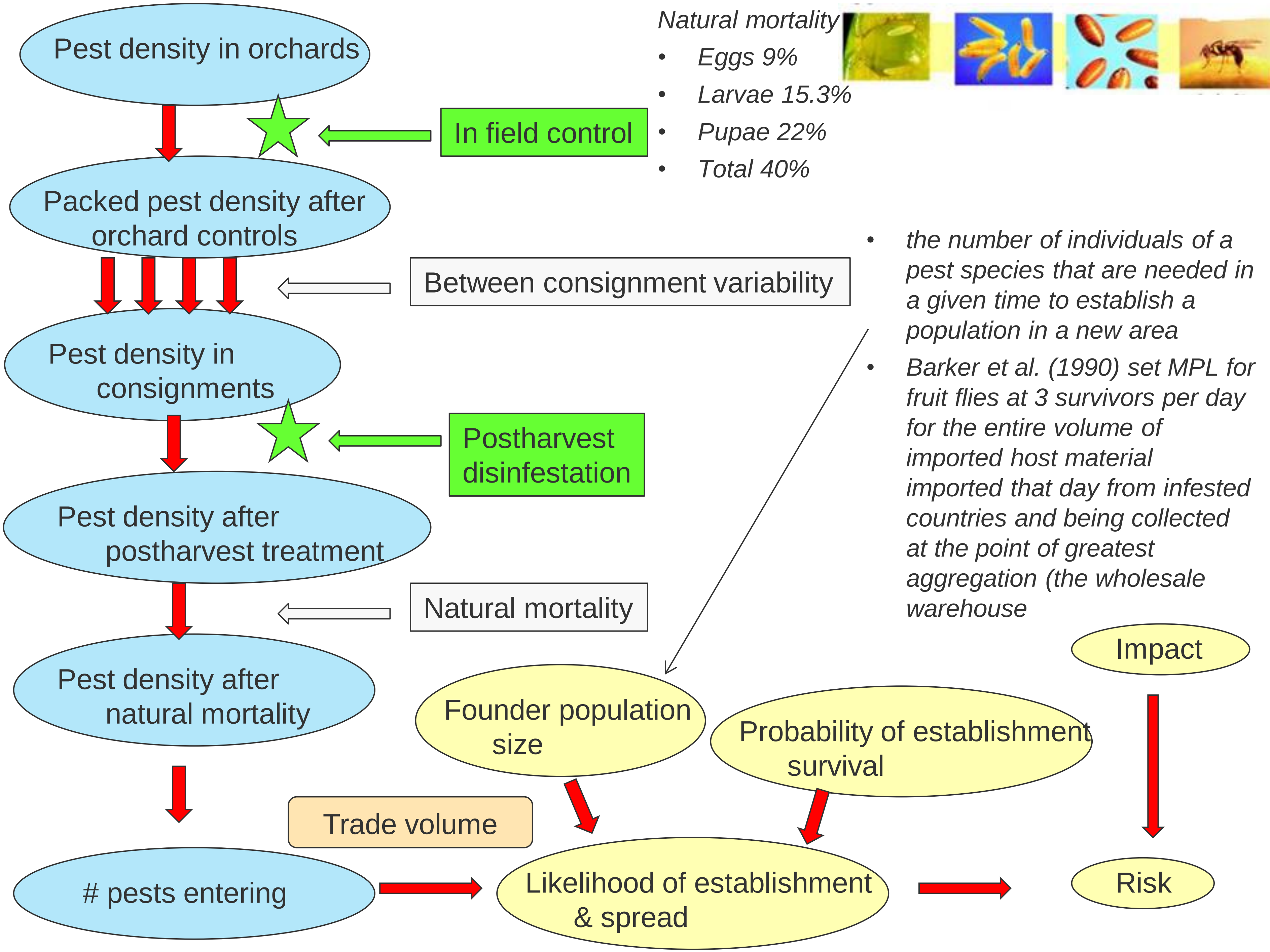
Types of queries

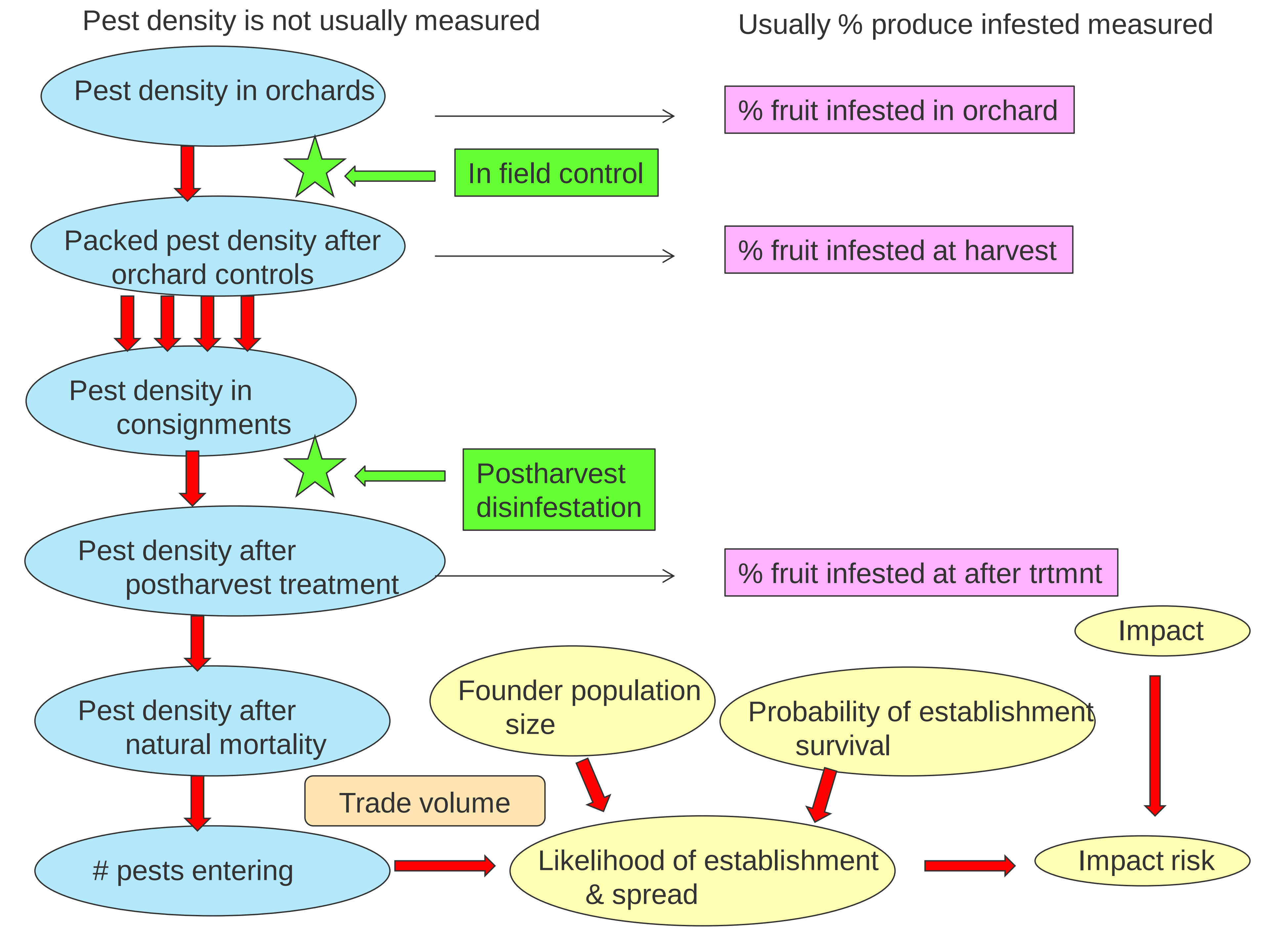
» What impact does
  - » pre-harvest control measures
  - » post-harvest control measures
  - » trade volume

  have on
  - the number of unwanted organisms imported
  - compare with a founder population size
    - the number of individuals of a pest species that are needed to establish a population in a new area
  - import risk



Sps A
Sps B.............
Sps 18
Crop Production: Infield pest management practices
Harvesting and post-harvest treatments
Fruit packaging and storage
Transport from production area to market
Warehouse consolidation at market
Distribution to retail sites in market
Retail consolidation and storage
Distribution to homes and food services
Pest density in orchards
In field control
Packed pest density after orchard controls
Between orchard / consignment variability
Pest density in consignments
Postharvest disinfestation
Pest density after postharvest treatment
Natural mortality
Pest density after natural mortality
Trade volume
pests entering


Pest density in orchards
In field control
Packed pest density after orchard controls
Between consignment variability
Pest density in consignments
Postharvest disinfestation
Pest density after postharvest treatment
Natural mortality
Pest density after natural mortality
pests entering
Trade volume
Likelihood of establishment & spread
Founder population size
Probability of establishment survival
Impact
Risk
Natural mortality
• Eggs 9%
• Larvae 15.3%
• Pupae 22%
• Total 40%
• the number of individuals of a pest species that are needed in a given time to establish a population in a new area
• Barker et al. (1990) set MPL for fruit flies at 3 survivors per day for the entire volume of imported host material imported that day from infested countries and being collected at the point of greatest aggregation (the wholesale warehouse



Pest density is not usually measured
Usually % produce infested measured
Pest density in orchards
% fruit infested in orchard
In field control
Packed pest density after orchard controls
% fruit infested at harvest
Pest density in consignments
Postharvest disinfestation
Pest density after postharvest treatment
% fruit infested at after trtmnt
Impact
Founder population size
Probability of establishment survival
Pest density after natural mortality
Trade volume
pests entering
Likelihood of establishment & spread
Impact risk

Pest density is not usually measured

Usually % produce infested measured

Pest density in orchard → % fruit infested in orchard

To convert pest density to proportion of infested fruit we can either assume pests are:

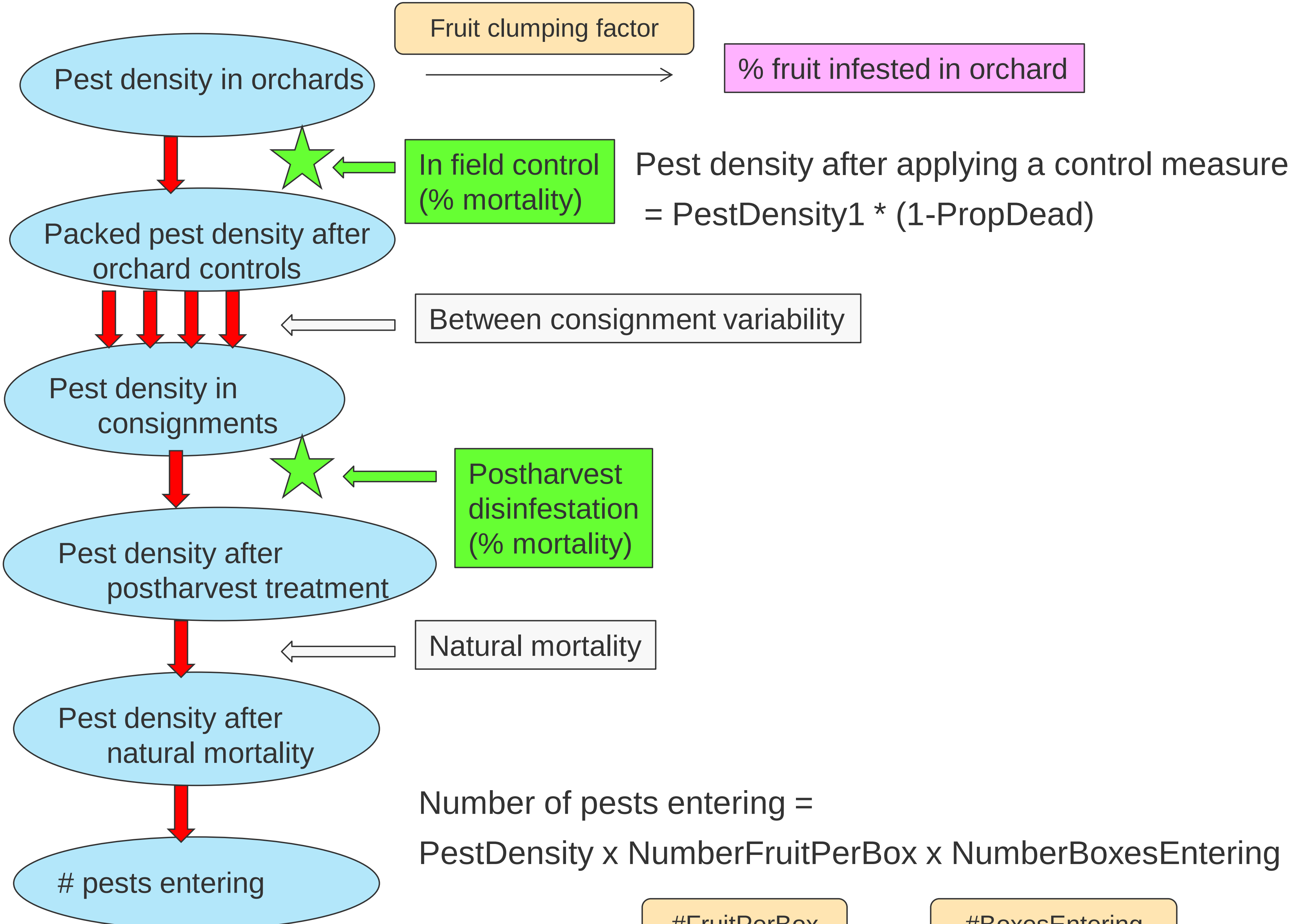
- randomly distributed (Poisson distribution)
- have a tendency to clump (Negative binomial)

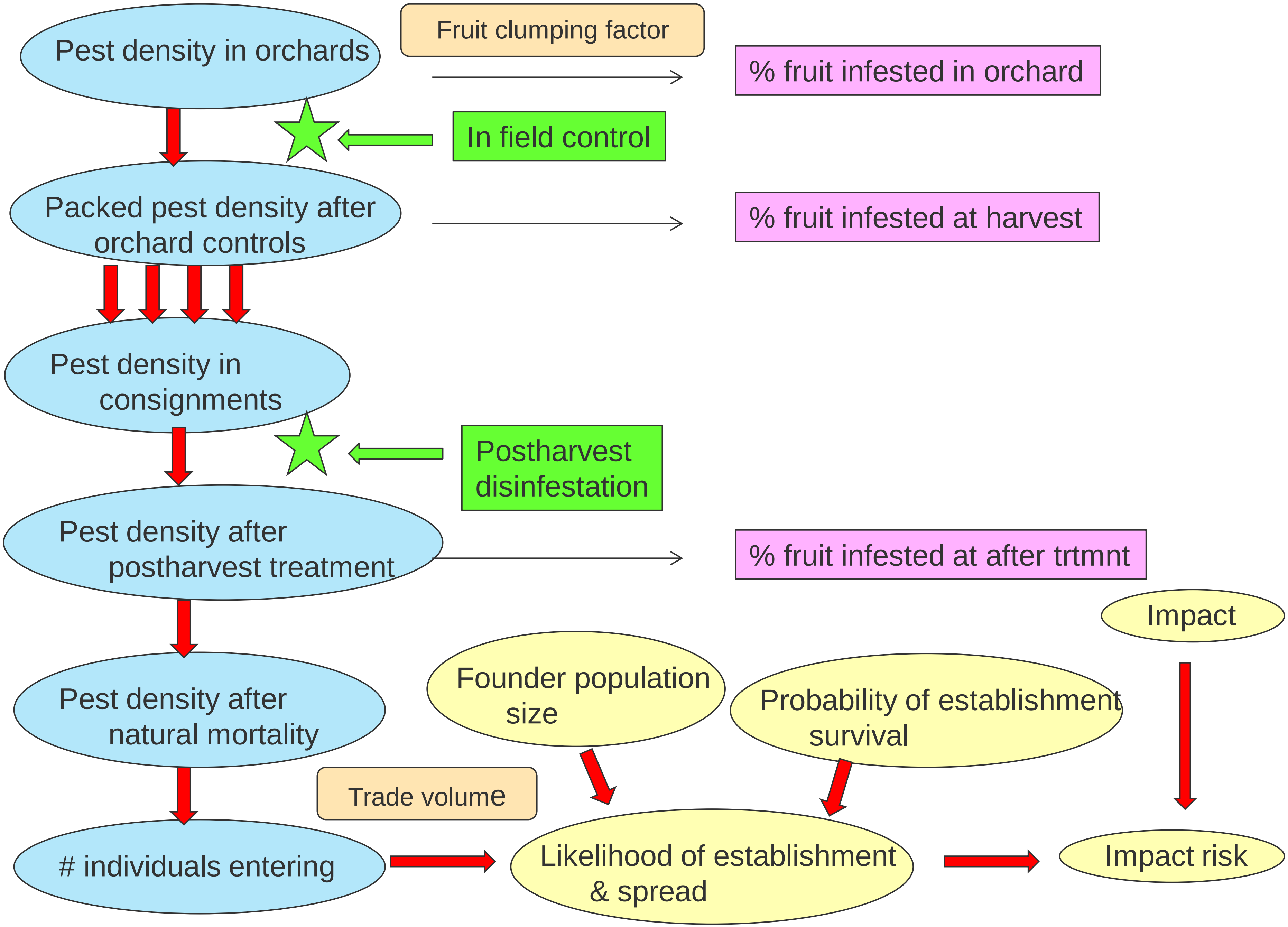
Only need to know proportions of fruit with no pests (P_0) then we can calculate proportion of fruit infested ($1-P_0$)

- Poisson (random):
  $P_o = e^{-m}$
  (where ***e*** is the base of the natural logarithm and ***m*** = mean # pests per fruit)
- Negative binomial required a clumping factor 0 = no clumping, 100 = extreme
  $P_o = (1+mC)^{-1/c}$
  (where ***m*** = mean # pests per fruit and *C* = clumping factor)

Pest density ⇄ % fruit infested

Fruit clumping factor


Fruit clumping factor
Pest density in orchards
% fruit infested in orchard
In field control (% mortality)
Pest density after applying a control measure
= PestDensity1 * (1-PropDead)
Packed pest density after orchard controls
Between consignment variability
Pest density in consignments
Postharvest disinfestation (% mortality)
Pest density after postharvest treatment
Natural mortality
Pest density after natural mortality
Number of pests entering =
PestDensity x NumberFruitPerBox x NumberBoxesEntering
pests entering
#FruitPerBox
#BoxesEntering



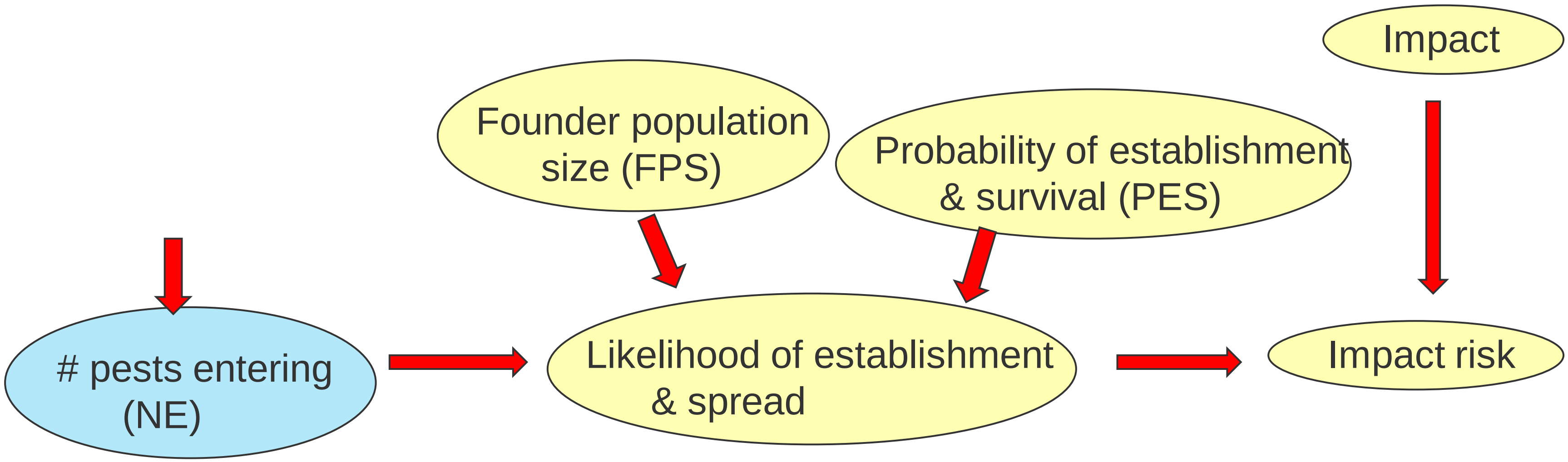
Pest density in orchards
Fruit clumping factor
% fruit infested in orchard
In field control
Packed pest density after orchard controls
% fruit infested at harvest
Pest density in consignments
Postharvest disinfestation
Pest density after postharvest treatment
% fruit infested at after trtmnt
Impact
Founder population size
Probability of establishment survival
Pest density after natural mortality
Trade volume
individuals entering
Likelihood of establishment & spread
Impact risk

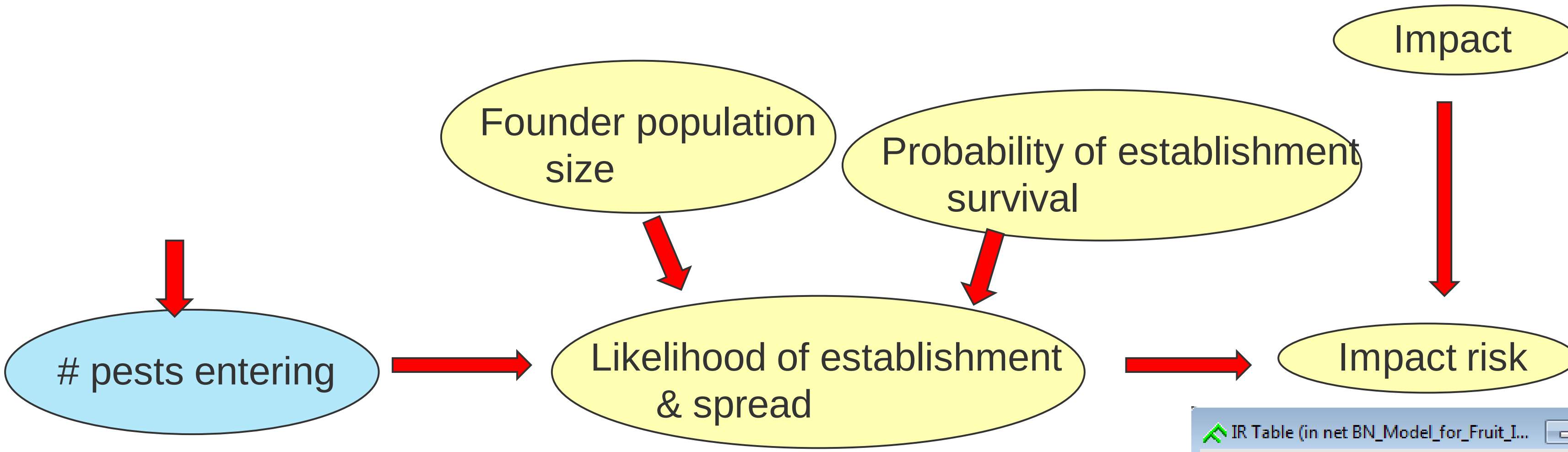
$(1 - PES)^{(NE/FPS)}$ = none establishing

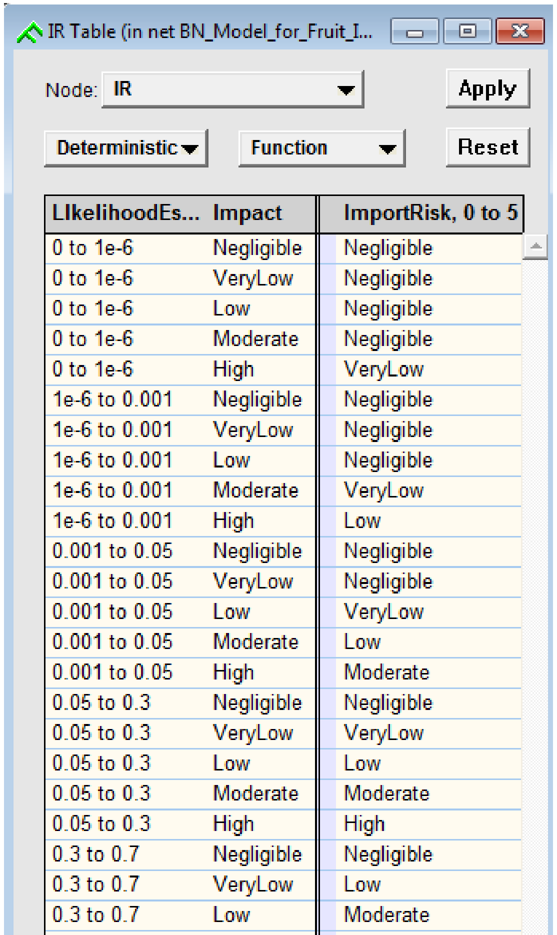
At least 1 establishing

NE/FPS = # viable units

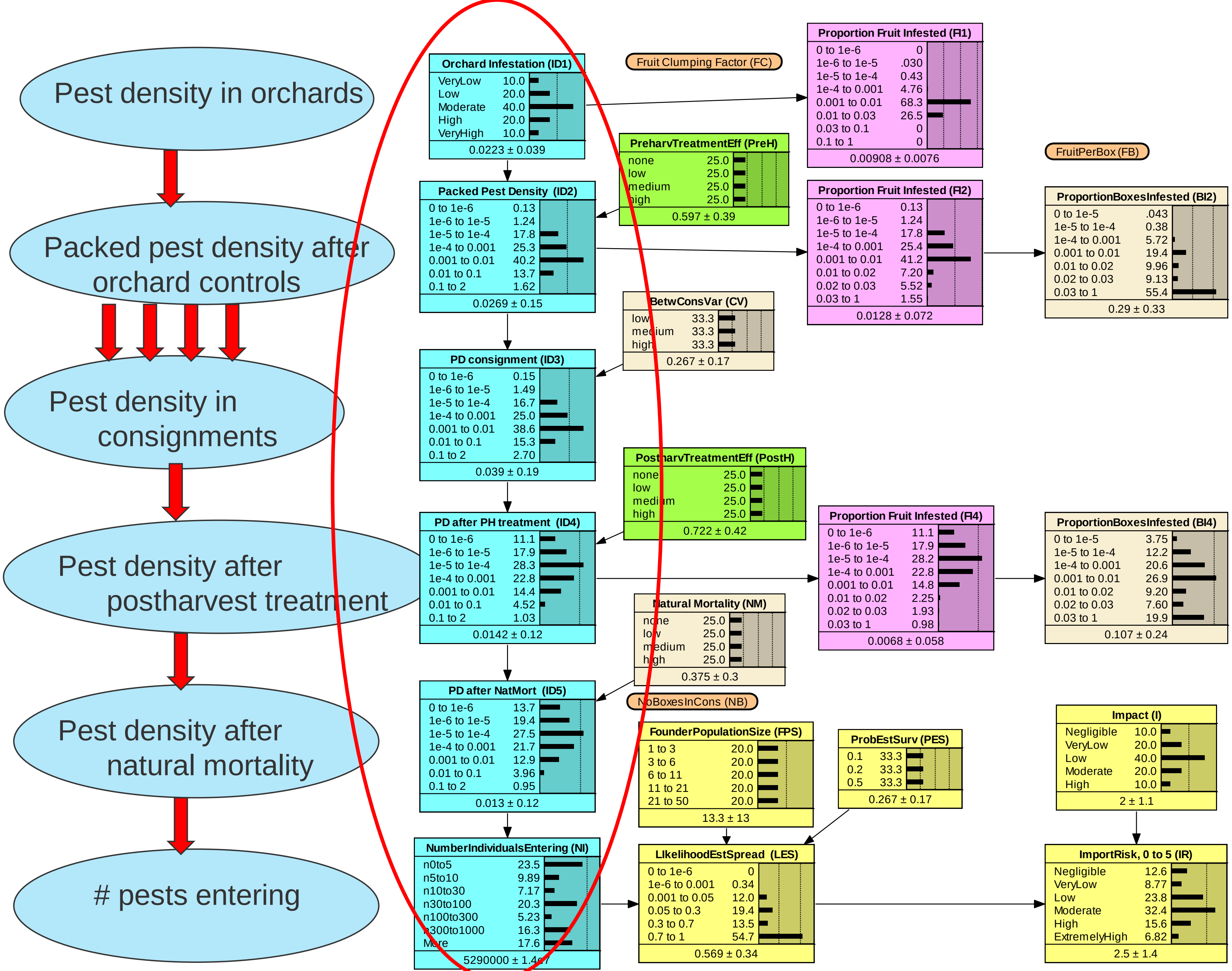
$$\text{Likelihood Establishment \& Spread} = 1 - (1 - PES)^{(NE/FPS)}$$



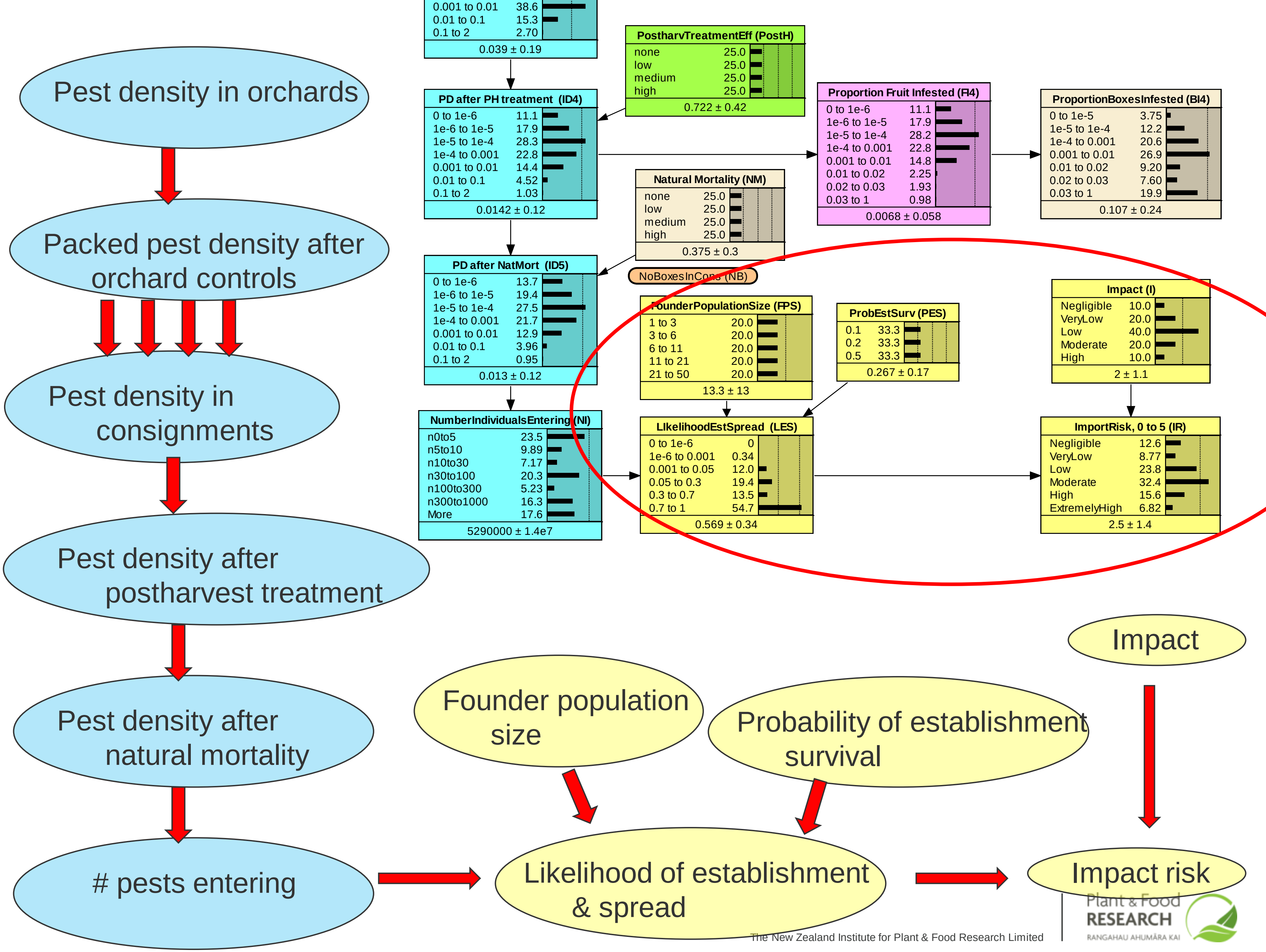




LIkelihoodEs...	Impact	ImportRisk, 0 to 5
0 to 1e-6	Negligible	Negligible
0 to 1e-6	VeryLow	Negligible
0 to 1e-6	Low	Negligible
0 to 1e-6	Moderate	Negligible
0 to 1e-6	High	VeryLow
1e-6 to 0.001	Negligible	Negligible
1e-6 to 0.001	VeryLow	Negligible
1e-6 to 0.001	Low	Negligible
1e-6 to 0.001	Moderate	VeryLow
1e-6 to 0.001	High	Low
0.001 to 0.05	Negligible	Negligible
0.001 to 0.05	VeryLow	Negligible
0.001 to 0.05	Low	VeryLow
0.001 to 0.05	Moderate	Low
0.001 to 0.05	High	Moderate
0.05 to 0.3	Negligible	Negligible
0.05 to 0.3	VeryLow	VeryLow
0.05 to 0.3	Low	Low
0.05 to 0.3	Moderate	Moderate
0.05 to 0.3	High	High
0.3 to 0.7	Negligible	Negligible
0.3 to 0.7	VeryLow	Low
0.3 to 0.7	Low	Moderate



Pest density in orchards
Packed pest density after orchard controls
Pest density in consignments
Pest density after postharvest treatment
Pest density after natural mortality
pests entering
Orchard Infestation (ID1)
VeryLow 10.0
Low 20.0
Moderate 40.0
High 20.0
VeryHigh 10.0
0.0223 ± 0.039
Packed Pest Density (ID2)
0 to 1e-6 0.13
1e-6 to 1e-5 1.24
1e-5 to 1e-4 17.8
1e-4 to 0.001 25.3
0.001 to 0.01 40.2
0.01 to 0.1 13.7
0.1 to 2 1.62
0.0269 ± 0.15
PD consignment (ID3)
0 to 1e-6 0.15
1e-6 to 1e-5 1.49
1e-5 to 1e-4 16.7
1e-4 to 0.001 25.0
0.001 to 0.01 38.6
0.01 to 0.1 15.3
0.1 to 2 2.70
0.039 ± 0.19
PD after PH treatment (ID4)
0 to 1e-6 11.1
1e-6 to 1e-5 17.9
1e-5 to 1e-4 28.3
1e-4 to 0.001 22.8
0.001 to 0.01 14.4
0.01 to 0.1 4.52
0.1 to 2 1.03
0.0142 ± 0.12
PD after NatMort (ID5)
0 to 1e-6 13.7
1e-6 to 1e-5 19.4
1e-5 to 1e-4 27.5
1e-4 to 0.001 21.7
0.001 to 0.01 12.9
0.01 to 0.1 3.96
0.1 to 2 0.95
0.013 ± 0.12
NumberIndividualsEntering (NI)
n0to5 23.5
n5to10 9.89
n10to30 7.17
n30to100 20.3
n100to300 5.23
n300to1000 16.3
More 17.6
5290000 ± 1.4e7
Fruit Clumping Factor (FC)
PreharvTreatmentEff (PreH)
none 25.0
low 25.0
medium 25.0
high 25.0
0.597 ± 0.39
BetwConsVar (CV)
low 33.3
medium 33.3
high 33.3
0.267 ± 0.17
PostharvTreatmentEff (PostH)
none 25.0
low 25.0
medium 25.0
high 25.0
0.722 ± 0.42
Natural Mortality (NM)
none 25.0
low 25.0
medium 25.0
high 25.0
0.375 ± 0.3
NoBoxesInCons (NB)
FounderPopulationSize (FPS)
1 to 3 20.0
3 to 6 20.0
6 to 11 20.0
11 to 21 20.0
21 to 50 20.0
13.3 ± 13
ProbEstSurv (PES)
0.1 33.3
0.2 33.3
0.5 33.3
0.267 ± 0.17
LikelihoodEstSpread (LES)
0 to 1e-6 0
1e-6 to 0.001 0.34
0.001 to 0.05 12.0
0.05 to 0.3 19.4
0.3 to 0.7 13.5
0.7 to 1 54.7
0.569 ± 0.34
Proportion Fruit Infested (FI1)
0 to 1e-6 0
1e-6 to 1e-5 .030
1e-5 to 1e-4 0.43
1e-4 to 0.001 4.76
0.001 to 0.01 68.3
0.01 to 0.03 26.5
0.03 to 0.1 0
0.1 to 1 0
0.00908 ± 0.0076
Proportion Fruit Infested (FI2)
0 to 1e-6 0.13
1e-6 to 1e-5 1.24
1e-5 to 1e-4 17.8
1e-4 to 0.001 25.4
0.001 to 0.01 41.2
0.01 to 0.02 7.20
0.02 to 0.03 5.52
0.03 to 1 1.55
0.0128 ± 0.072
Proportion Fruit Infested (FI4)
0 to 1e-6 11.1
1e-6 to 1e-5 17.9
1e-5 to 1e-4 28.2
1e-4 to 0.001 22.8
0.001 to 0.01 14.8
0.01 to 0.02 2.25
0.02 to 0.03 1.93
0.03 to 1 0.98
0.0068 ± 0.058
FruitPerBox (FB)
ProportionBoxesInfested (BI2)
0 to 1e-5 .043
1e-5 to 1e-4 0.38
1e-4 to 0.001 5.72
0.001 to 0.01 19.4
0.01 to 0.02 9.96
0.02 to 0.03 9.13
0.03 to 1 55.4
0.29 ± 0.33
ProportionBoxesInfested (BI4)
0 to 1e-5 3.75
1e-5 to 1e-4 12.2
1e-4 to 0.001 20.6
0.001 to 0.01 26.9
0.01 to 0.02 9.20
0.02 to 0.03 7.60
0.03 to 1 19.9
0.107 ± 0.24
Impact (I)
Negligible 10.0
VeryLow 20.0
Low 40.0
Moderate 20.0
High 10.0
2 ± 1.1
ImportRisk, 0 to 5 (IR)
Negligible 12.6
VeryLow 8.77
Low 23.8
Moderate 32.4
High 15.6
ExtremelyHigh 6.82
2.5 ± 1.4


Pest density in orchards
Packed pest density after orchard controls
Pest density in consignments
Pest density after postharvest treatment
Pest density after natural mortality
pests entering
Likelihood of establishment & spread
Founder population size
Probability of establishment survival
Impact
Impact risk
0.001 to 0.01 38.6
0.01 to 0.1 15.3
0.1 to 2 2.70
0.039 ± 0.19
PD after PH treatment (ID4)
0 to 1e-6 11.1
1e-6 to 1e-5 17.9
1e-5 to 1e-4 28.3
1e-4 to 0.001 22.8
0.001 to 0.01 14.4
0.01 to 0.1 4.52
0.1 to 2 1.03
0.0142 ± 0.12
PD after NatMort (ID5)
0 to 1e-6 13.7
1e-6 to 1e-5 19.4
1e-5 to 1e-4 27.5
1e-4 to 0.001 21.7
0.001 to 0.01 12.9
0.01 to 0.1 3.96
0.1 to 2 0.95
0.013 ± 0.12
NumberIndividualsEntering (NI)
n0to5 23.5
n5to10 9.89
n10to30 7.17
n30to100 20.3
n100to300 5.23
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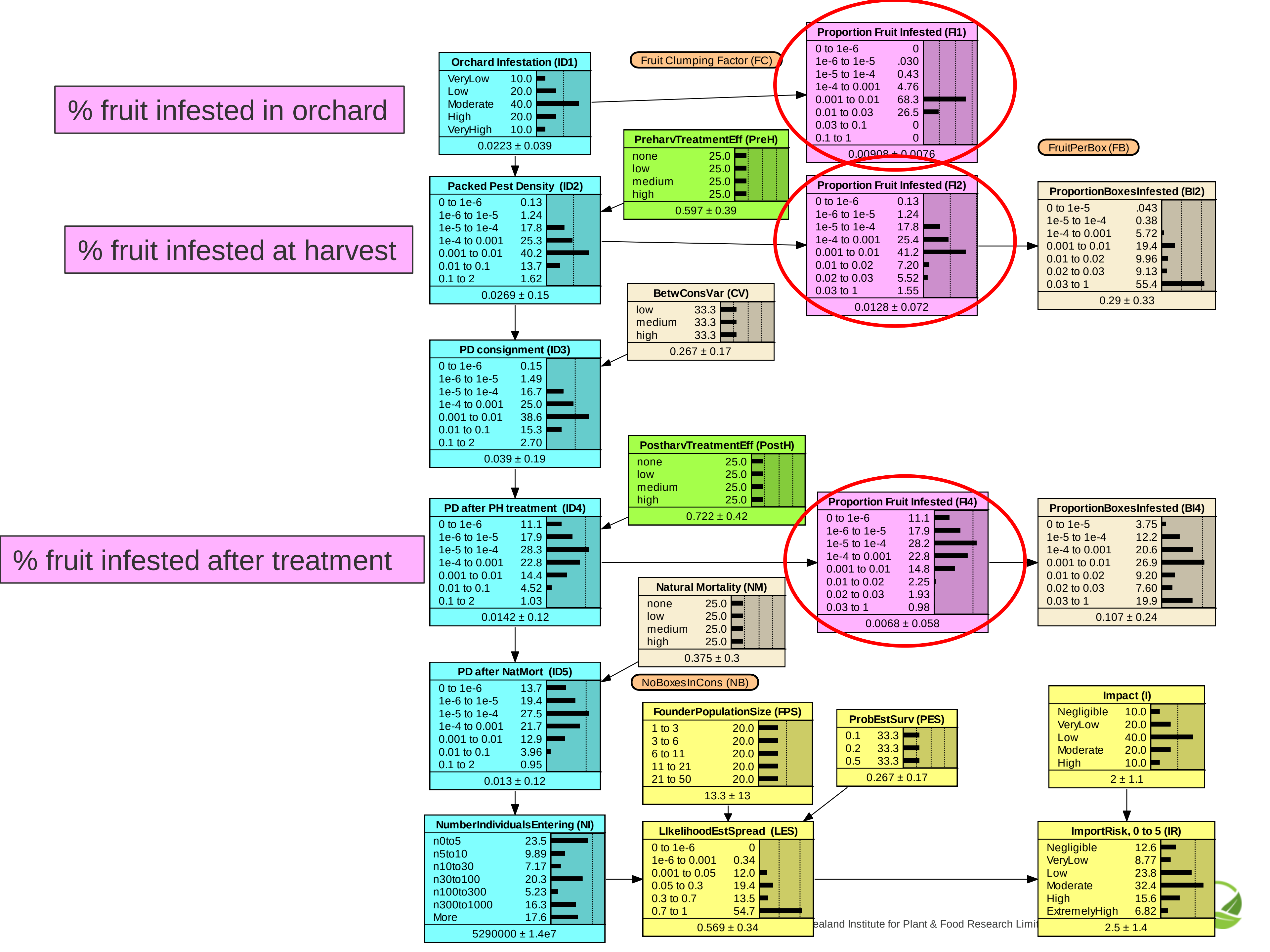
More 17.6
5290000 ± 1.4e7
PostharvTreatmentEff (PostH)
none 25.0
low 25.0
medium 25.0
high 25.0
0.722 ± 0.42
Natural Mortality (NM)
none 25.0
low 25.0
medium 25.0
high 25.0
0.375 ± 0.3
NoBoxesInCons (NB)
Proportion Fruit Infested (FI4)
0 to 1e-6 11.1
1e-6 to 1e-5 17.9
1e-5 to 1e-4 28.2
1e-4 to 0.001 22.8
0.001 to 0.01 14.8
0.01 to 0.02 2.25
0.02 to 0.03 1.93
0.03 to 1 0.98
0.0068 ± 0.058
ProportionBoxesInfested (BI4)
0 to 1e-5 3.75
1e-5 to 1e-4 12.2
1e-4 to 0.001 20.6
0.001 to 0.01 26.9
0.01 to 0.02 9.20
0.02 to 0.03 7.60
0.03 to 1 19.9
0.107 ± 0.24
FounderPopulationSize (FPS)
1 to 3 20.0
3 to 6 20.0
6 to 11 20.0
11 to 21 20.0
21 to 50 20.0
13.3 ± 13
ProbEstSurv (PES)
0.1 33.3
0.2 33.3
0.5 33.3
0.267 ± 0.17
Impact (I)
Negligible 10.0
VeryLow 20.0
Low 40.0
Moderate 20.0
High 10.0
2 ± 1.1
LikelihoodEstSpread (LES)
0 to 1e-6 0
1e-6 to 0.001 0.34
0.001 to 0.05 12.0
0.05 to 0.3 19.4
0.3 to 0.7 13.5
0.7 to 1 54.7
0.569 ± 0.34
ImportRisk, 0 to 5 (IR)
Negligible 12.6
VeryLow 8.77
Low 23.8
Moderate 32.4
High 15.6
ExtremelyHigh 6.82
2.5 ± 1.4



% fruit infested in orchard
% fruit infested at harvest
% fruit infested after treatment
Orchard Infestation (ID1)
VeryLow 10.0
Low 20.0
Moderate 40.0
High 20.0
VeryHigh 10.0
0.0223 ± 0.039
Fruit Clumping Factor (FC)
Proportion Fruit Infested (FI1)
0 to 1e-6 0
1e-6 to 1e-5 .030
1e-5 to 1e-4 0.43
1e-4 to 0.001 4.76
0.001 to 0.01 68.3
0.01 to 0.03 26.5
0.03 to 0.1 0
0.1 to 1 0
0.00908 ± 0.0076
FruitPerBox (FB)
PreharvTreatmentEff (PreH)
none 25.0
low 25.0
medium 25.0
high 25.0
0.597 ± 0.39
Packed Pest Density (ID2)
0 to 1e-6 0.13
1e-6 to 1e-5 1.24
1e-5 to 1e-4 17.8
1e-4 to 0.001 25.3
0.001 to 0.01 40.2
0.01 to 0.1 13.7
0.1 to 2 1.62
0.0269 ± 0.15
Proportion Fruit Infested (FI2)
0 to 1e-6 0.13
1e-6 to 1e-5 1.24
1e-5 to 1e-4 17.8
1e-4 to 0.001 25.4
0.001 to 0.01 41.2
0.01 to 0.02 7.20
0.02 to 0.03 5.52
0.03 to 1 1.55
0.0128 ± 0.072
ProportionBoxesInfested (BI2)
0 to 1e-5 .043
1e-5 to 1e-4 0.38
1e-4 to 0.001 5.72
0.001 to 0.01 19.4
0.01 to 0.02 9.96
0.02 to 0.03 9.13
0.03 to 1 55.4
0.29 ± 0.33
BetwConsVar (CV)
low 33.3
medium 33.3
high 33.3
0.267 ± 0.17
PD consignment (ID3)
0 to 1e-6 0.15
1e-6 to 1e-5 1.49
1e-5 to 1e-4 16.7
1e-4 to 0.001 25.0
0.001 to 0.01 38.6
0.01 to 0.1 15.3
0.1 to 2 2.70
0.039 ± 0.19
PostharvTreatmentEff (PostH)
none 25.0
low 25.0
medium 25.0
high 25.0
0.722 ± 0.42
PD after PH treatment (ID4)
0 to 1e-6 11.1
1e-6 to 1e-5 17.9
1e-5 to 1e-4 28.3
1e-4 to 0.001 22.8
0.001 to 0.01 14.4
0.01 to 0.1 4.52
0.1 to 2 1.03
0.0142 ± 0.12
Proportion Fruit Infested (FI4)
0 to 1e-6 11.1
1e-6 to 1e-5 17.9
1e-5 to 1e-4 28.2
1e-4 to 0.001 22.8
0.001 to 0.01 14.8
0.01 to 0.02 2.25
0.02 to 0.03 1.93
0.03 to 1 0.98
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0 to 1e-5 3.75
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1e-4 to 0.001 20.6
0.001 to 0.01 26.9
0.01 to 0.02 9.20
0.02 to 0.03 7.60
0.03 to 1 19.9
0.107 ± 0.24
Natural Mortality (NM)
none 25.0
low 25.0
medium 25.0
high 25.0
0.375 ± 0.3
PD after NatMort (ID5)
0 to 1e-6 13.7
1e-6 to 1e-5 19.4
1e-5 to 1e-4 27.5
1e-4 to 0.001 21.7
0.001 to 0.01 12.9
0.01 to 0.1 3.96
0.1 to 2 0.95
0.013 ± 0.12
NoBoxesInCons (NB)
FounderPopulationSize (FPS)
1 to 3 20.0
3 to 6 20.0
6 to 11 20.0
11 to 21 20.0
21 to 50 20.0
13.3 ± 13
ProbEstSurv (PES)
0.1 33.3
0.2 33.3
0.5 33.3
0.267 ± 0.17
Impact (I)
Negligible 10.0
VeryLow 20.0
Low 40.0
Moderate 20.0
High 10.0
2 ± 1.1
NumberIndividualsEntering (NI)
n0to5 23.5
n5to10 9.89
n10to30 7.17
n30to100 20.3
n100to300 5.23
n300to1000 16.3
More 17.6
5290000 ± 1.4e7
LIkelihoodEstSpread (LES)
0 to 1e-6 0
1e-6 to 0.001 0.34
0.001 to 0.05 12.0
0.05 to 0.3 19.4
0.3 to 0.7 13.5
0.7 to 1 54.7
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ImportRisk, 0 to 5 (IR)
Negligible 12.6
VeryLow 8.77
Low 23.8
Moderate 32.4
High 15.6
ExtremelyHigh 6.82
2.5 ± 1.4
ealand Institute for Plant & Food Research Limit

In field control (% mortality)

Postharvest disinfestation (% mortality)

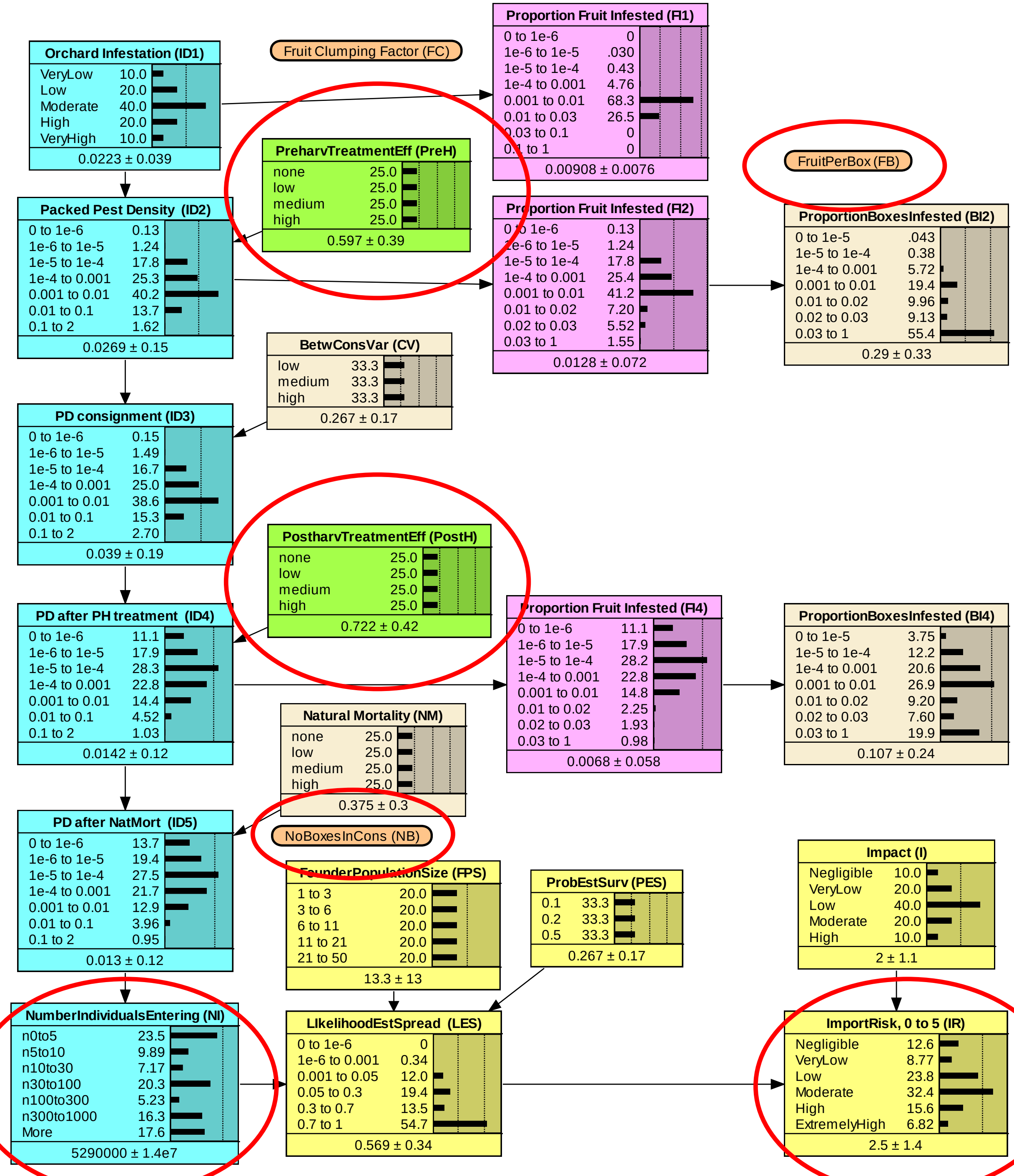
Trade volume

#FruitPerBox

#BoxesEntering

What impact does
- pre-harvest control measures
- postharvest control measures
- trade volume

have on
- the number of unwanted organisms imported
- import risk?



» Set

» 0.1-1% fruit infested in orchard

» No preharvest control

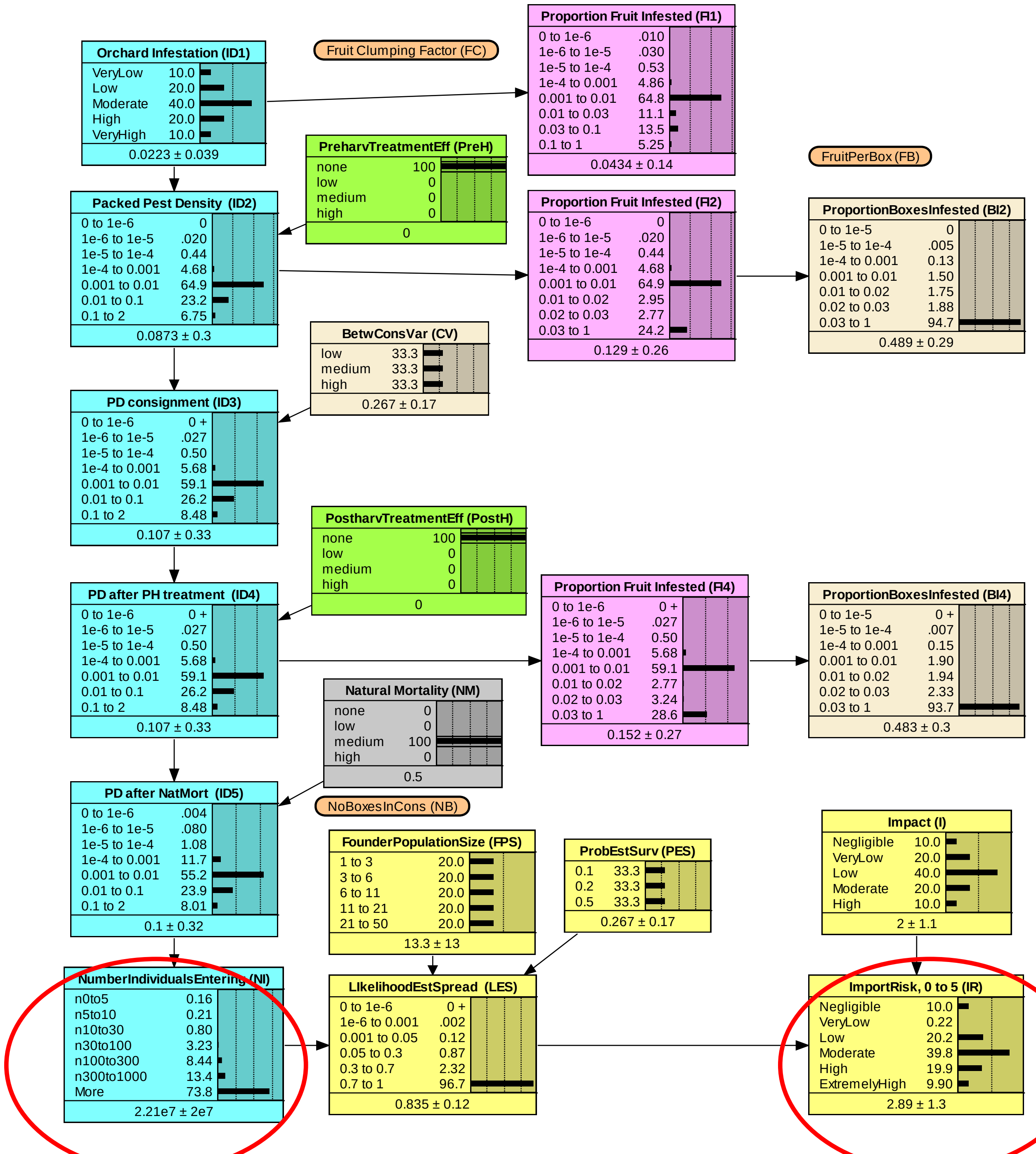
» No postharvest control

» 10,000 boxes, 30 fruit per box

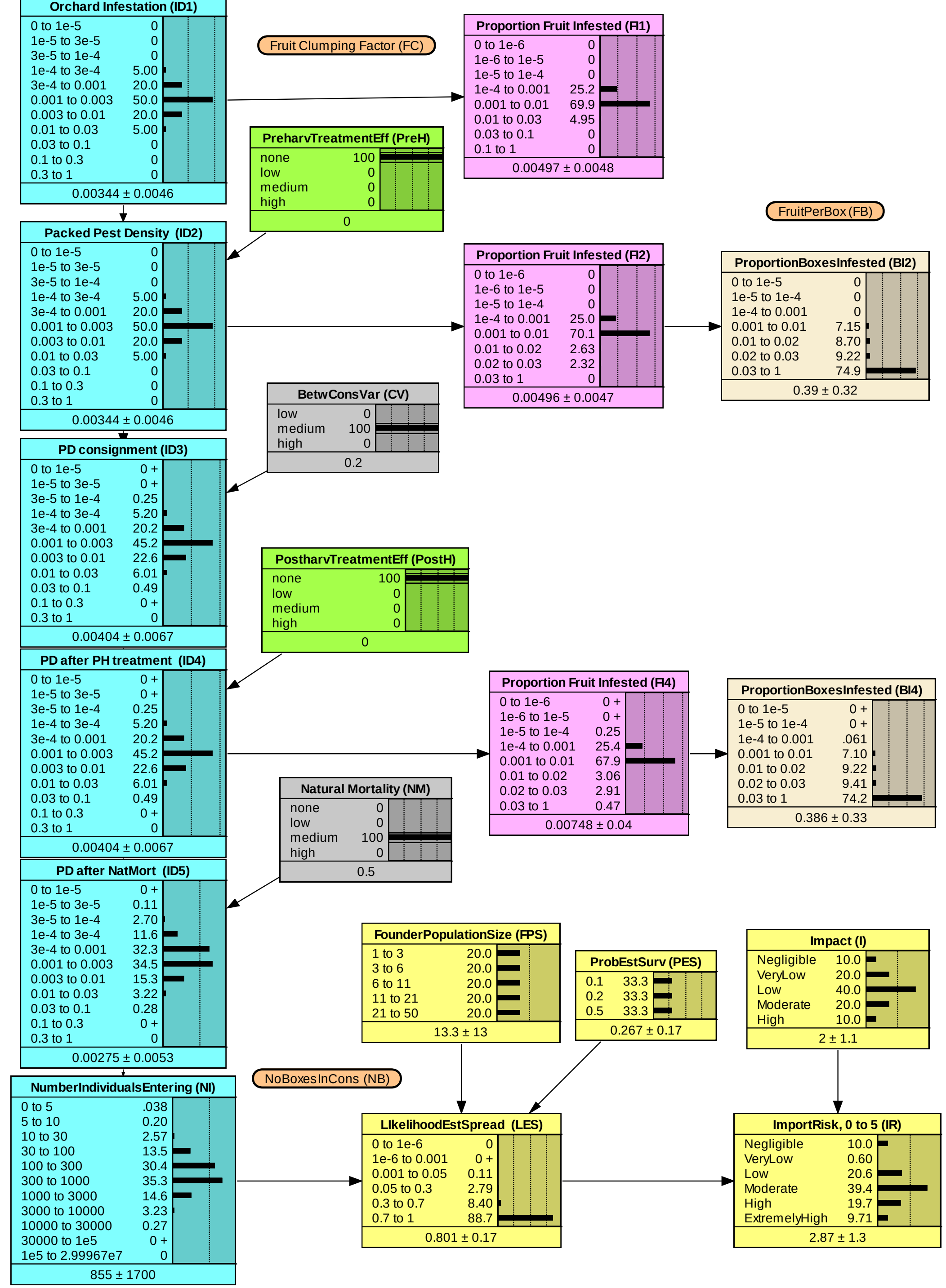
» Outcome

» Millions of individuals arriving

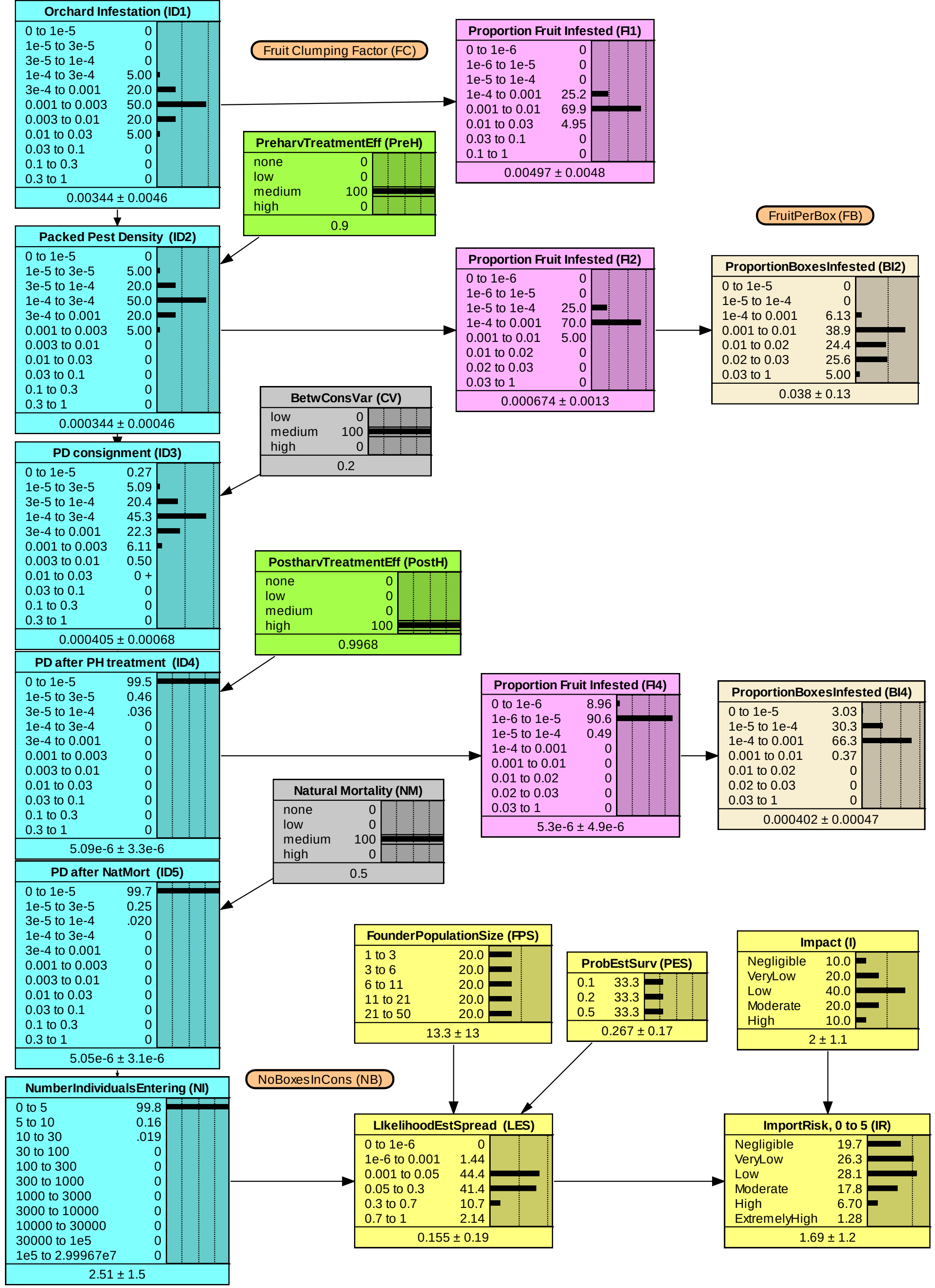
» Discretization over-estimated numbers arriving



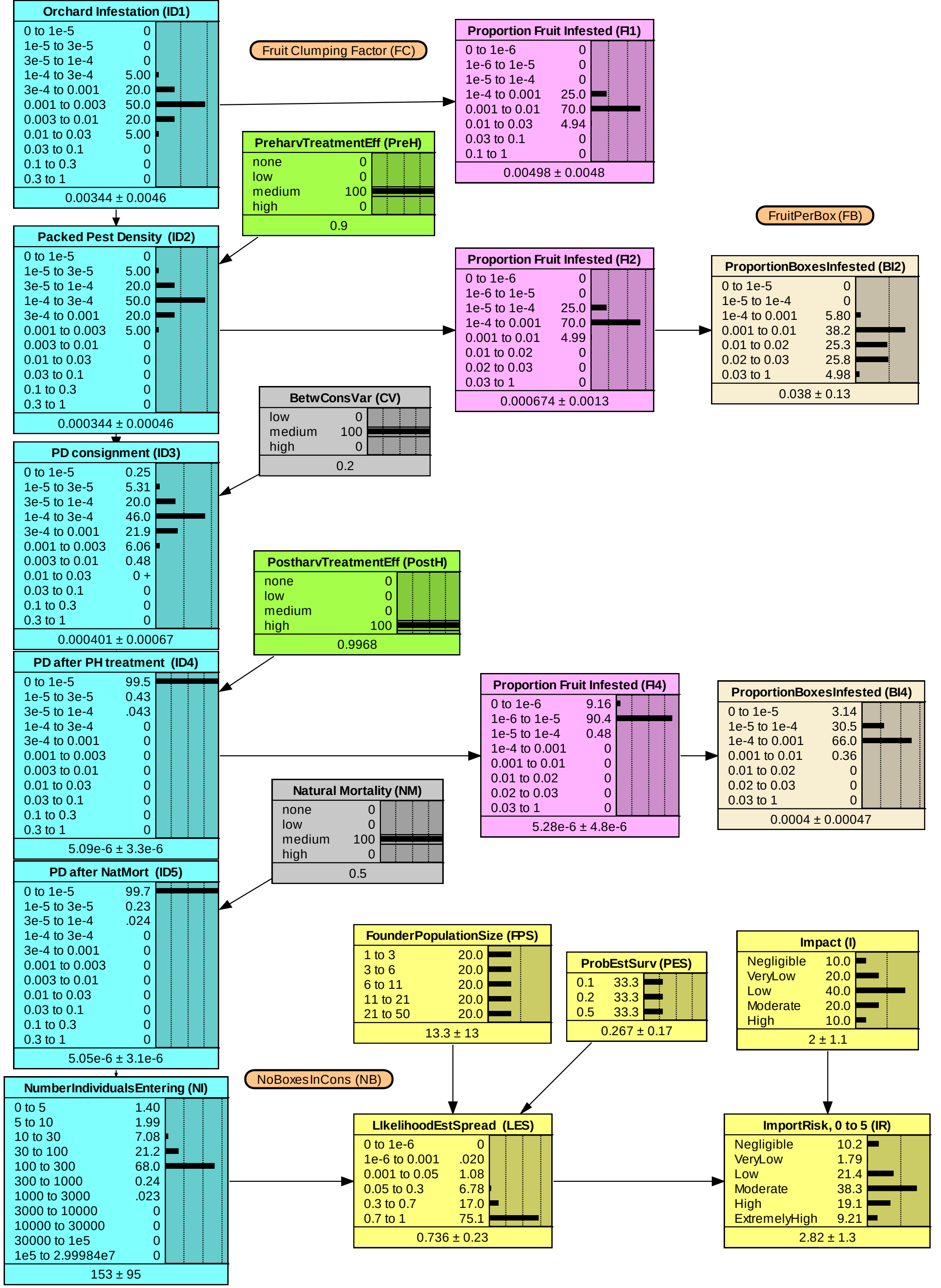
- Set
  - 0.1-1% fruit infested in orchard
  - No preharvest control
  - No postharvest control
  - 10,000 boxes, 30 fruit per box
- Outcome
  - 885 ±1700 individuals



- Set
  - 0.1-1% fruit infested in orchard
  - 90% preharvest control
  - 99.9968% postharvest control
  - 50% natural mortality
  - 10,000 boxes, 30 fruit per box
- Outcome
  - 2.5 ± 1.5 individuals



- Set
  - 0.1-1% fruit infested in orchard
  - 90% preharvest control
  - 99.9968% postharvest control
  - 50% natural mortality
  - 1 million boxes
- Outcome
  - 153 ± 95 individuals



Model Uses

» For “forward” use set all nature nodes to “unknown” expect for Orchard Infestation and Impact

» Estimate the orchard Infestation level from other observations. For example, orchard infestation can be set to “unknown” then fruit infestation at harvest could be set instead

» Measure impact of various levels of mitigation along the pathway by first running model with pre- and post-harvest treatment efficacy set to none and then set to a particular efficacy rate

Progress

In the process of developing a BN to:

- the level of efficacy required on the pathway
- volume of trade allowable before founder population levels exceeded

Expansion (sub BNs) include:

- other entry risk factors e.g. time of year, time taken for transport
- establishment and spread risk factors e.g. attributes of environment: climate, resource availability; attributes of sps: detection, rate of increase, ability to spread
- impact
  - economic, environmental, social, cultural, political
- add decision nodes and cost of
  - treatments / mitigation / measuring compliance
  - surveillance
  - eradication
  - offset that with cost of impact - pest management

Lessons learnt so far

- Inclusion of mathematical relationships to construct CPTs - validation
- Discretization can have major effect on outcome
- More consultation required involving subject matter experts, modellers and stakeholders






Acknowledgements

- This research was funded by the New Zealand Government (contract CO2X0501) and Plant and Food Research as part of the Better Border Biosecurity (B3) (www.b3nz.org) research collaboration
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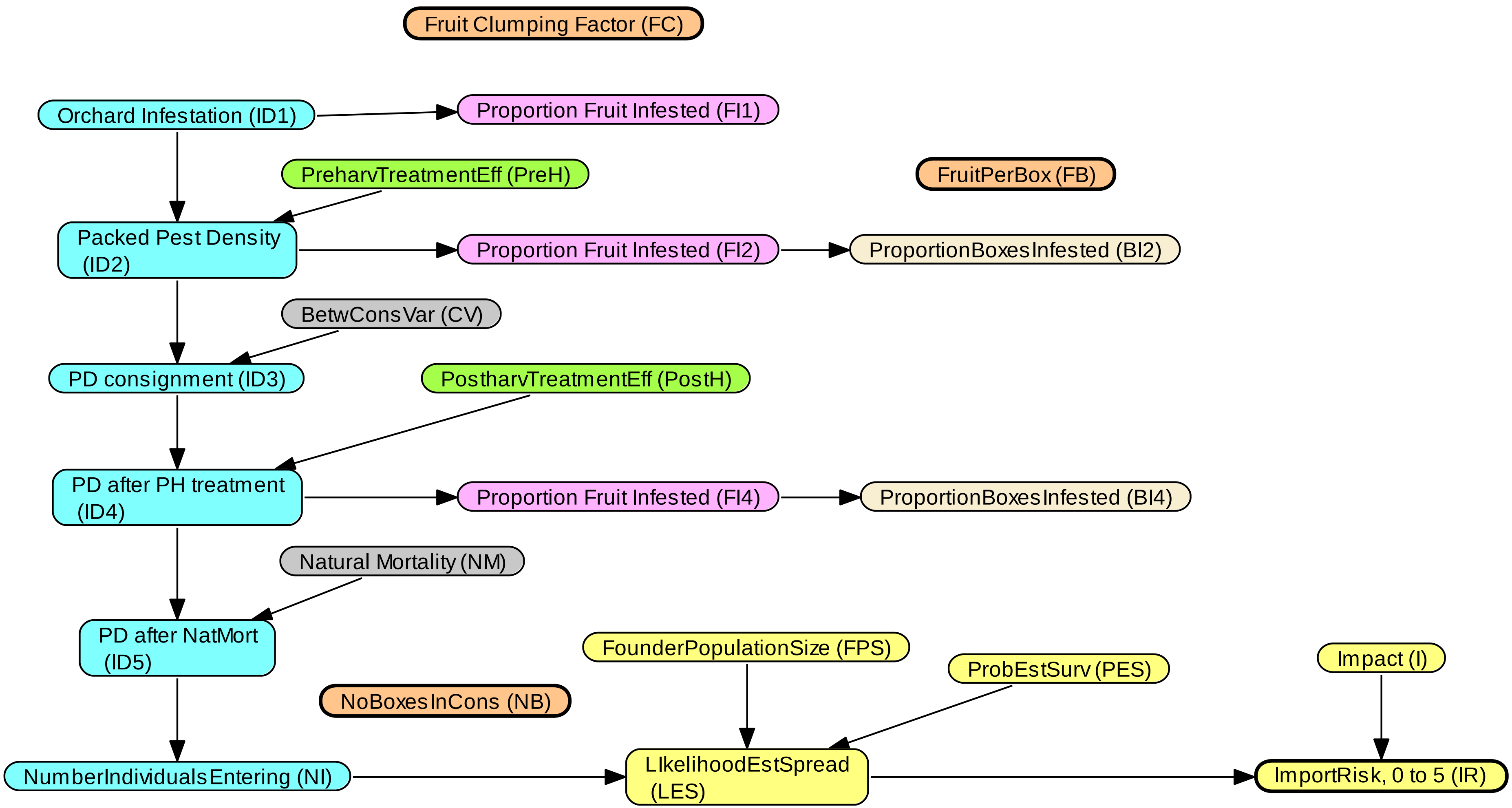

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