
Which action for which species?
Prioritising the management of multiple plant invasions
not native
Joslin Moore, Alana Moore, Mike Runge, Libby Rumpff
MONASH University

Biological invasions

Quantifying Threats to Imperiled Species in the United States

Assessing the relative importance of habitat destruction, alien species, pollution, overexploitation, and disease

David S. Wilcove, David Rothstein, Jason Dubow, Ali Phillips, an

Biologists are nearly unanimous in their belief that humanity is in the process of extirpating a significant portion of the earth's species. The ways in which we are doing so reflect the magnitude and scale of human enterprise. Everything from highway construction to cattle ranching to leaky bait buckets has been implicated in the demise or endangerment of particular species. According to Wilson (1992), most of

Habitat loss is the single greatest threat to biodiversity, followed by the spread of alien species

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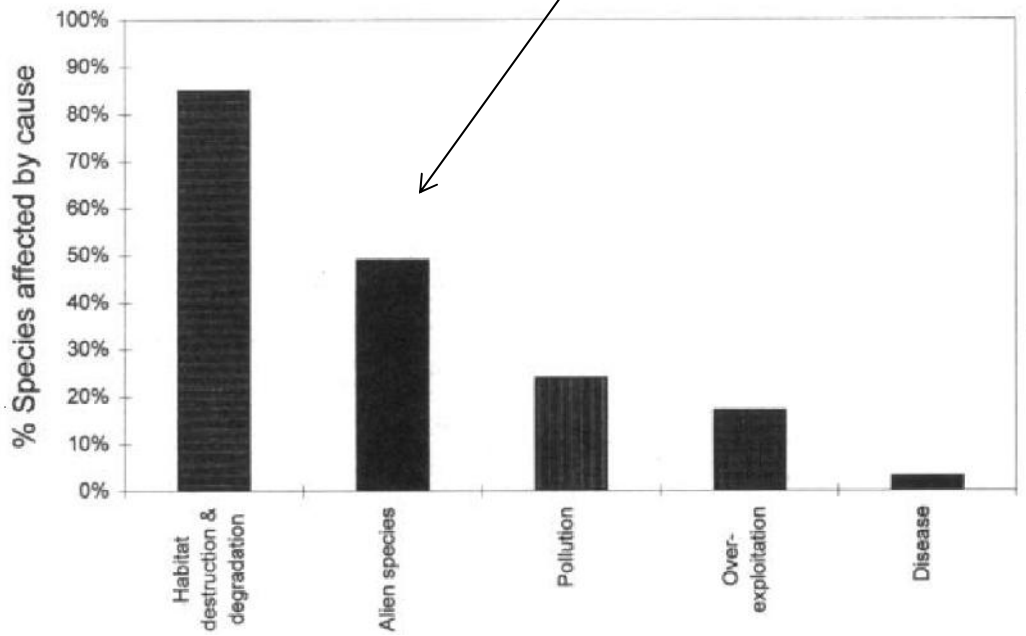
Biological invasions



Wilcove *et al.*, 1998. *BioScience*, ***48, 607-615.***

Biological invasions

ECOLOGY

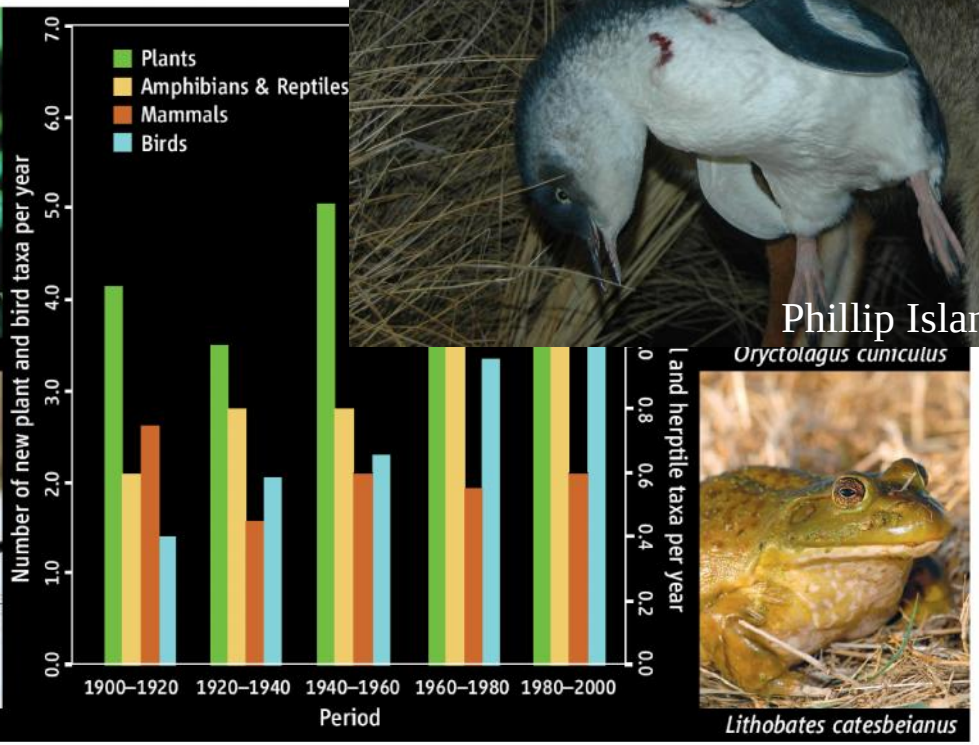
Will Threat of Biological Invasion Unite the European Union?

Philip E. Hulme,[1]* Petr Pyšek,[2] Wolfgang Nentwig,[3] Montserrat Vilà[4]

Phillip Island Nature Parks

Rhododendron ponticum

Branta canadensis



Oryctolagus cuniculus

Lithobates catesbeianus

Biological invasions

Introduced plants affect 45% of threatened species

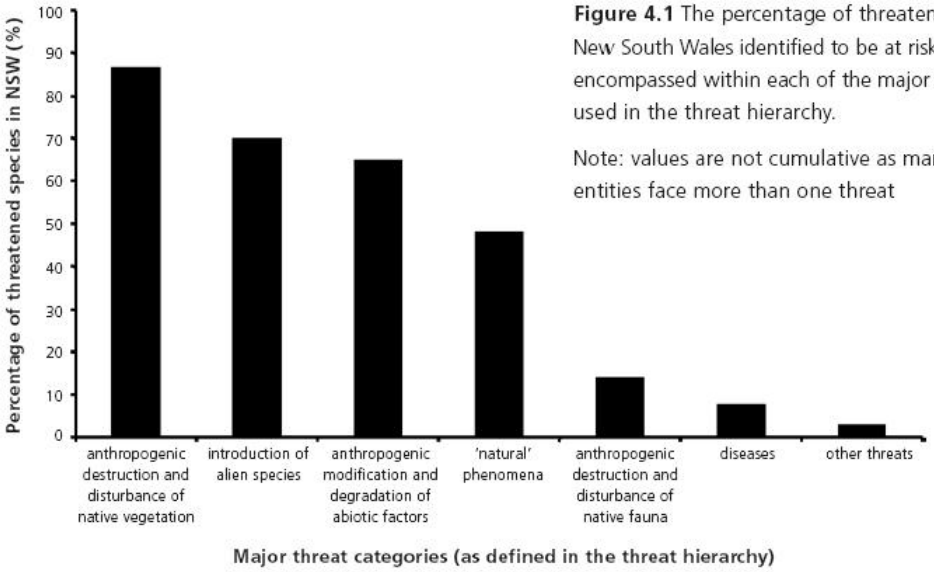
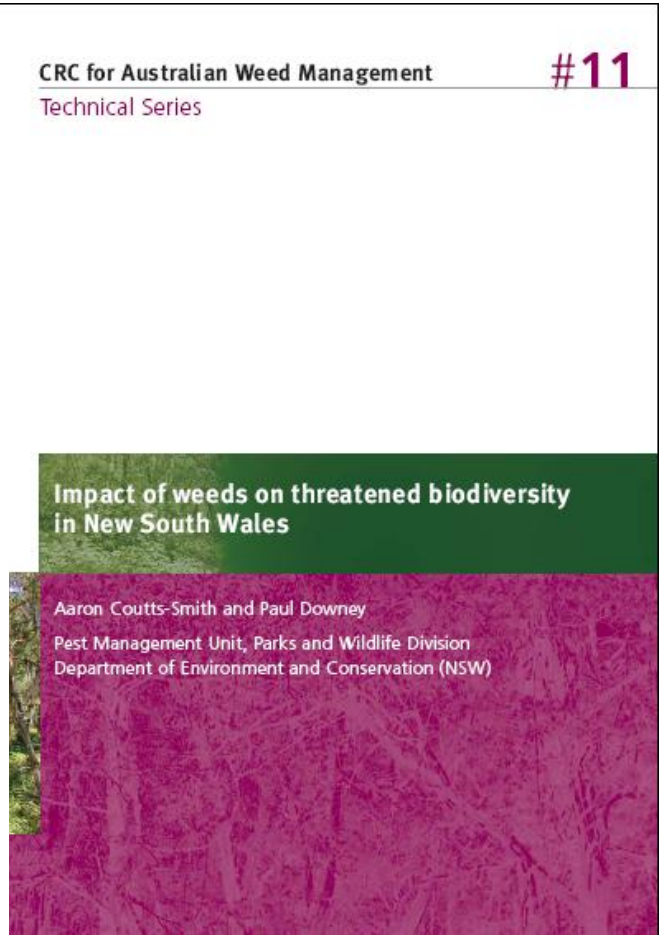


Figure 4.1 The percentage of threatened biodiversity in New South Wales identified to be at risk from the threats encompassed within each of the major threat categories used in the threat hierarchy.

Note: values are not cumulative as many biological entities face more than one threat



Biological invasions

Australia

~20,000 native plant species

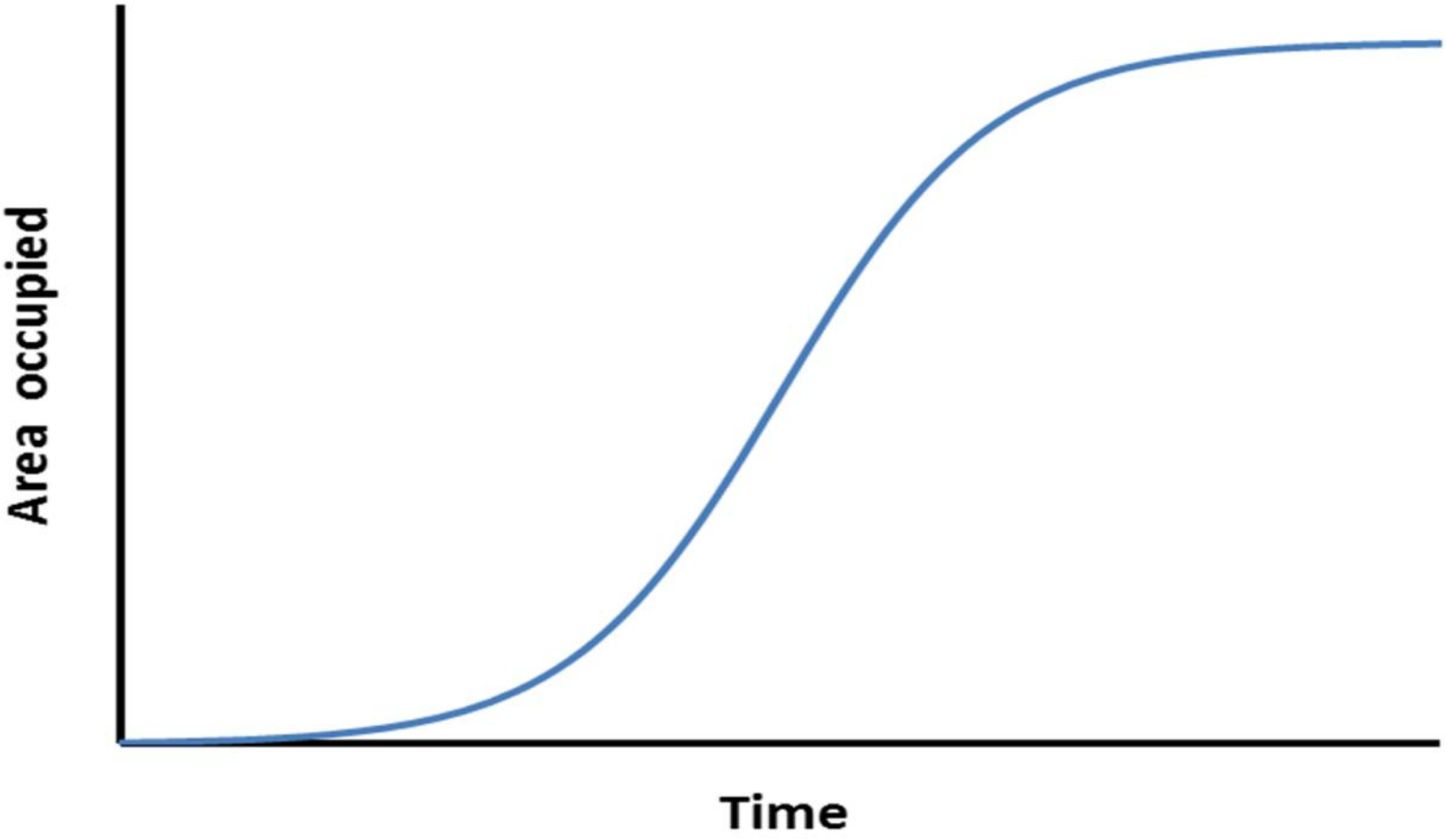
> 27,000 plant species introduced

~ 2,700 naturalised

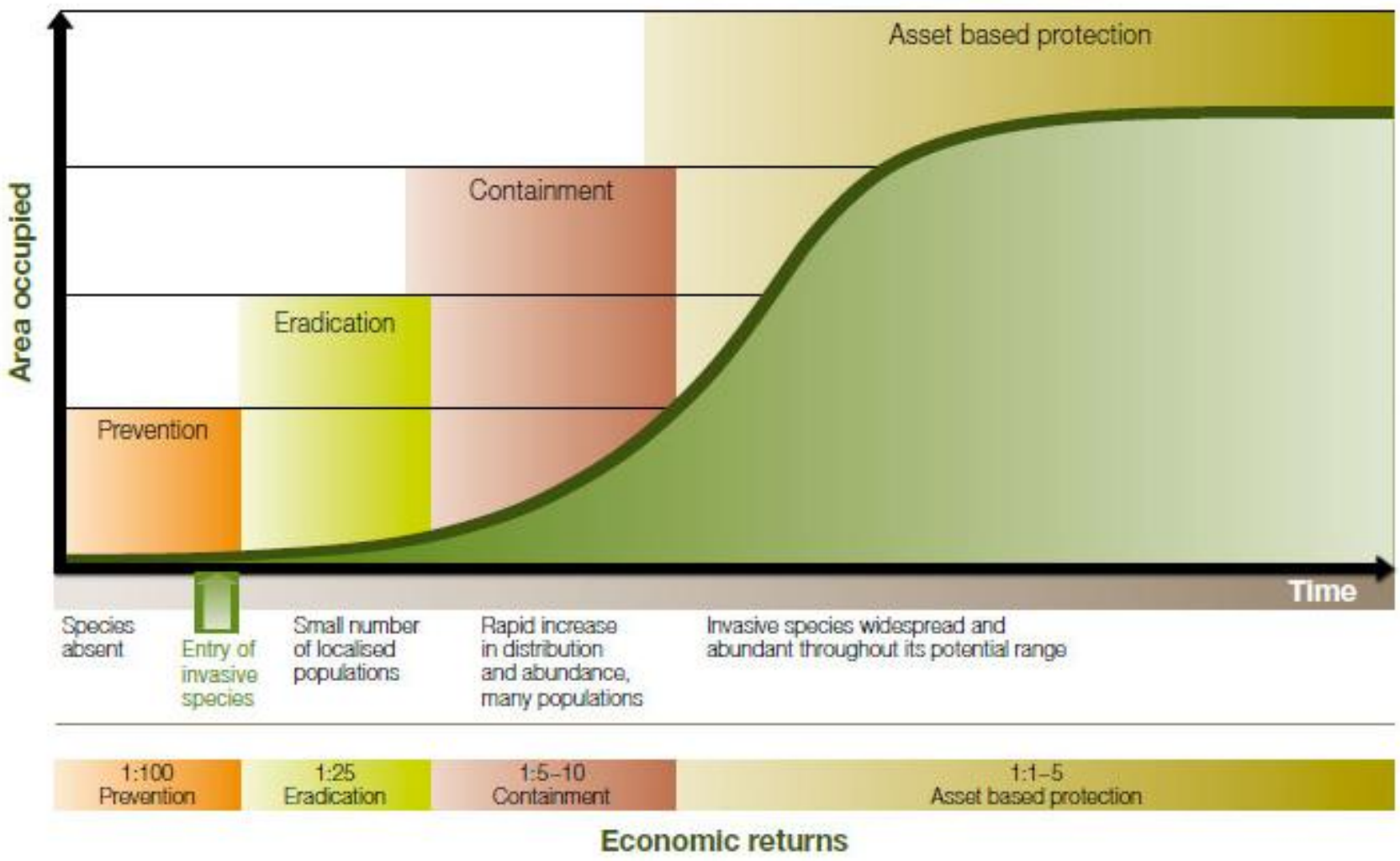
~ 479 regulated

- Biodiversity Fund 2013: $360 million (€225 million)
- 95% funding on projects that include introduced species management

For a single species…



For a single species…



Which species?

- Many candidates
- Different phases of invasion
- Different invasion potential
- Varying impacts
- Varying ease of management
- Limited budgets
- Uncertainty re invasion and impacts

Ranking approaches

Rank species and manage in order of

- invasiveness
- impact
- management ease
- benefit
- efficiency
- invasiveness + potential distribution + impact + management ease

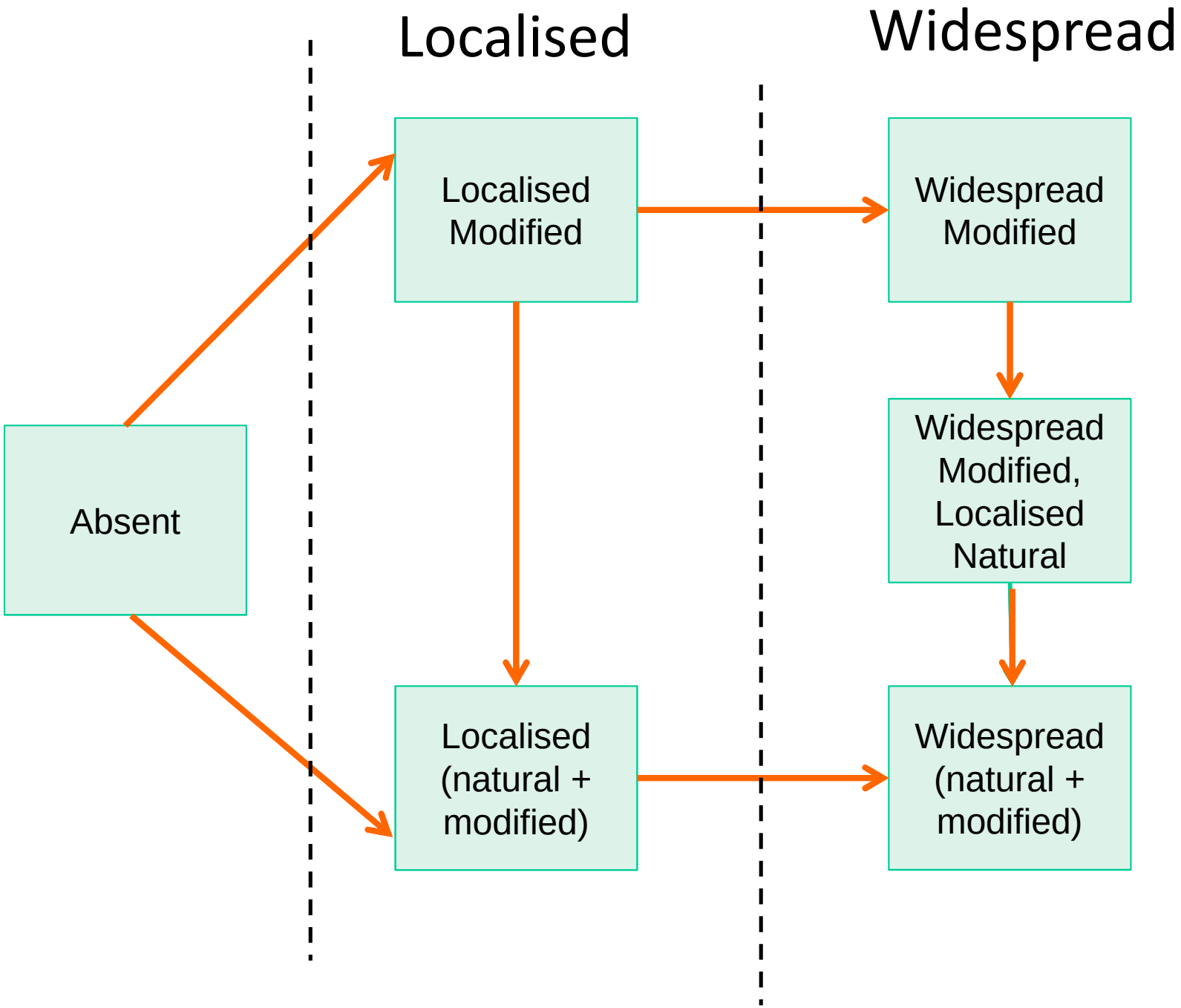
Ranking limitations

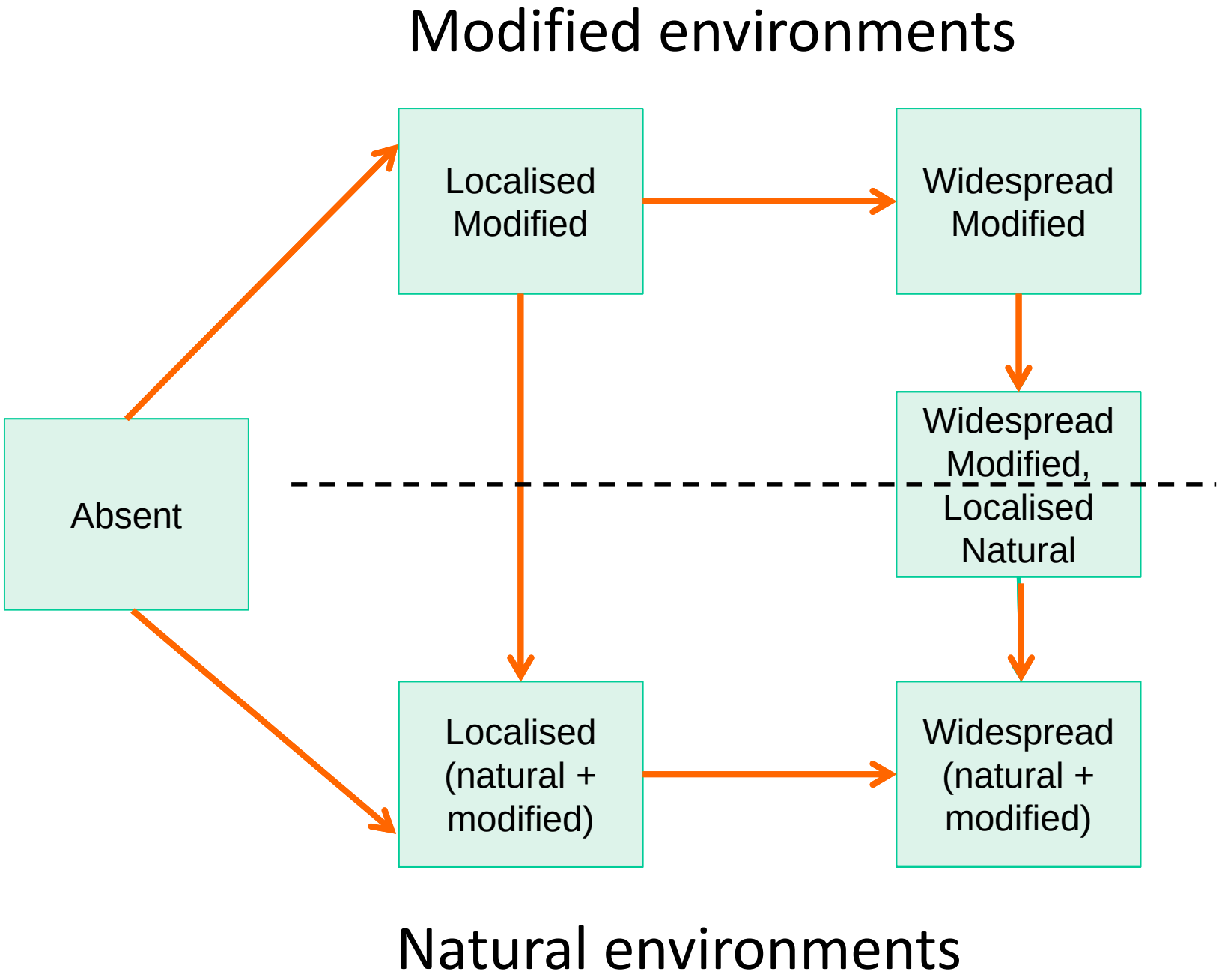
- No explicit model of system
- Species are managed or not
- Does not consider context (P/A other species)
- Does not account for available resources
- Hard to account for uncertainty
- Assumes components substitutable (additive indexes)

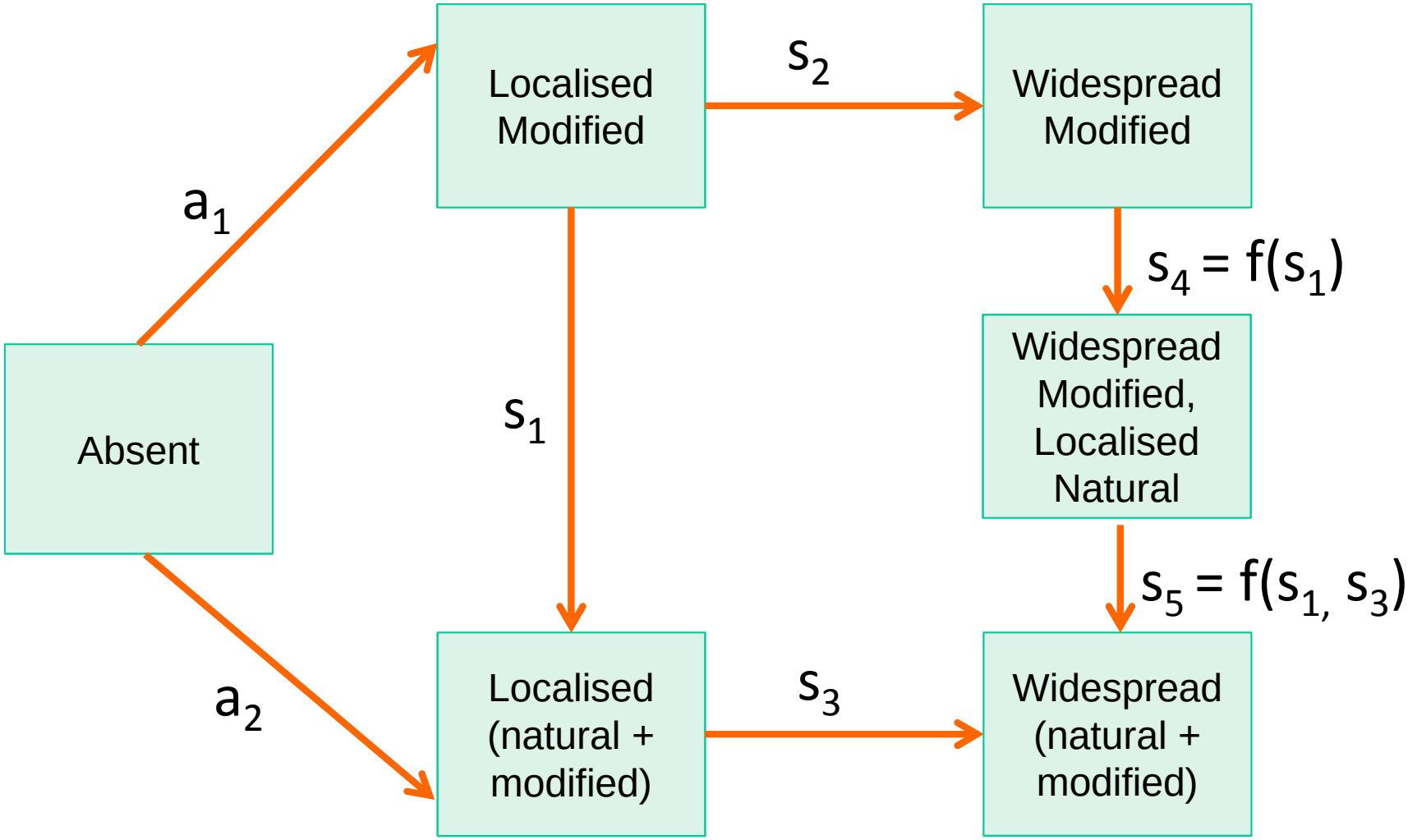
Resource allocation approach

Account for

- Multiple species
- Invasion process, impacts and management ease
- Multiple candidate management actions
- Available resources
- Context
- Uncertainty


Localised
Widespread
Localised Modified
Widespread Modified
Absent
Widespread Modified, Localised Natural
Localised (natural + modified)
Widespread (natural + modified)


Modified environments
Localised Modified
Widespread Modified
Absent
Widespread Modified, Localised Natural
Localised (natural + modified)
Widespread (natural + modified)
Natural environments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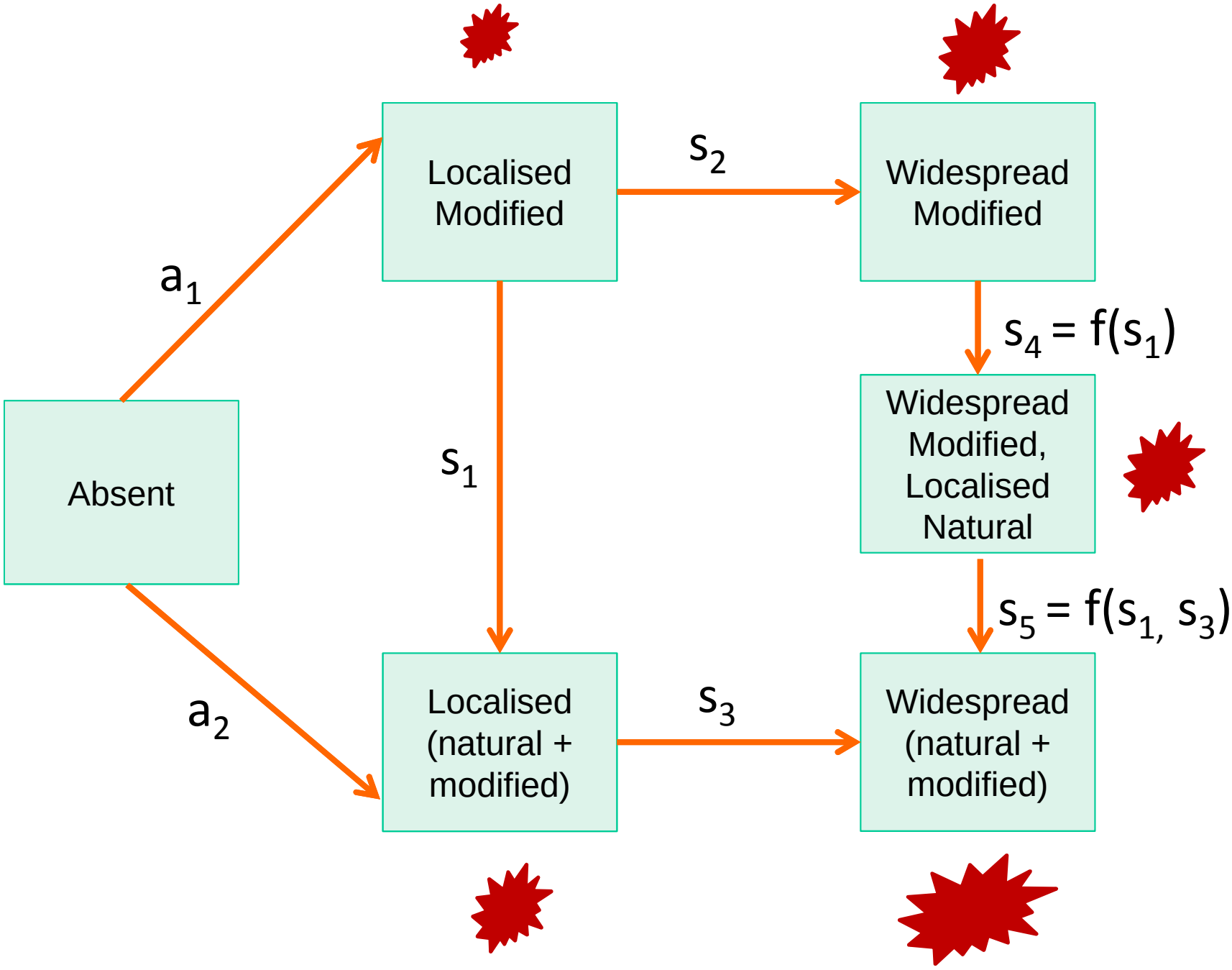
a1
a2
s1
s2
s3
s4 = f(s1)
s5 = f(s1, s3)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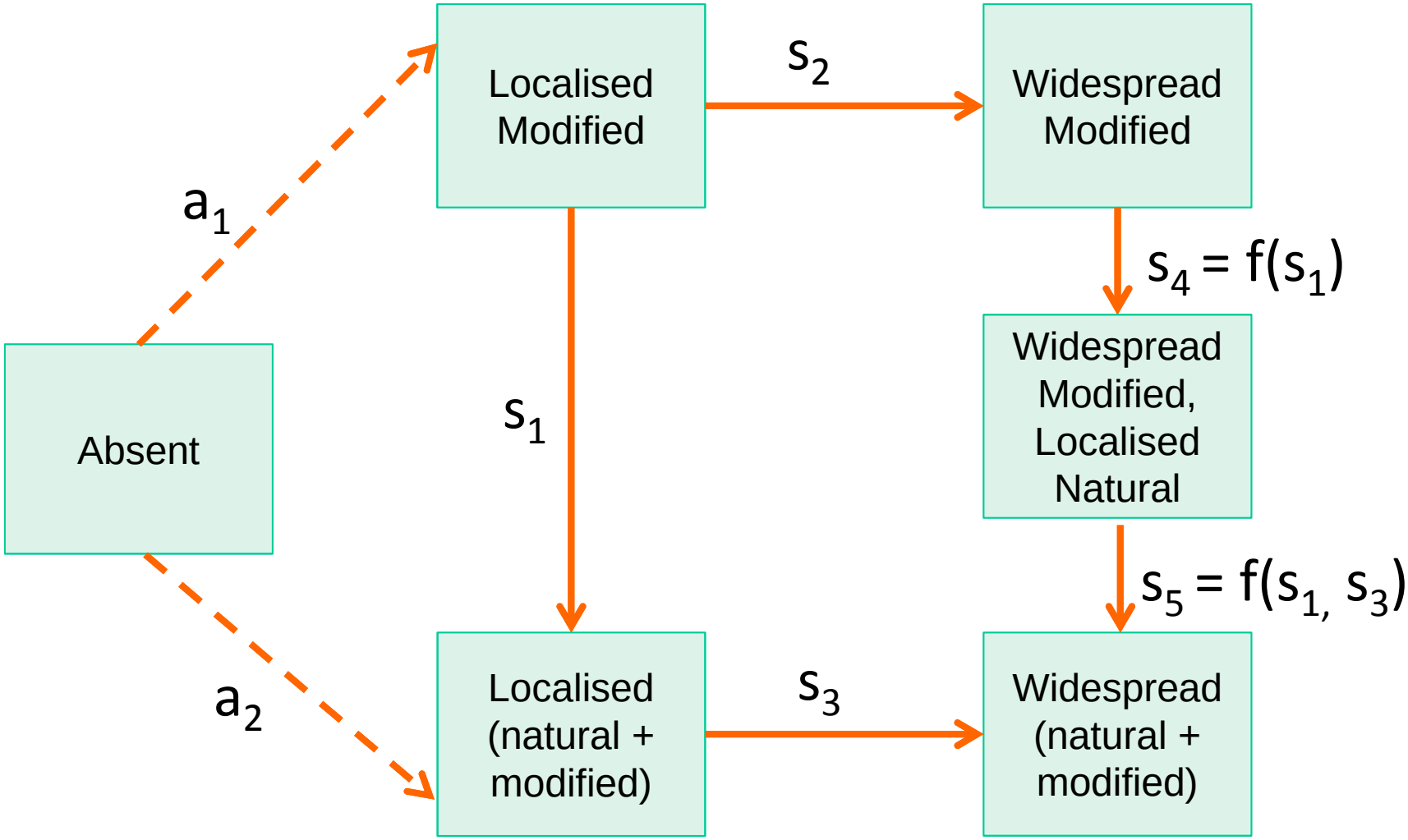
Actions

- Prevent ($, $$$)
  - acts on all absent species at once
- Eradicate ($$$)
- Contain ($, $$$)
- Reduce impact ($, $$$)

Management ease specifies how effective these actions are for each species

Prevent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Widespread Modified
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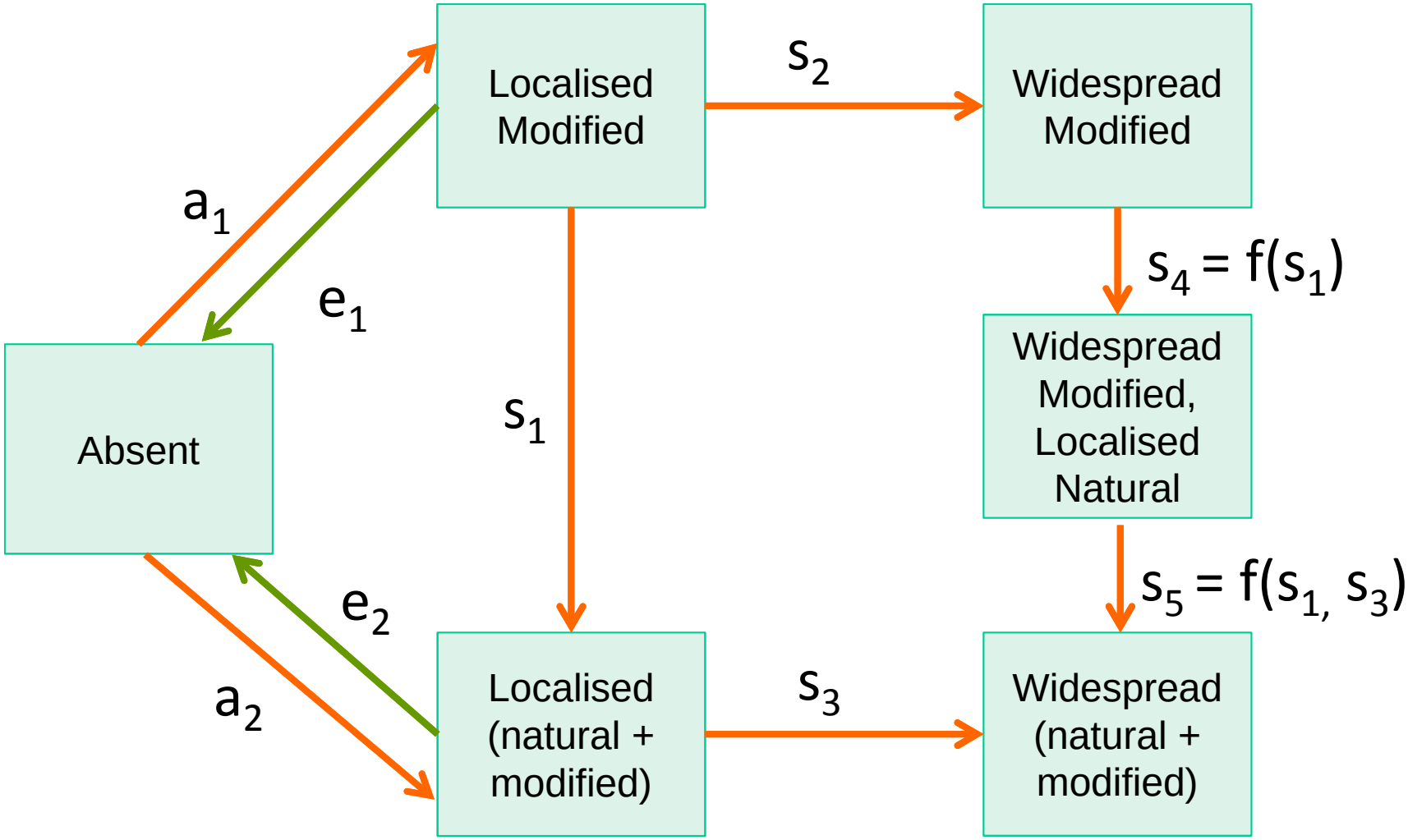
a_1
a_2
s_1
s_2
s_3
$s_4 = f(s_1)$
$s_5 = f(s_1, s_3)$

Eradicate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a_2
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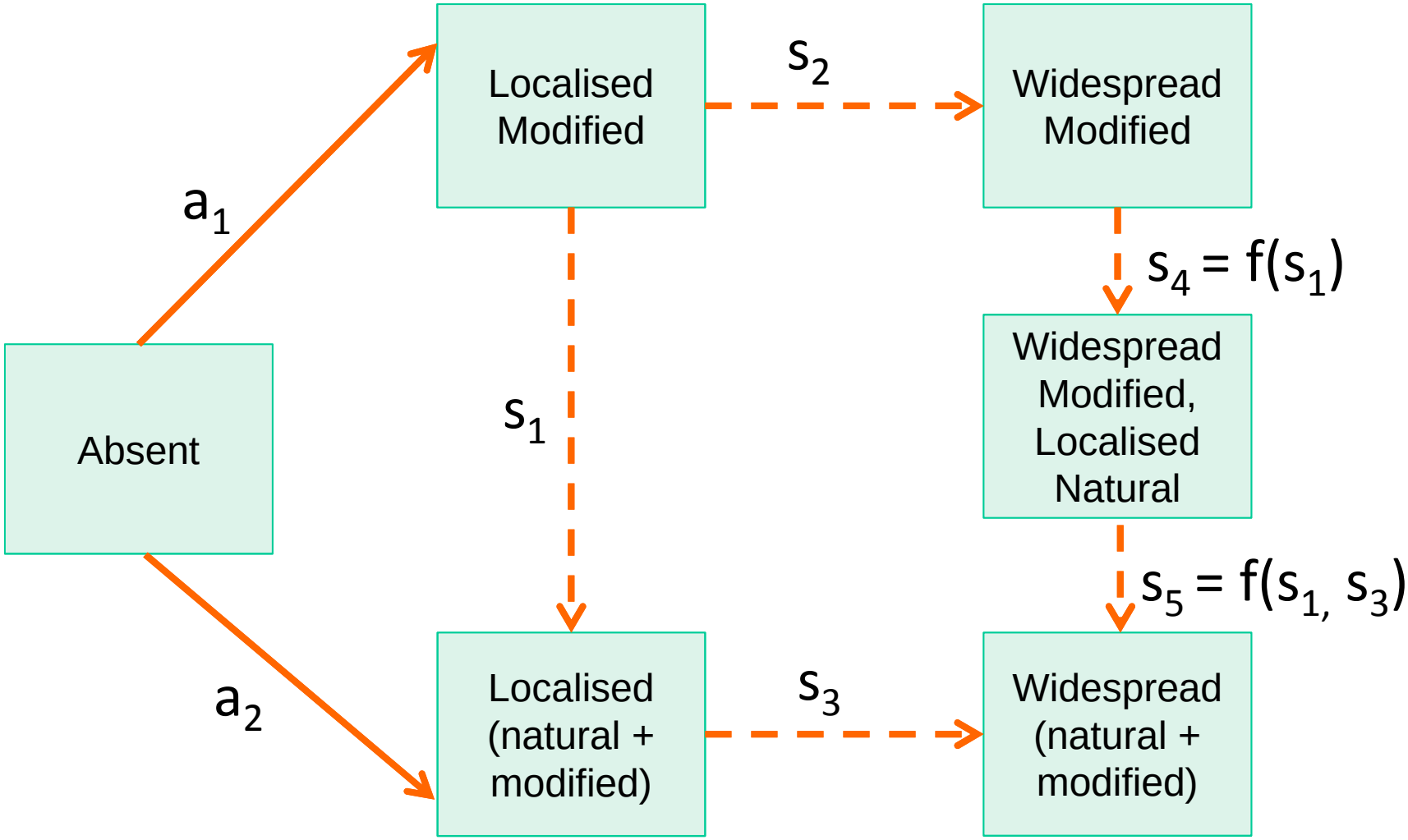
Contain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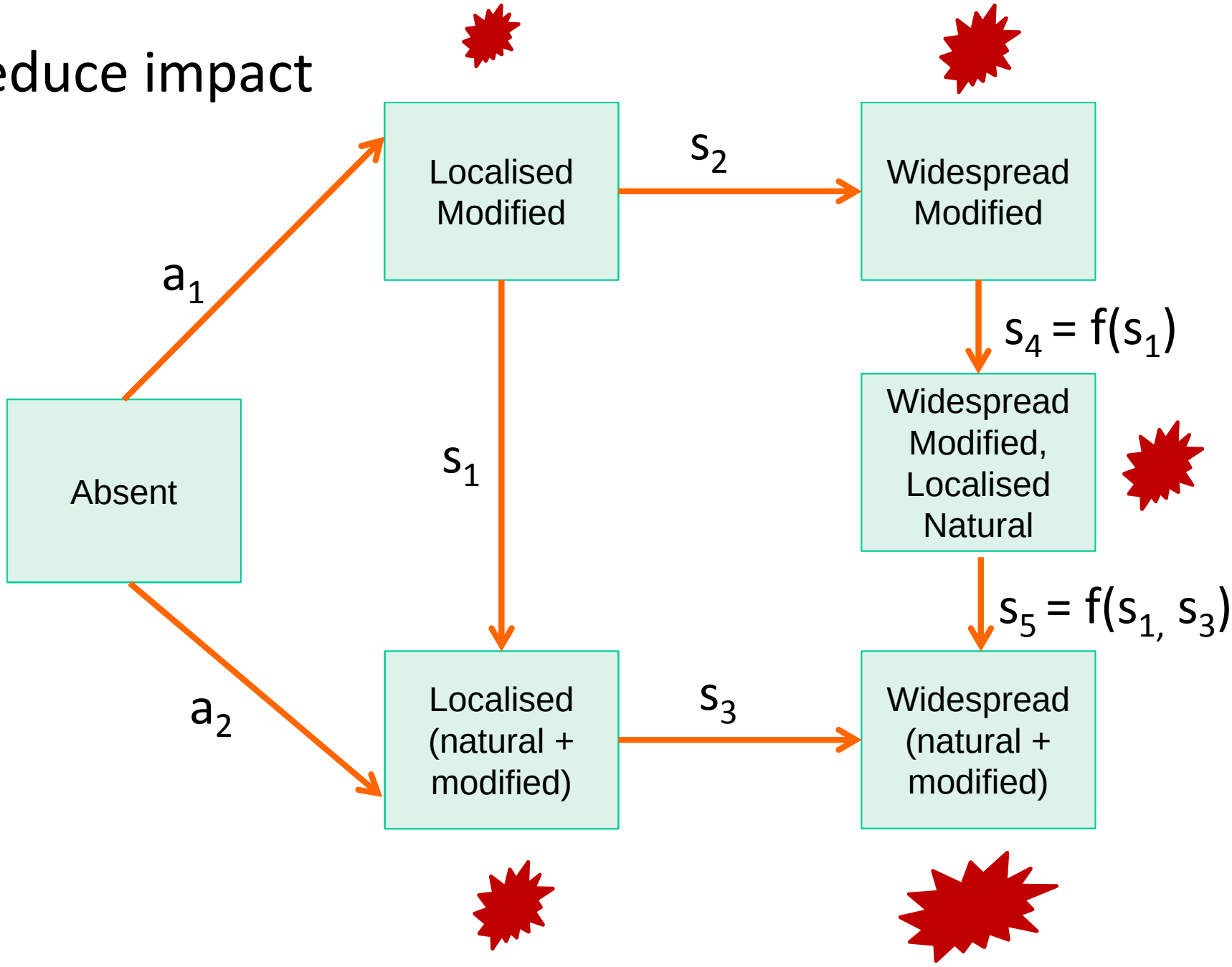
Reduce impact



Parameters

- Species
  - 4-15 per species
  - initial state
  - arrival, spread, eradication, impact
  - management ease
- Actions
  - 10 including ’no action’
  - cost

Multiple-choice knapsack problem

Consider n sets of candidate actions S_1, ..., S_n with each set S_i corresponding to a managing a species.

maximise $$\sum_{i}^{n} \sum_{j \in S_i} b_{ij} x_{ij}$$

subject to $$\sum_{i}^{n} \sum_{j \in S_i} c_{ij} x_{ij} \leq B,$$

$$\sum_{j \in S_i} x_{ij} = 1, \quad i = 1, \ldots, m,$$

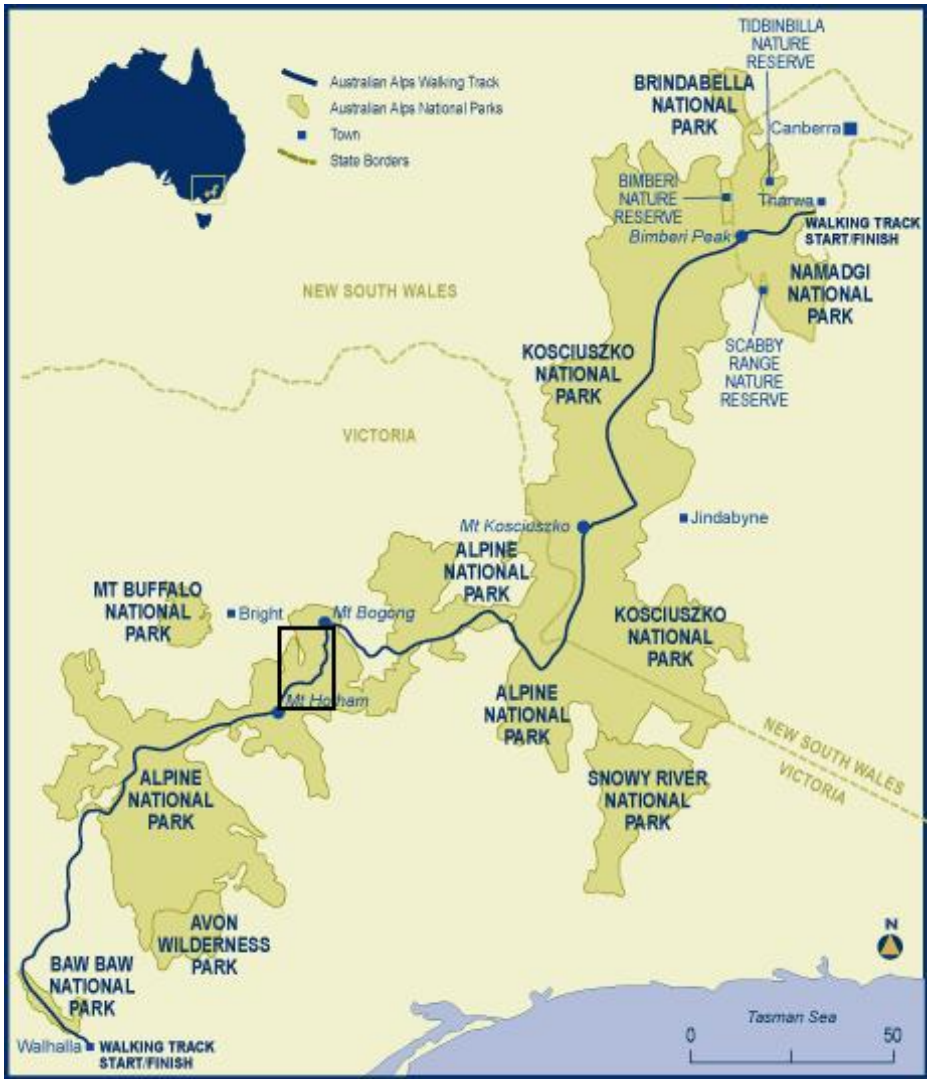
$$x_{ij} \in \{0,1\}, \quad i = 1, \ldots, m, \quad j \in S_i,$$

where b_{ij} = benefit of taking action j on species i,

c_{ij} = cost of taking action j on species i,

B = budget ($ per year).

Australian Alps case study



Australian Alps case study

Parameters elicited from managers and scientists

Uncertainty

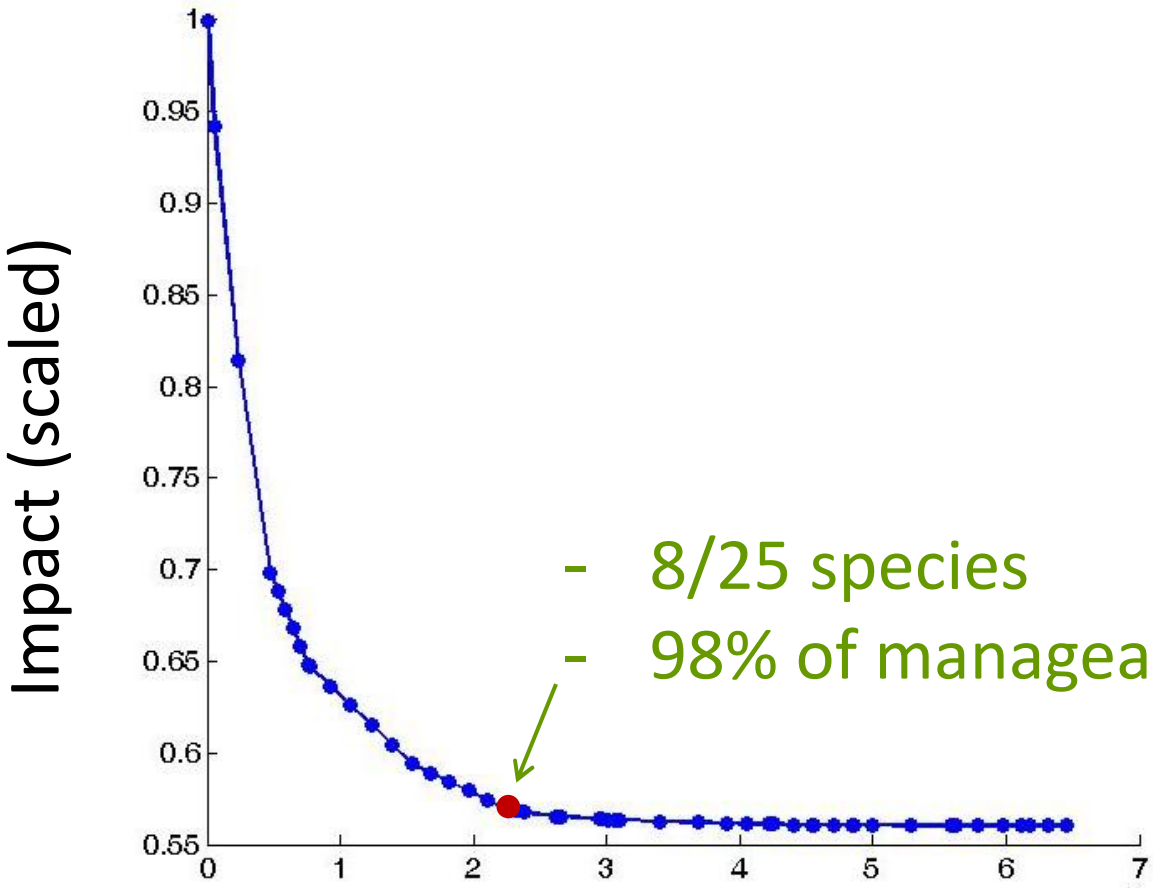
- Minimum
- Maximum
- Best estimate (mode)

No uncertainty for cost estimates

Candidate species

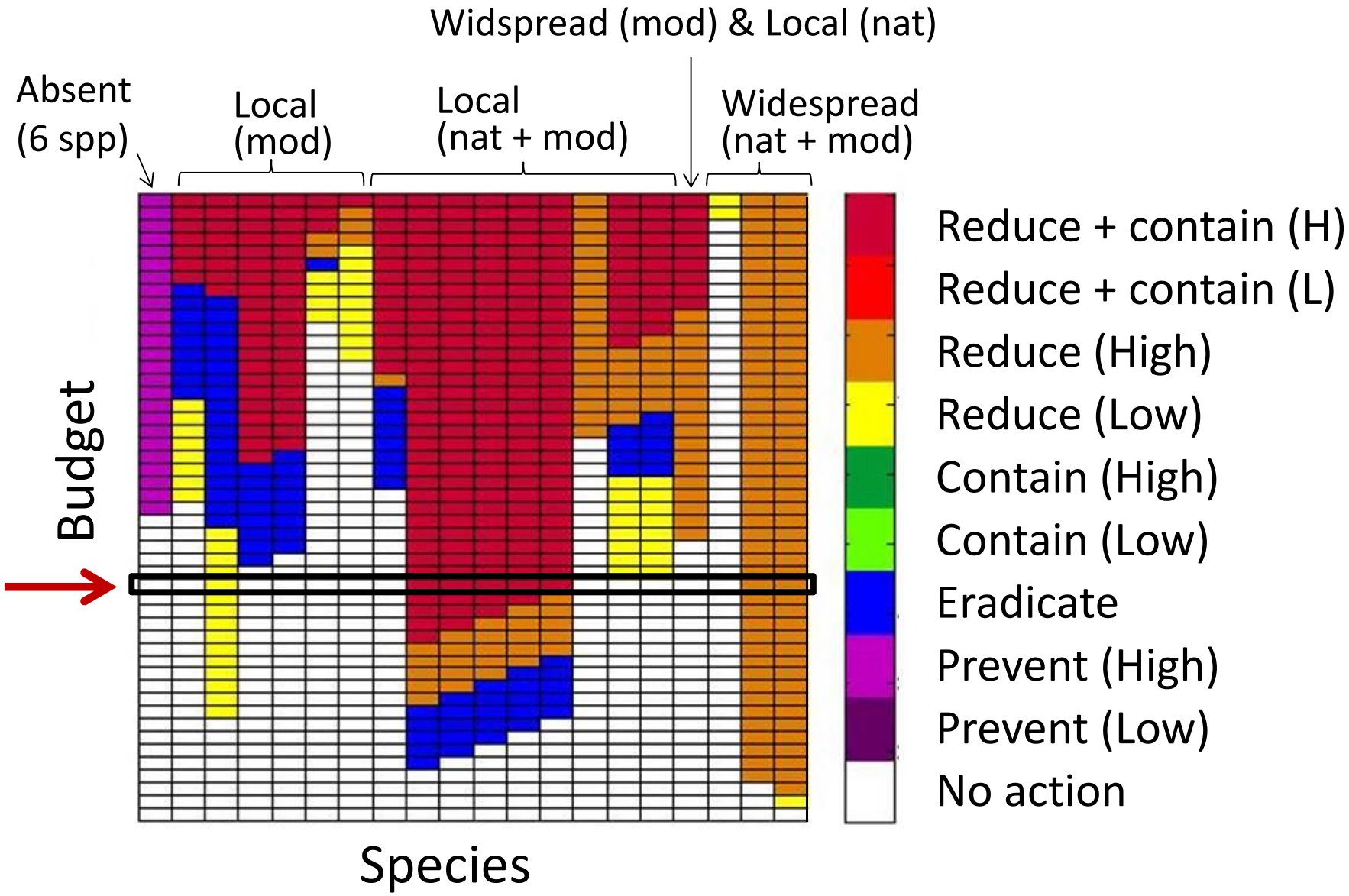
25 focal species
(6 absent)

Efficiency frontier



- 8/25 species
- 98% of manageable impact

Optimal strategy

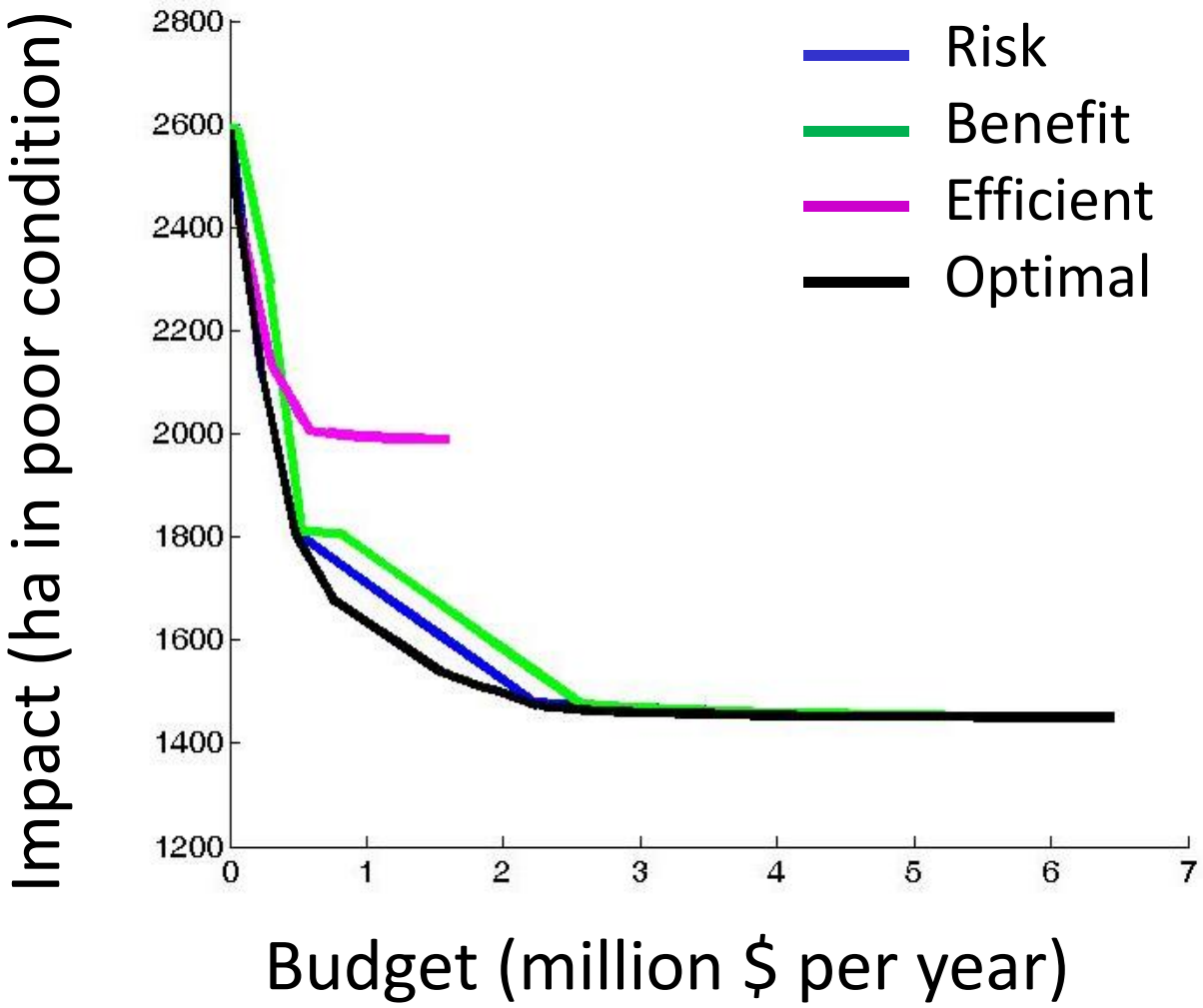


Ranking schemes

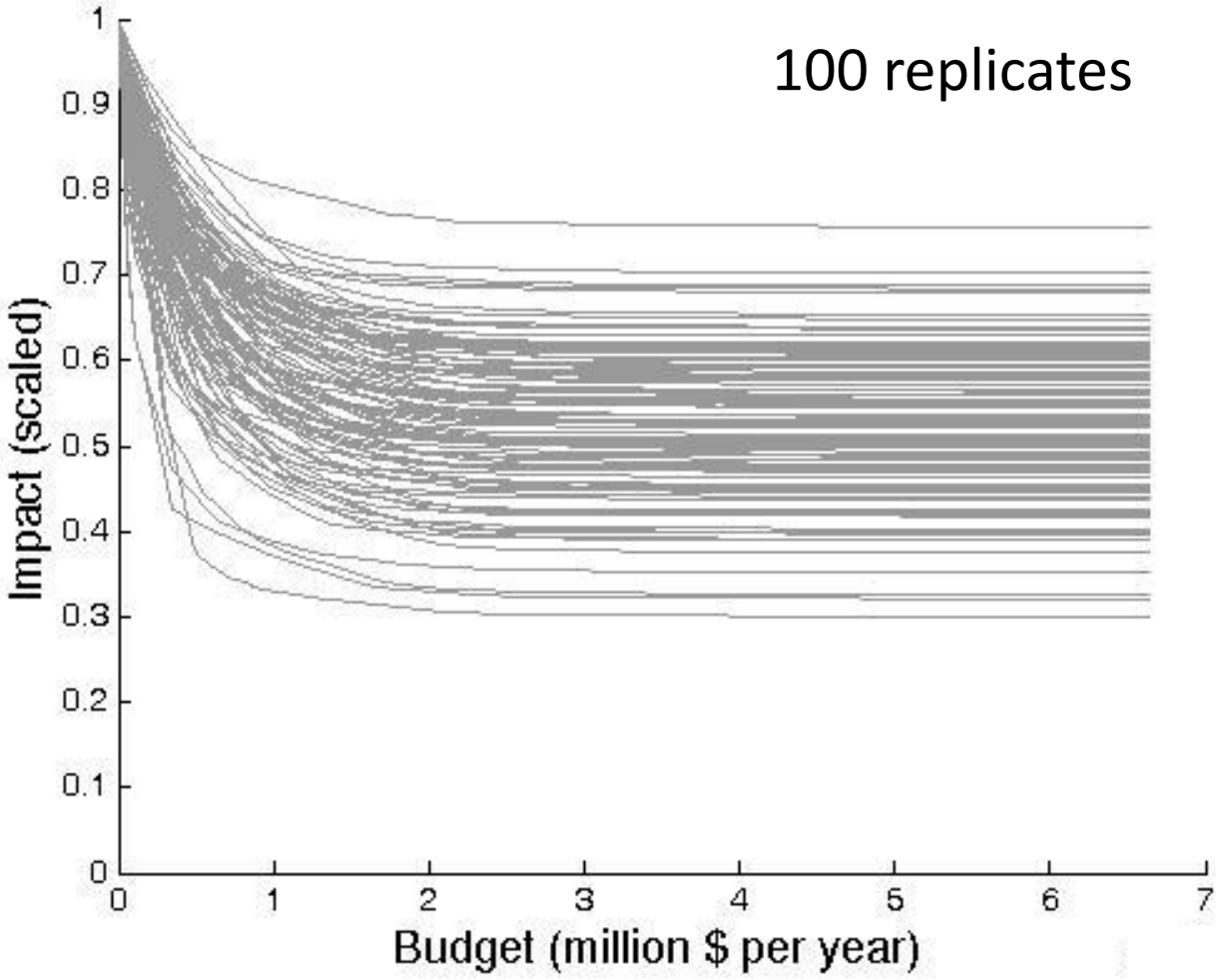
Manage in order of greatest:

1. Risk (probability * impact)
2. Benefit (impact & management ease)
3. Efficiency (benefit/cost)

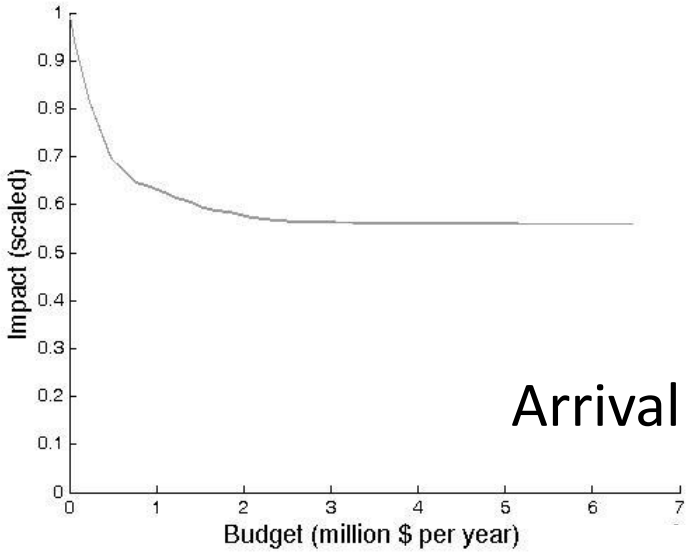
Ranking performance

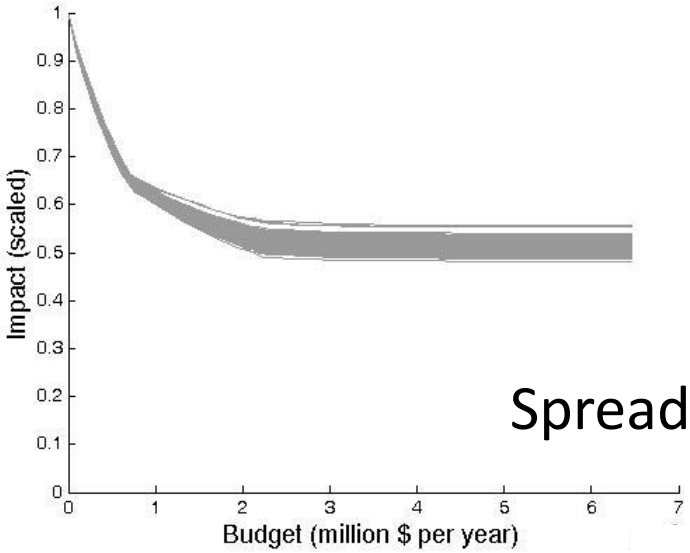


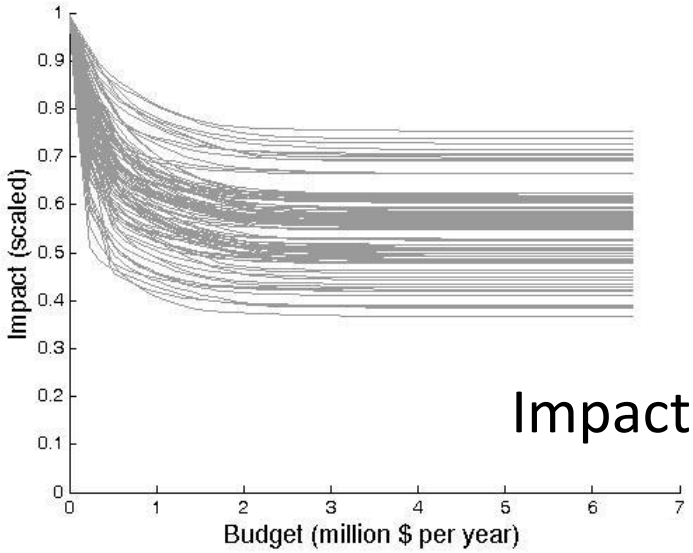
Uncertainty

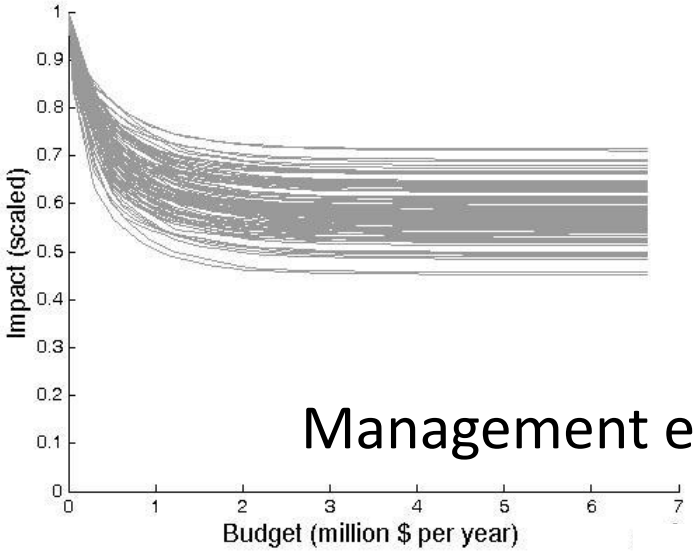


Uncertainty contributions









Uncertainty analyses

- Effect of uncertainty on optimal strategy
- Can we identify robust strategies?
- Sensitivity analysis
  - which parameters most influence the system?
- Value of information analysis
  - which parameters most influence the best management strategy?

Key assumptions

- Impact is evaluated at 50 years
- Same management action undertaken each year over entire period
- Management applied to initial state
- No interaction between species or actions

Other applications

- Parameterise for other regions
- Multiple-choice knapsack suitable for many applications:
  - multiple processes (species, threats)
  - multiple levels of management effort
- e.g. Managing multiple threats

Summary

- Which action for which species?
- Resource allocation approach
- Majority of benefit gained with moderate budgets
- Optimal management depends on resources and context
- Performs better than ranking schemes (limited resources)

Thanks

Workshop participants

- Parks Victoria
- NSW Parks and Heritage
- ACT Urban services

Funding

- Australian Alps Liaison Committee

http://joslinmooreresearch.wordpress.com/