Cost-Sensitive Machine Learning Algorithms

Invasive Species Decision Support, Risk Analysis, and Policy

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New Thinking

Overview

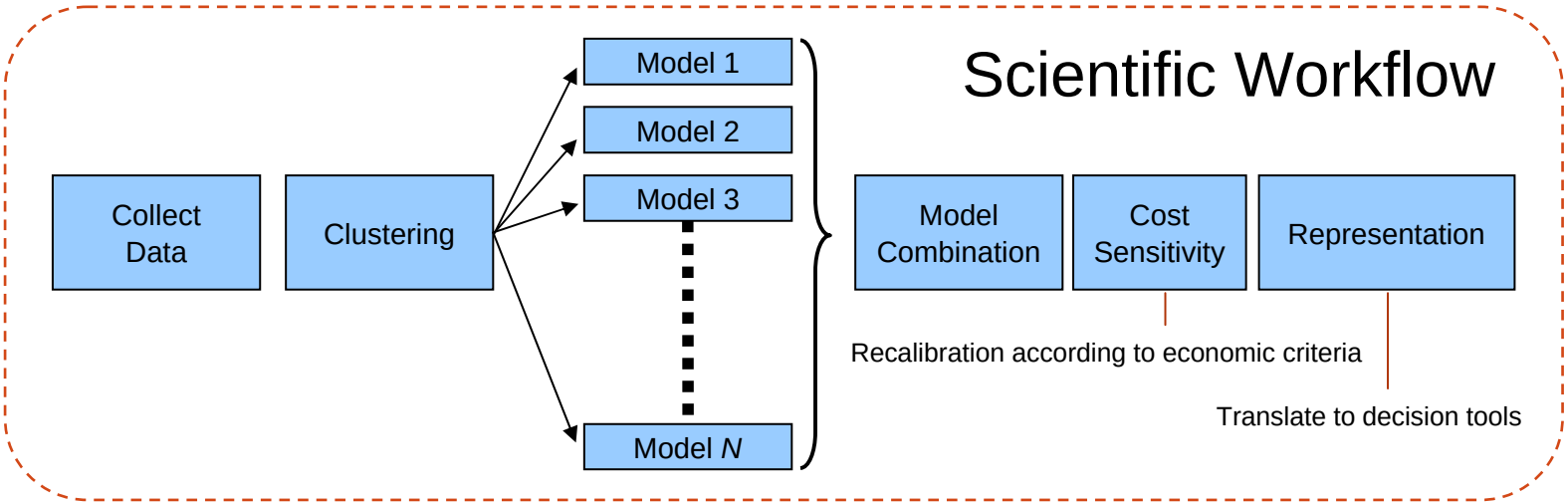
Problem statement

- Costs of invasive species are $US billions per year
- Risk analysis and policy mechanisms in place or under development (Quarantine 37")
- Ecological risk assessment procedures inadequate

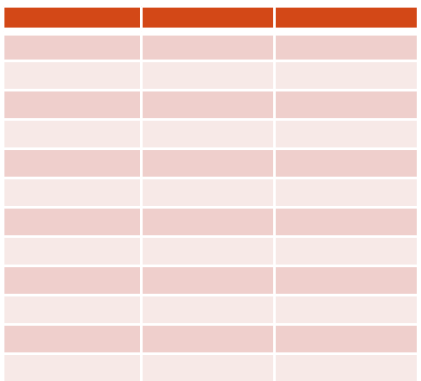
Objective

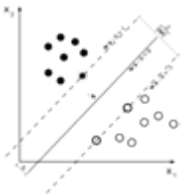
- Develop cost-sensitive decision support tools to aid risk analysis for species proposed for introduction and rapidly evaluate new non-indigenous species concerning potential for further spread

Scientific Workflow

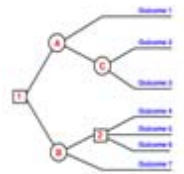


Relational database
•classes of invasive species
•species traits





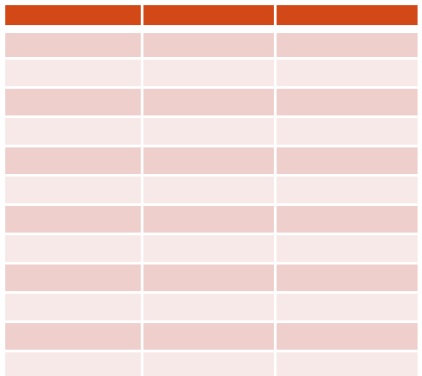
Support vector machines



Regression trees

Neural nets

Relational database
•classes of invasive species
•revenue, damages, control costs



Construction of the database

Species classes

	Species	Weeds	State listed	Federally listed
total	5954	1110	435	46
present in >1 state	3076	974	373	31
ornamental	1292	394	143	10

*Includes Alaska, Hawaii, Puerto Rico, and the Virgin Islands

145 Variables

~10% relate to native distribution

~15% relate to introduced distribution

~70% relate to biological traits

Large datasets

- seed mass (>2000)
- chromosome number (>1000)
- and maximum height (>500)

Biological traits

Growth form

Life history

Wetland habitat association

maximum height

maximum chromosome number/species

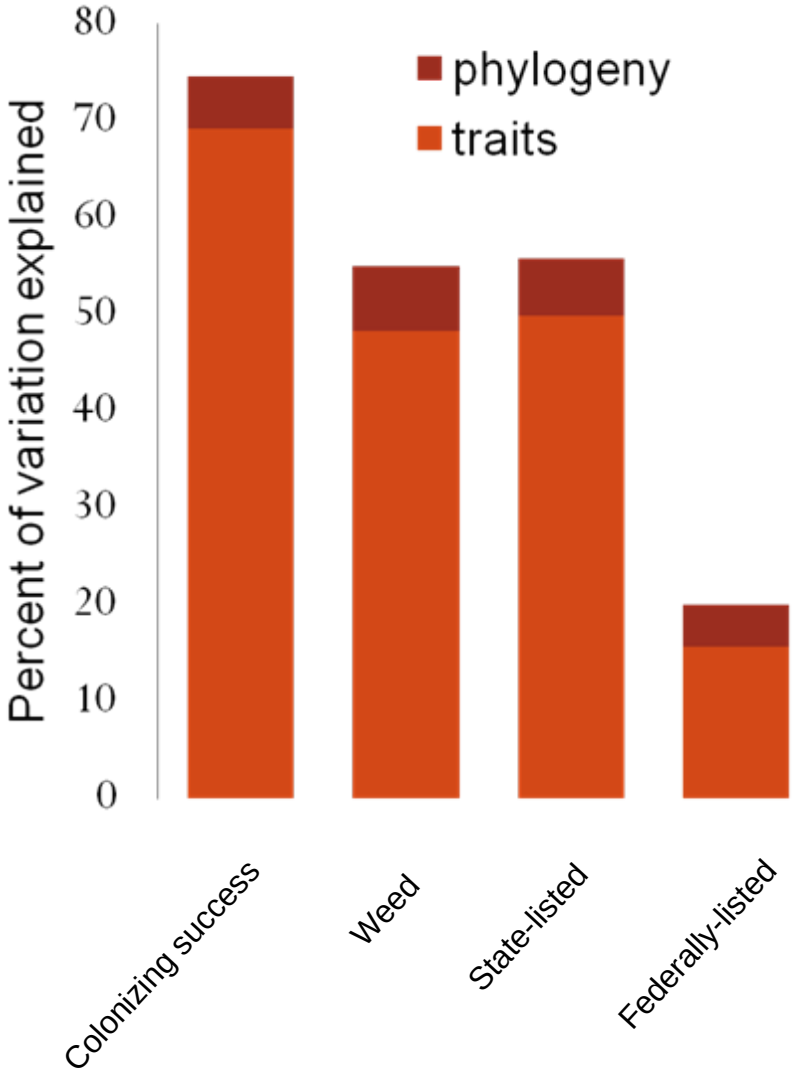
seed mass

Leaf traits

Native latitudinal and longitudinal range

Predictive covariates of invasive genera

*also Family-level and Order-level



Genus	Common	Invasive class
Emex		Federal
Imperata	Cogon	Federal
Pennisetum	Fountain grass, Kikuyu grass, Feathertop grass	Federal
Prosopsis	Mesquite	Fed, State, Weed
Carduus	Thistle	State, Weed
Centaurea	Star-thistle, knapweed	State
Dipsacus	Teasel	State
Miscanthus	Silvergrass	State
Onopordum	Thistle	State
Solanum	Nightshade	State
Salsola	Tumbleweed	State, Weed

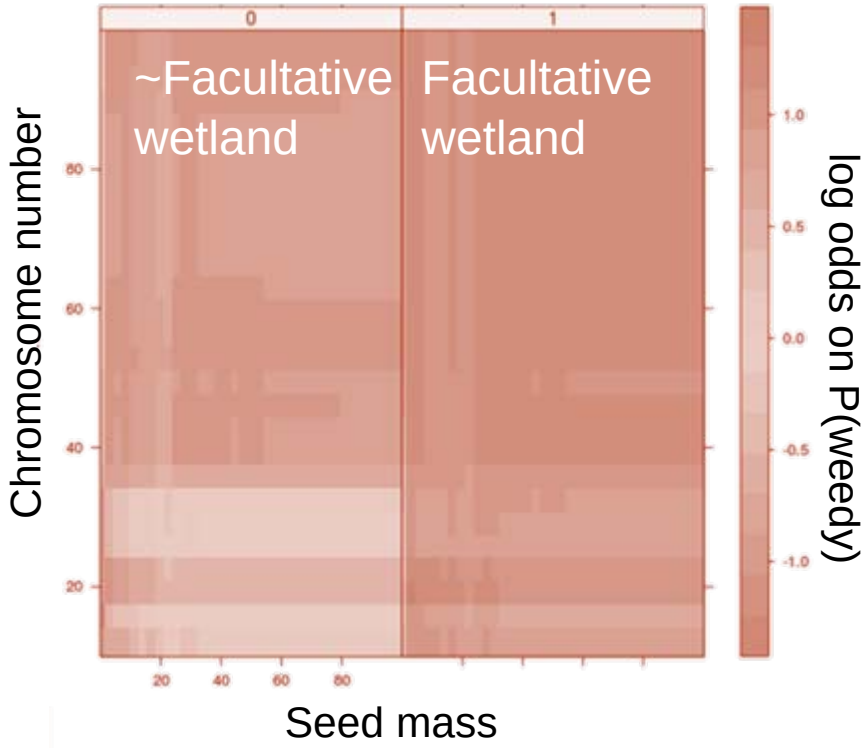
Species classification on a balanced dataset:
Maximal performance

- Facultative wetland association
- Oligate wetland association
- Maximum height
- Seed mass
- Maximum chromosome number
- Leaf traits: evergreen-ness, C:N ratio, leaf specific area

Key biological traits

Performance Summary

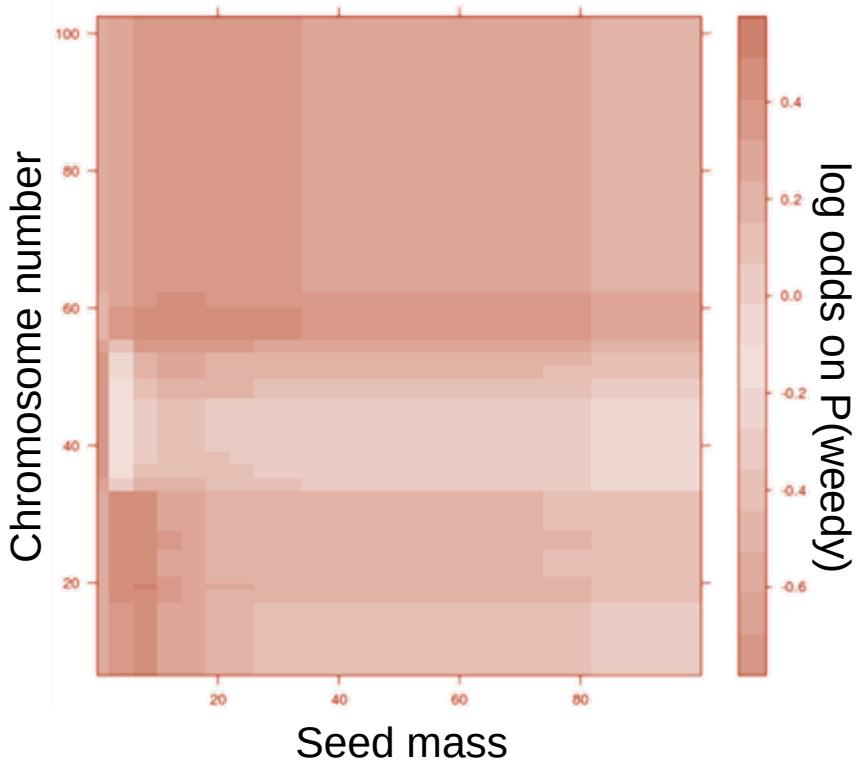
	Weeds		State-listed	
	prediction on 20% holdout (95% CI)	**sample size (test set)**	**prediction on 20% holdout (95% CI)**	**sample size (test set)**
all species	0.74 (0.69,0.78)	447	0.69 (0.62,0.76)	174
species present in > 1 state	0.78 (0.73,0.82)	385	0.78 (0.70,0.84)	149
ornamentals	0.85 (0.79,0.9)	160	0.75 (0.62,0.86)	56



3-variable model

Variables
- seed mass
- chromosome number
- facultative wetland affinity

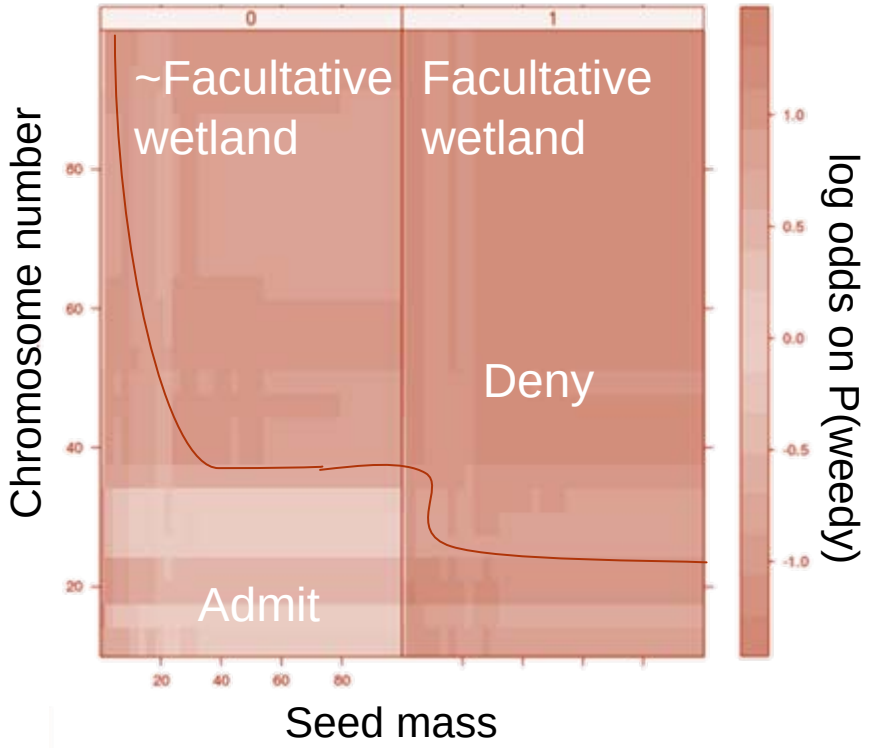
Performance on balanced withheld test dataset (n=385)
- Absolute accuracy: 72%
- 95% confidence interval: (66%,80%)

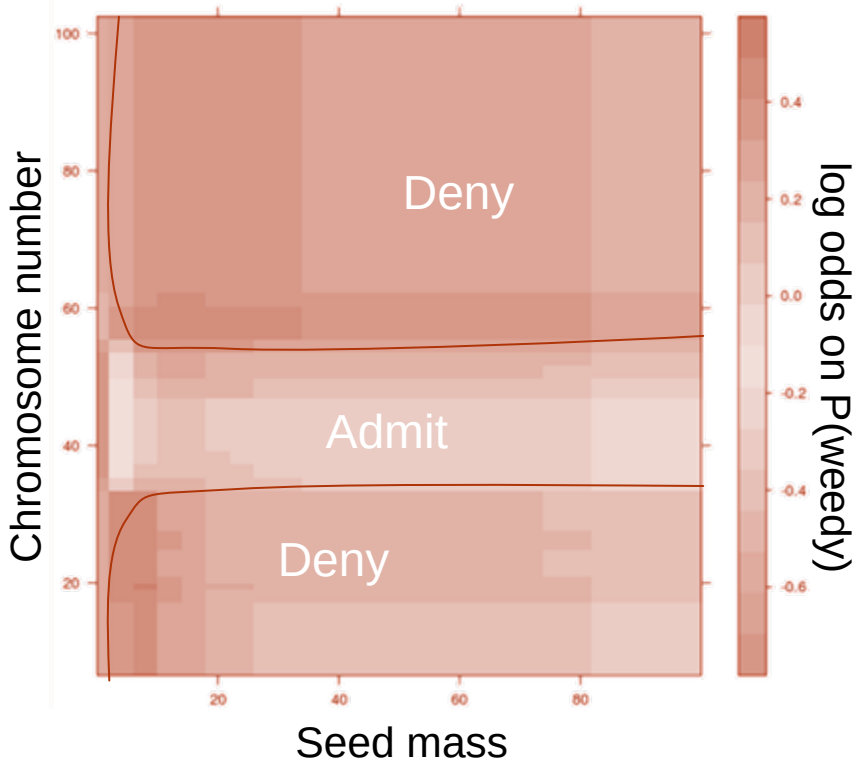


2-variable model

Variables
- seed mass
- chromosome number

Performance on balanced withheld test dataset (n=151):
- Absolute accuracy: 74%
- 95% confidence interval: (62%,86%)





Construction of Decision Boundaries

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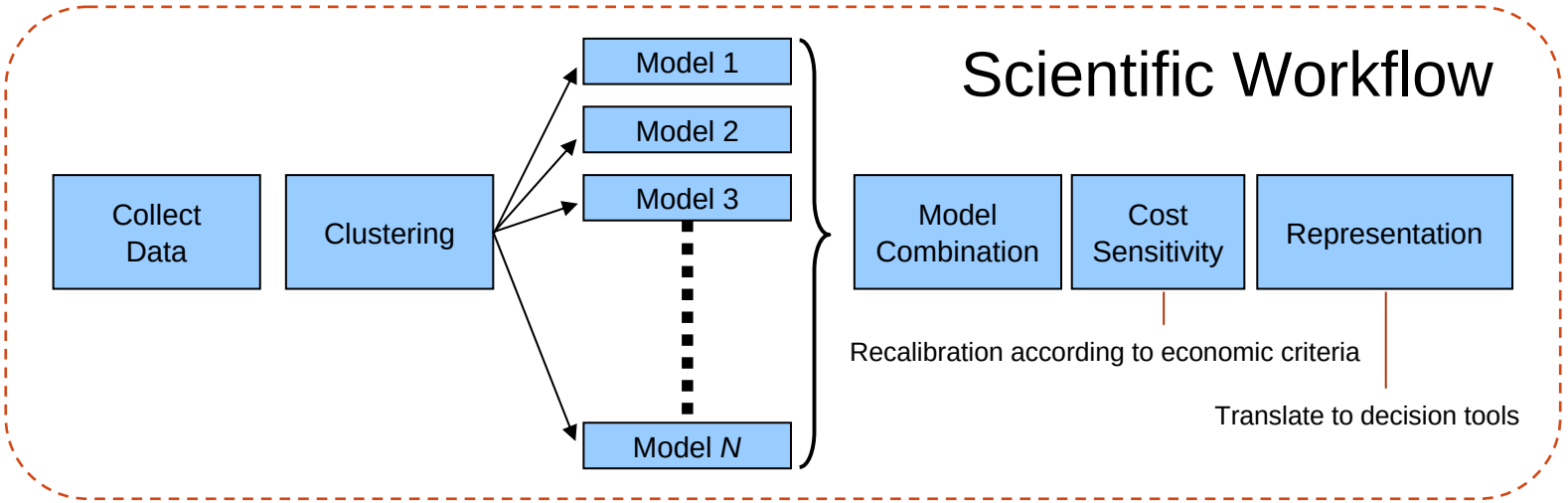
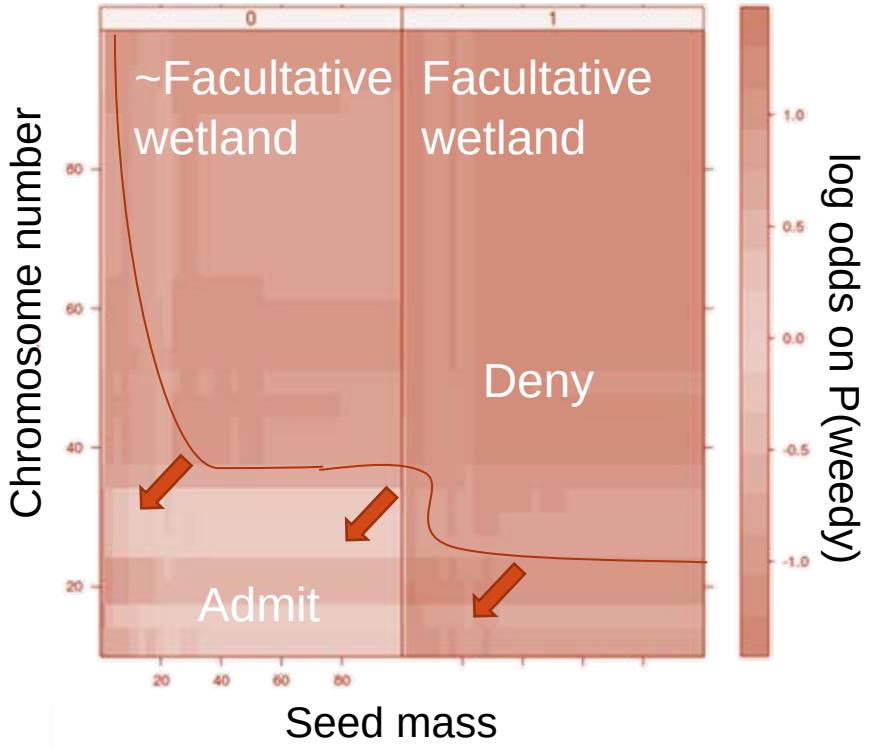
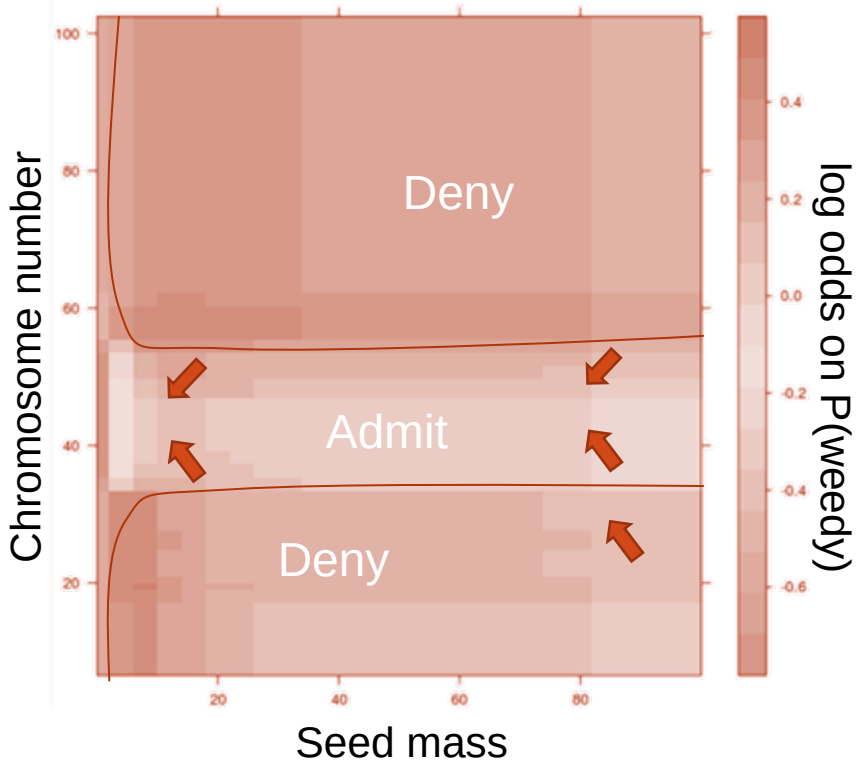
Economic data



Cost/Benefit data on 311 pairs of species (one invasive, one non-invasive con-generic)
Cost of control: 16 spp
Marginal Cost: 1 sp.
Total Cost: 9 spp.
Benefit of control: 8 spp.
Economic benefit: 2 spp.





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Summary

- Findings to date
  - Invasive species are clustered within taxonomic groupings
  - Invasive propensity predictable to the level necessary to justify cost efficient trait-based admit/deny decision analysis

- Next Steps
  - Model calibration
  - Complete cost-benefit analysis and cost-sensitive learning
  - Visualization of more complex models