Quantitative Horizon Scanning for Invasive Pests

Joseph Stinziano
joseph.stinziano@inspection.gc.ca

Wood Boring Beetles: Wanying Zheng, Megan Abergel, Martin Damus

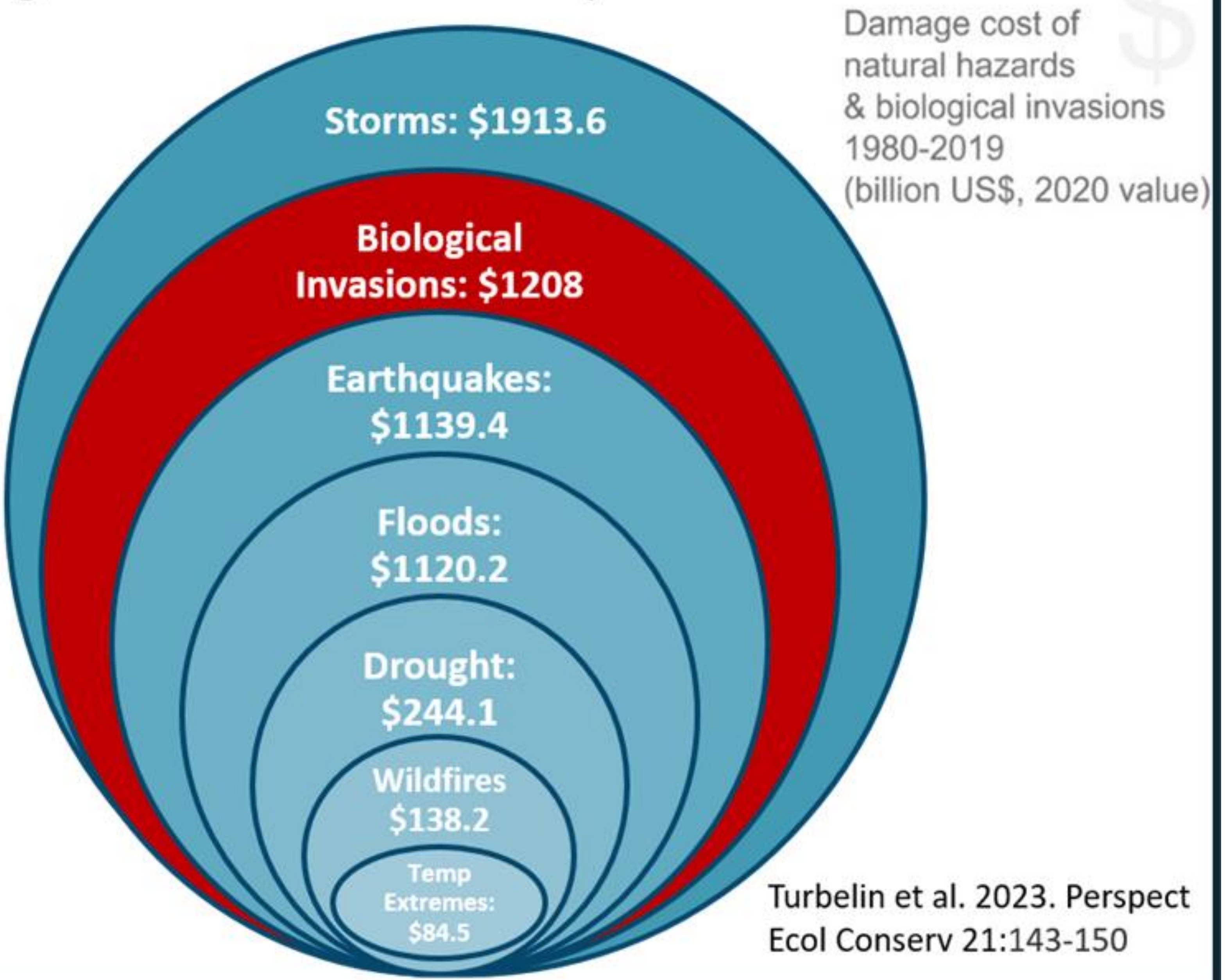
Invasive Grasses: Wanying Zheng, Alexandre Blain, Karen Castro

Plant Health Science Directorate
Canadian Food Inspection Agency

Canadian Food Inspection Agency
Agence canadienne d'inspection des aliments

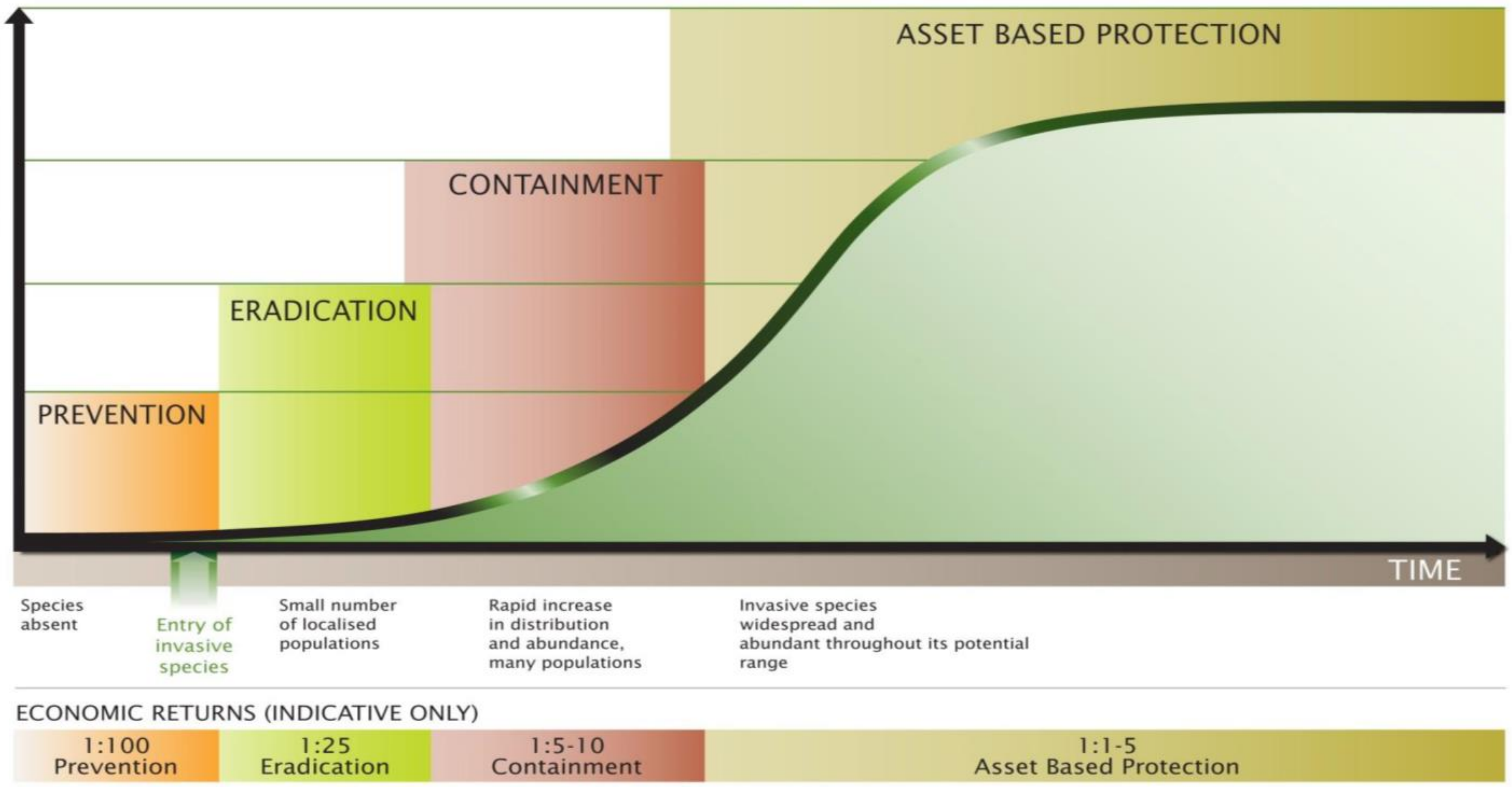
Plant Health Analytics Hub

Biological Invasions are as costly as natural disasters



Turbelin et al. 2023. Perspect
Ecol Conserv 21:143-150

Prevention is the most cost-effective defense



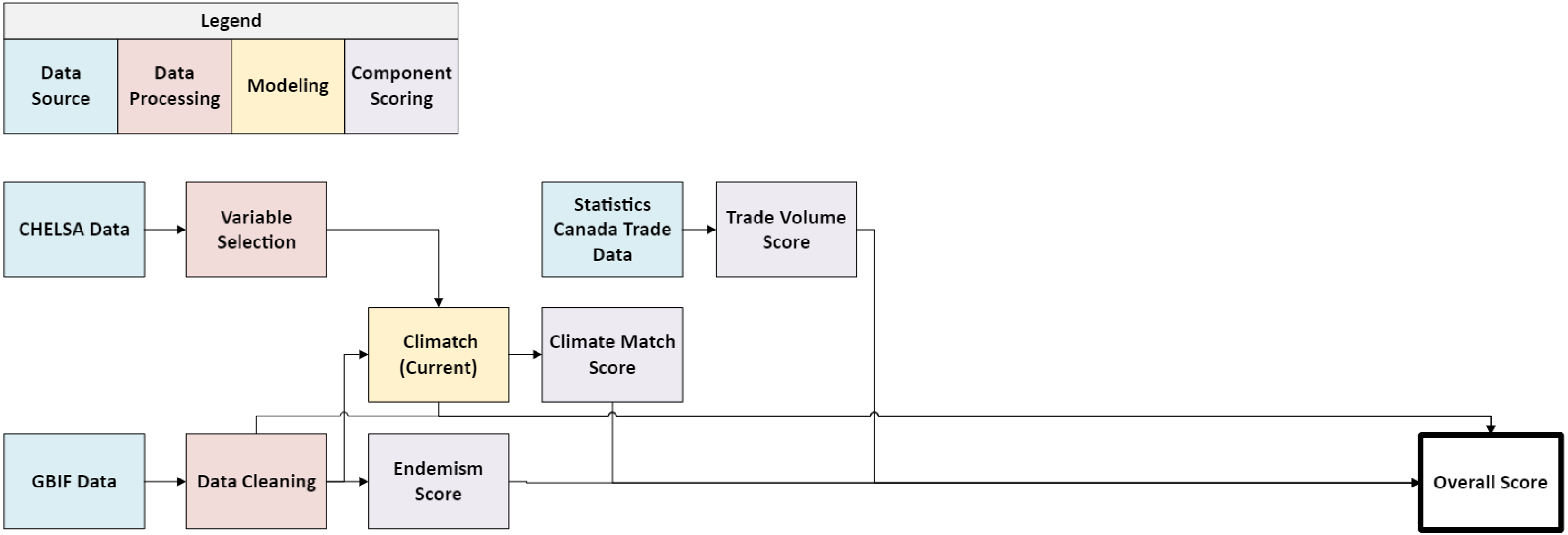
Department of Primary Industries, 2010. Invasive plants and animals policy framework

What is quantitative horizon scanning?

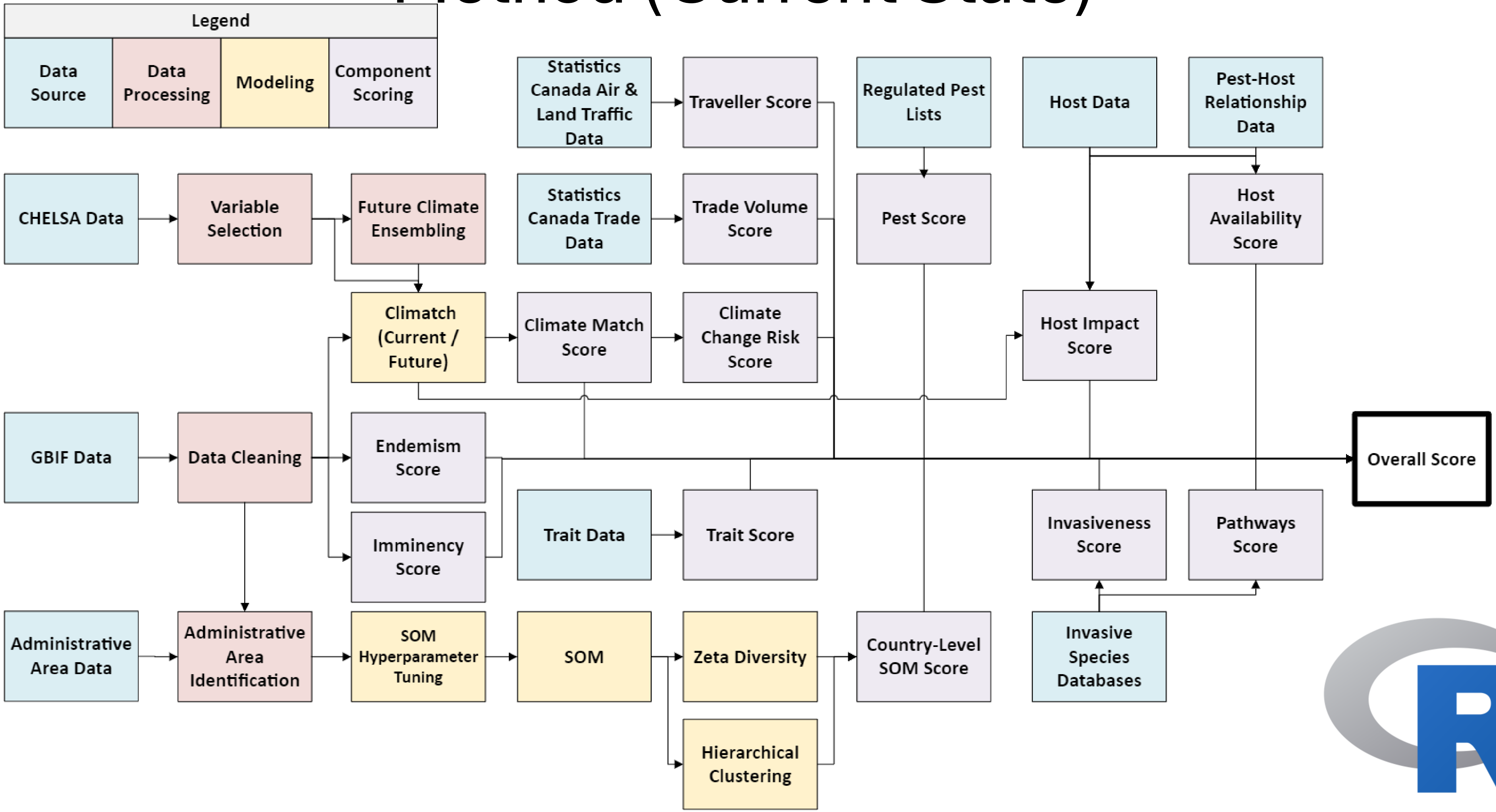
- A data-intensive, systematic search to identify potential emerging threats
  - Objective to identify pests early and often to be able to prevent, and prepare immediate responses for, novel pests
  - Identify target taxa, risk criteria, and data sources
- Proactive identification of potential pests *before* we would typically consider regulating
- Identify gaps in biosecurity
- Many existing horizon scan methods are time intensive, do not produce readily actionable results for NPPOs, or are non-quantitative

NPPO: National Plant Protection Organization

Method (where we started in 2022)

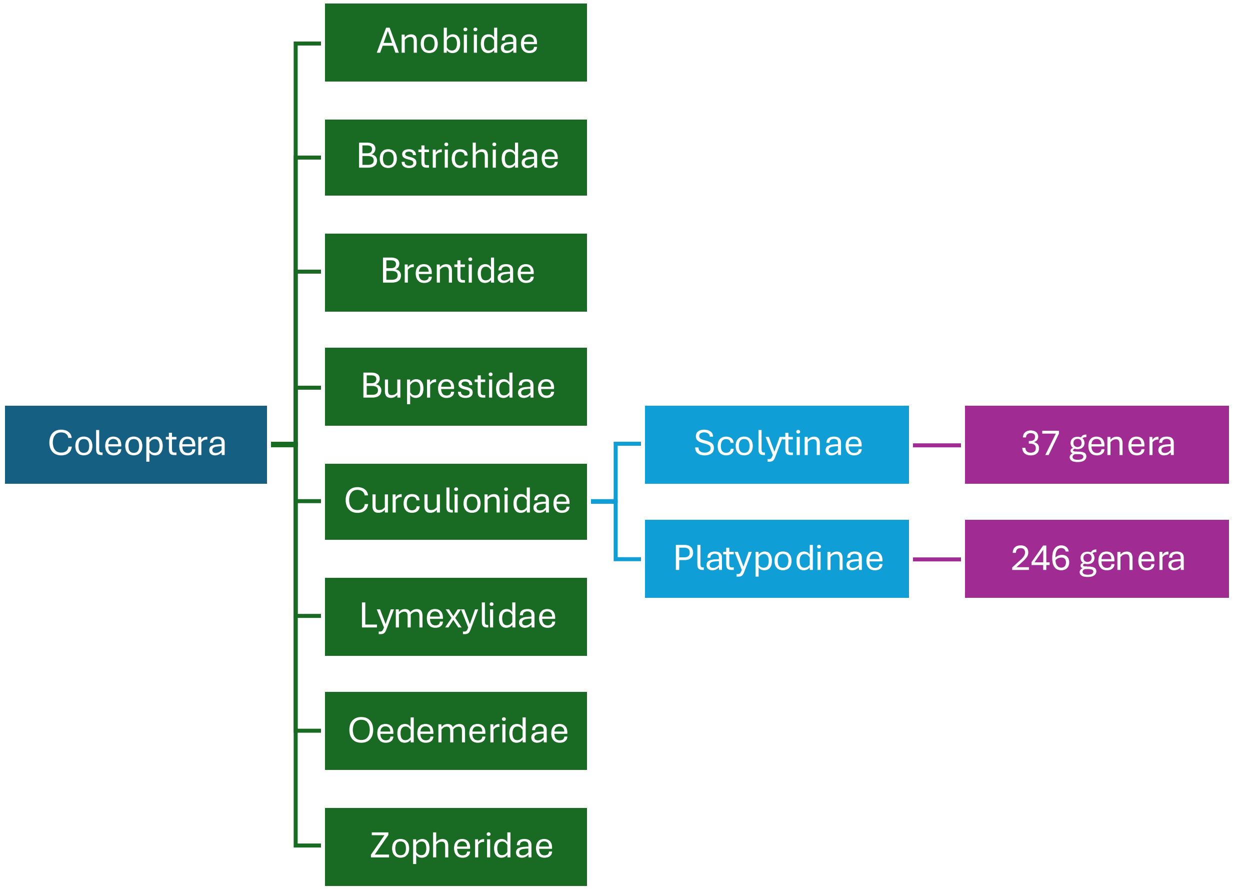


Method (Current State)



Taxonomic Inputs

- Scan 1: Wood-boring Beetles
  - Note the taxonomic grouping has some off-target species (i.e. non-wood-boring)
- Scan 2: Invasive Grasses
  - Poaceae

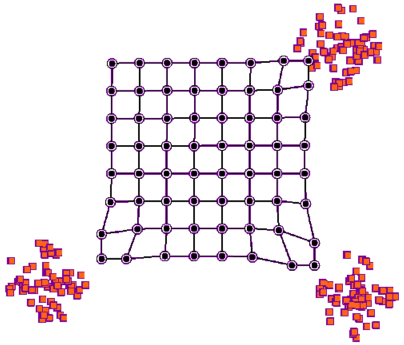


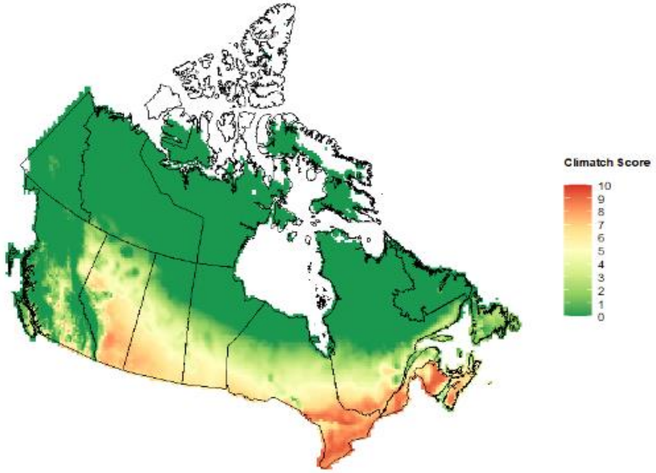
Stinziano et al., *in prep*

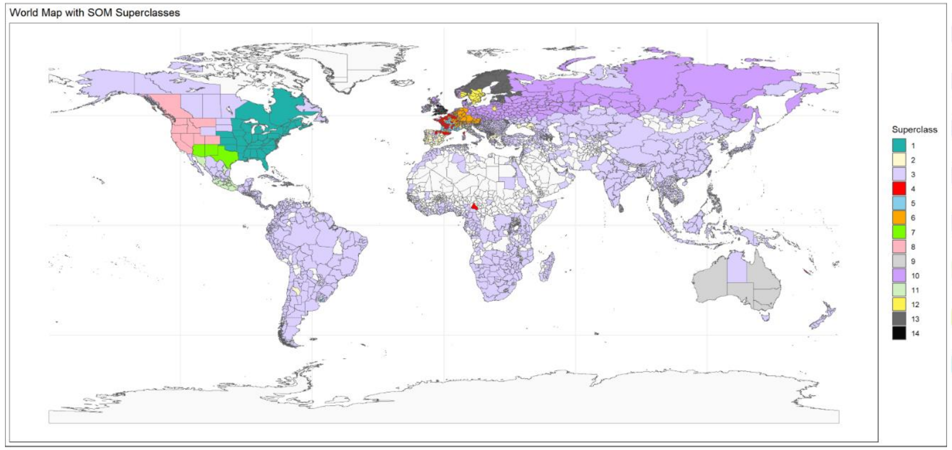
Modeling – 2 Model Ensemble

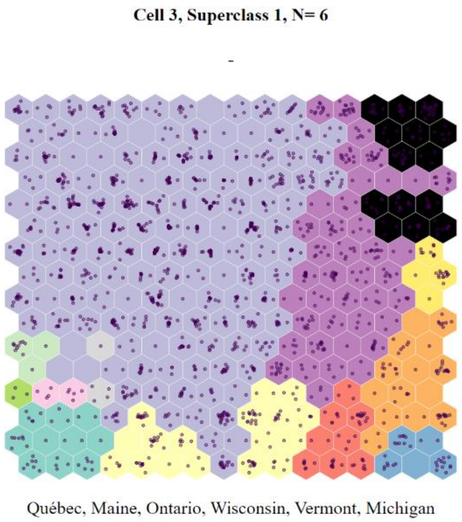
- High throughput climate matching with climatchR
- Uses the CLIMATE Euclidean distance based matching algorithm

- Self-organizing maps group regions based on similar groupings of species
- Each purple point is a location
- Cell colours indicate clusters









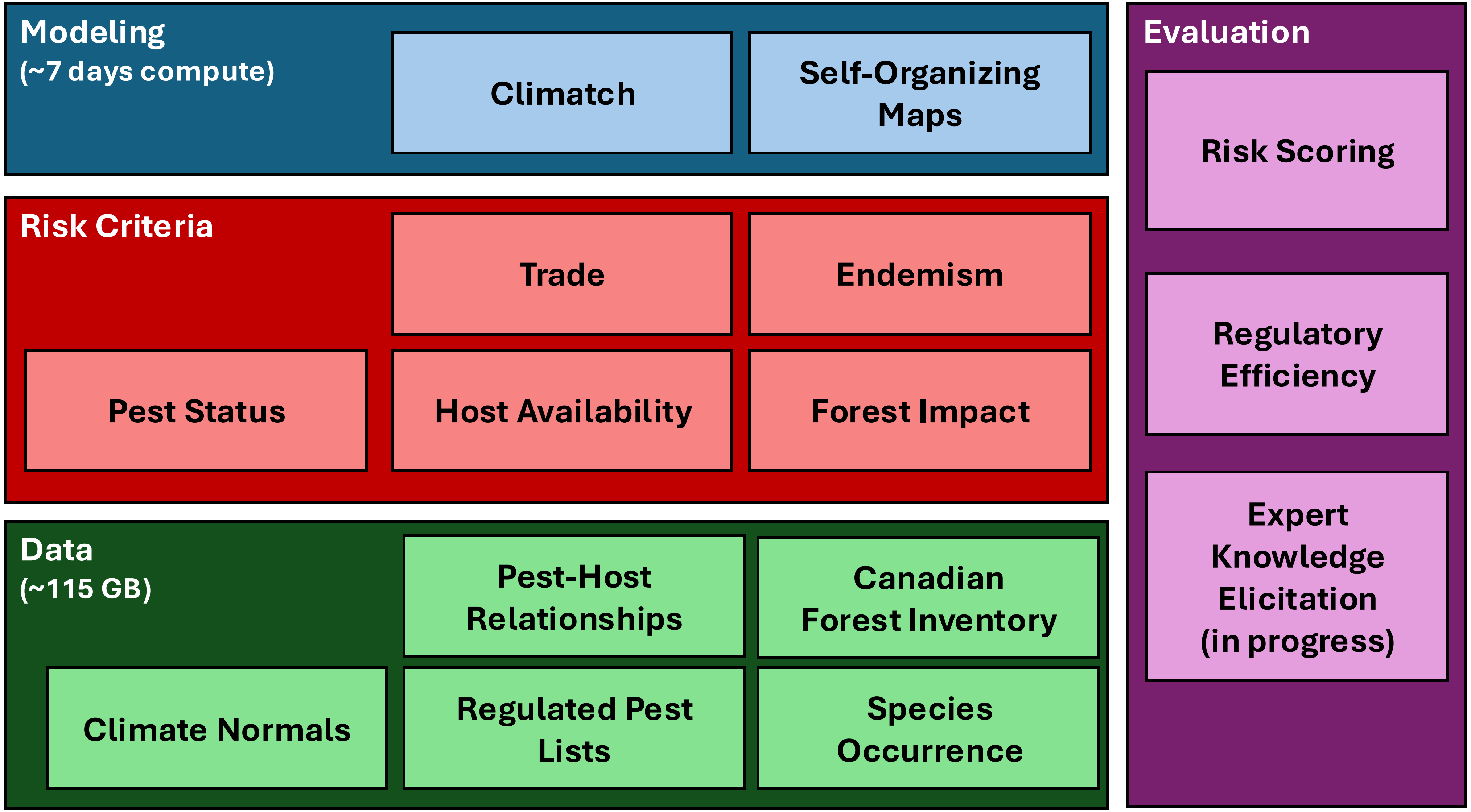
Stinziano et al., *in prep*

Scoring

- Each risk criterion calculated as a score between 0 and 1, rescaled to between 1 and 5
  - For climate change risk between –1 and 0, rescaled to between 0 and 1

- Overall Score = $\prod$ (Component Scores)
  - 7 metrics for wood boring beetles
    - Climate suitability, SOM, endemism, pest status, trade volume, host availability, forest impact
  - 11 metrics for invasive grasses
    - Climate suitability, SOM, endemism, pest status, trade volume, invasiveness, climate change risk, traveller volume, imminency, traits, global risk score

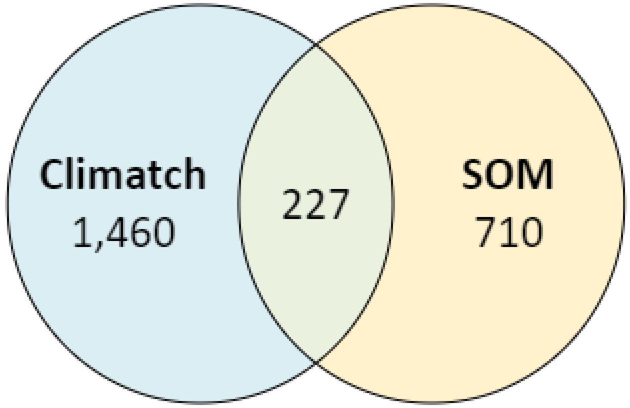
Scan 1: Wood Boring Beetles

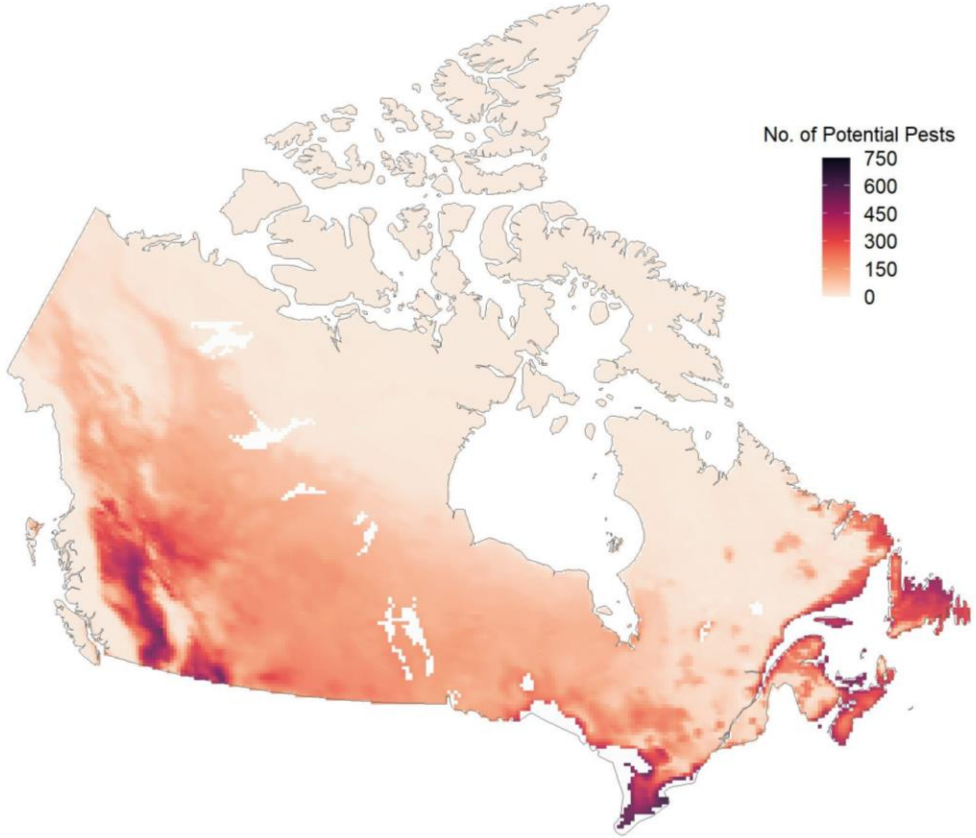


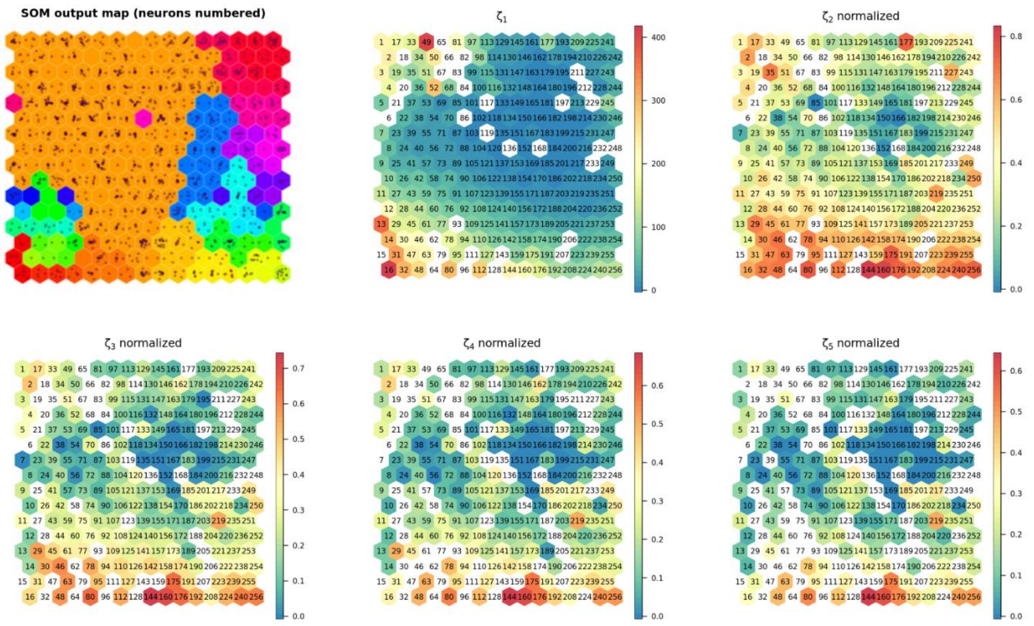
Stinziano et al., *in prep*

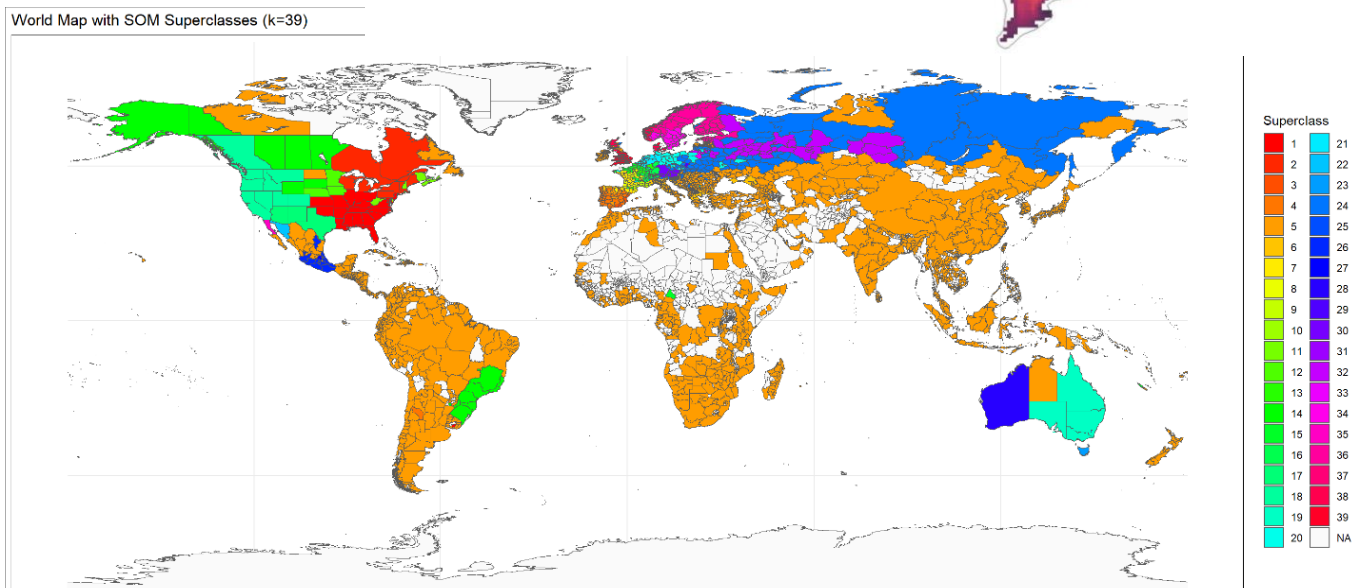
Scan 1: Wood Boring Beetles

Input
~11,000 species



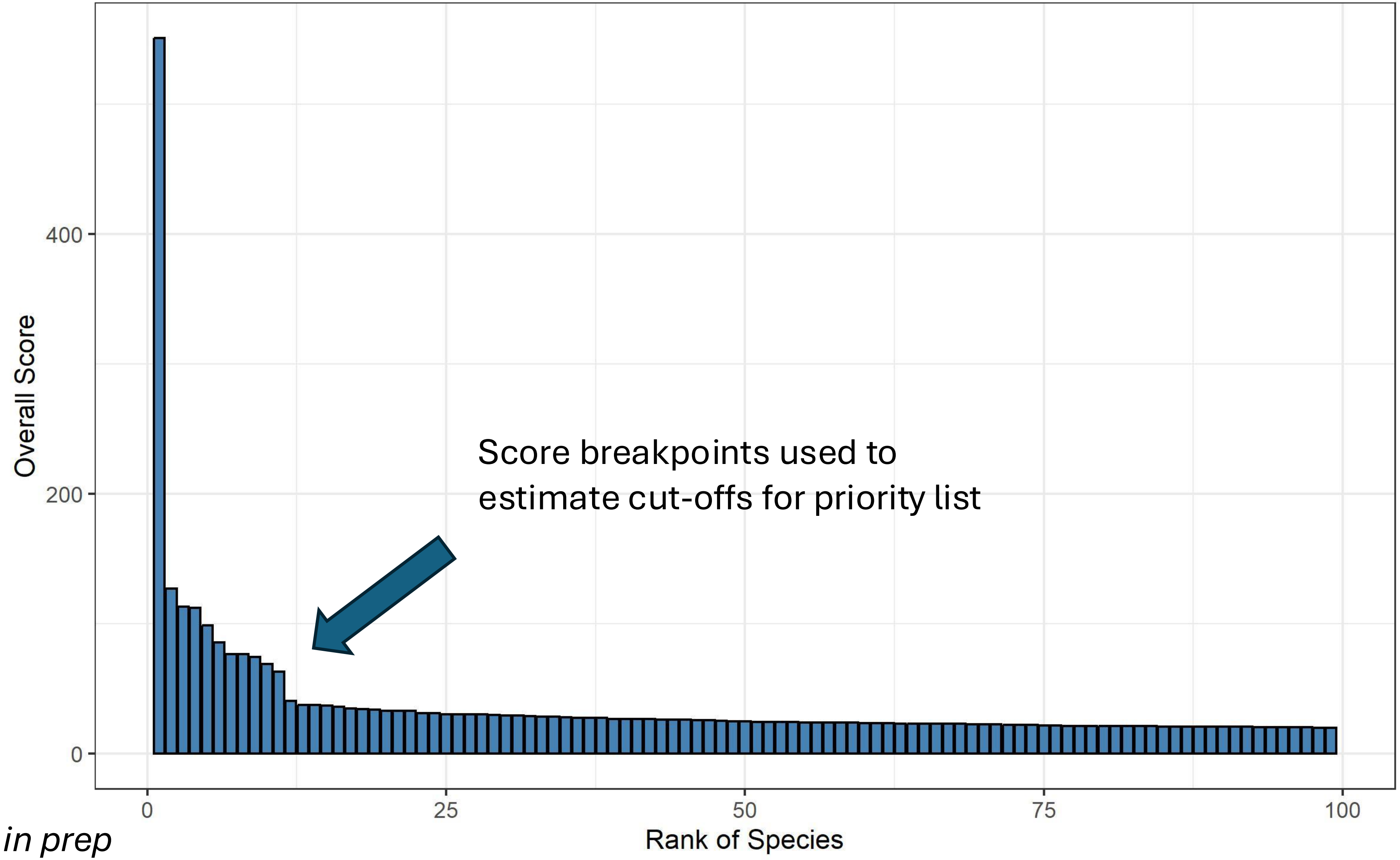






Stinziano et al., *in prep*

Scan 1: Wood Boring Beetles



Stinziano et al., *in prep*

Already regulated
Considered for regulation
Categorisation in progress
~99.9% reduction in targets

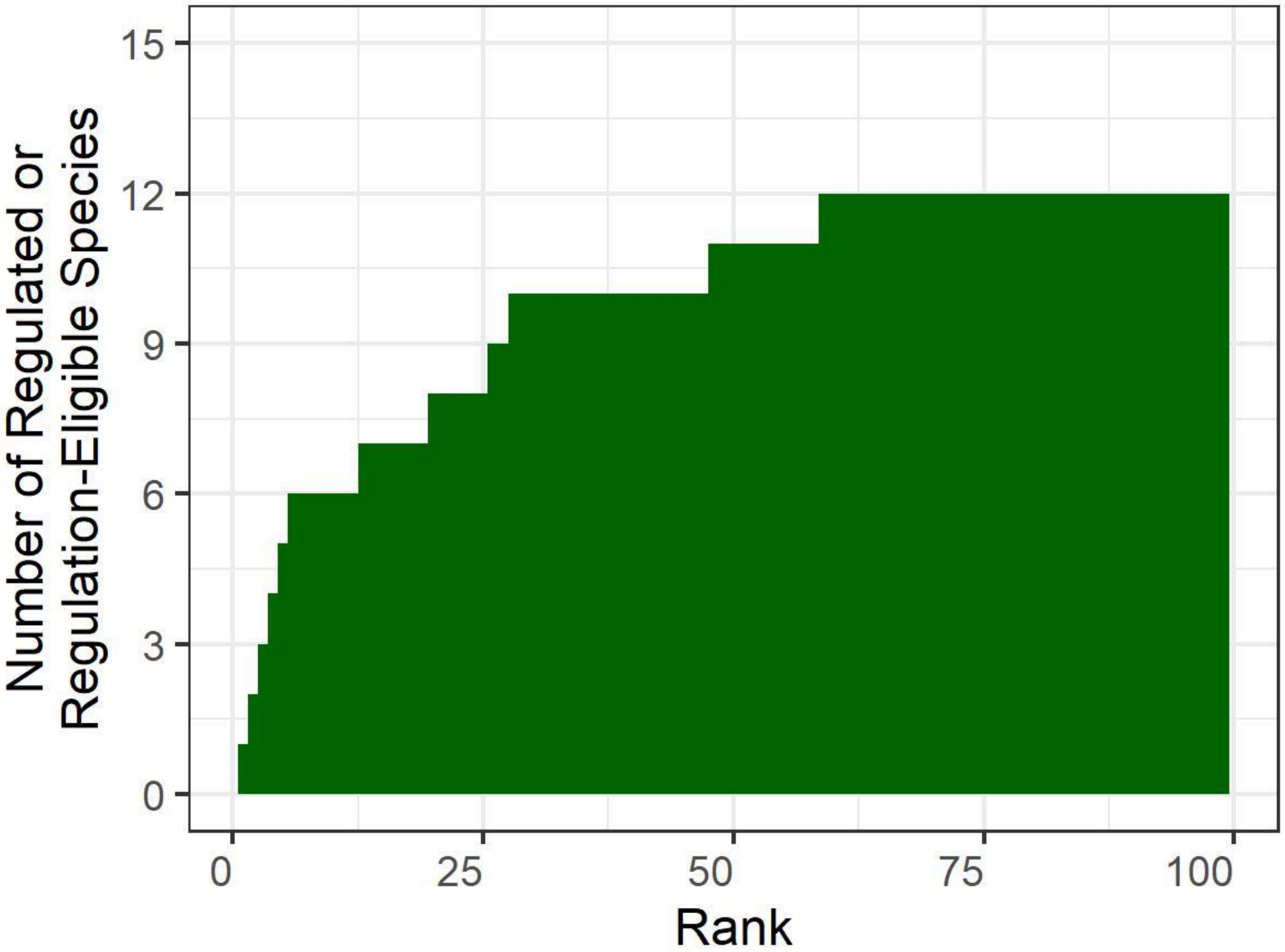
Scan 1: Wood Boring Beetle Shortlist

Rank	Species	Scores						
		SOM	Climatch	Pest	Trade	Host	Impact	Overall
1	*Monochamus sutor*	NA	4.08	5	3.82	1.47	2.91	551
2	*Monochamus urussovii*	NA	3.34	5	1.71	1.47	2.50	127
3	*Ips typographus*	1.08	2.52	5	1.33	1.59	2.64	113
4	*Hylesinus varius*	1.51	2.93	5	3.28	NA	NA	112
5	*Monochamus galloprovincialis*	1.12	2.82	5	1.37	1.24	2.26	99
6	*Anoplophora glabripennis*	NA	1.23	5	3.74	2.76	1.07	85
7	*Trypodendron signatum*	1.54	2.28	5	3.25	NA	NA	77
8	*Trachys minutus*	1.08	2.55	5	3.33	NA	NA	76
9	*Callidium aeneum*	1.28	2.57	5	3.22	NA	NA	74
10	*Pityogenes bidentatus*	1.34	2.26	5	3.27	NA	NA	69
11	*Ips sexdentatus*	NA	2.21	5	1.31	1.47	2.16	63
12	*Agapanthia villosoviridescens*	1.23	2.76	5	1.38	NA	NA	40
13	*Anoplophora chinensis*	NA	1.02	5	1.74	3.35	1.00	37

Stinziano et al., *in prep*

Scan 1: Wood Boring Beetles

- Regulatory efficiency:
  - Ranks 1 – 12: 50%
  - Ranks 13 – 28: 25%
  - Ranks 29 – 60: 6.25%



Stinziano et al., *in prep*

Stinziano et al., *in prep*

Scan 2: Invasive Grasses

Modeling
(~10 days compute)

- Climatch 1981-2010
- Climatch 2011-2040
- Self-Organizing Maps

Risk Criteria

- Imminency
- Climate Change Risk
- Trade
- Endemism
- Traits
- Pest Status
- Invasiveness
- Pathways

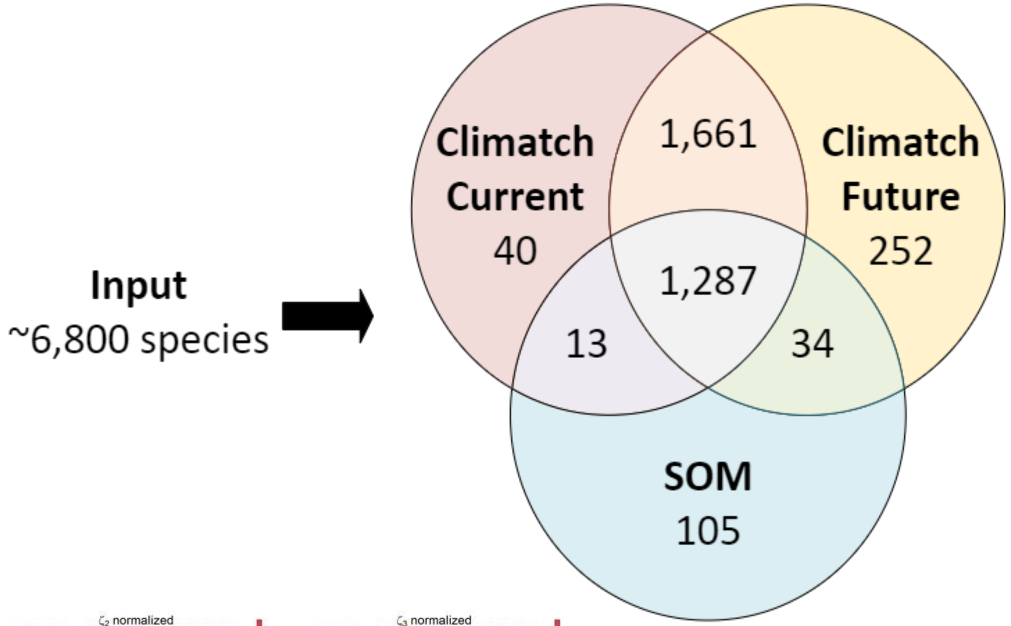
Data
(~75 GB)

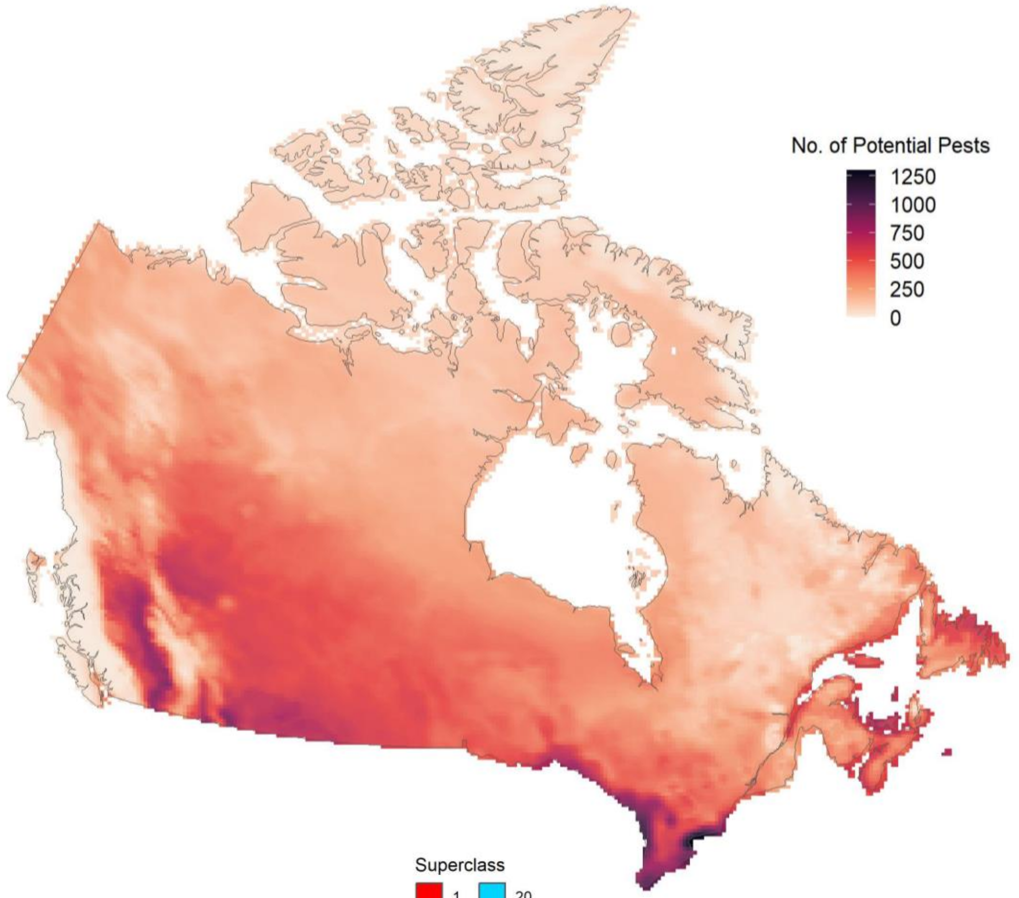
- TRY Database
- Climate Normals
- Global Compendium of Weeds
- International Air Visitors
- International Vehicle Traffic
- Invasive Species Databases
- Regulated Pest Lists
- Species Occurrence

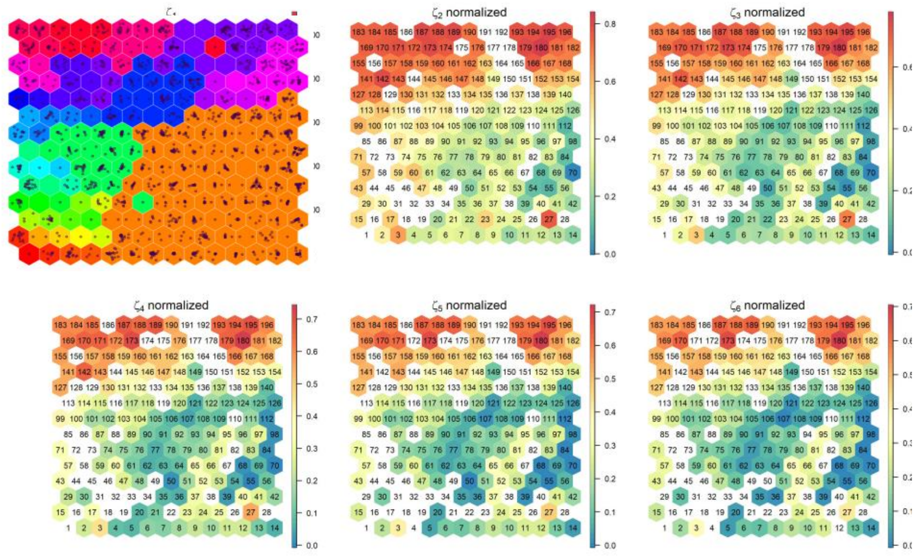
Evaluation

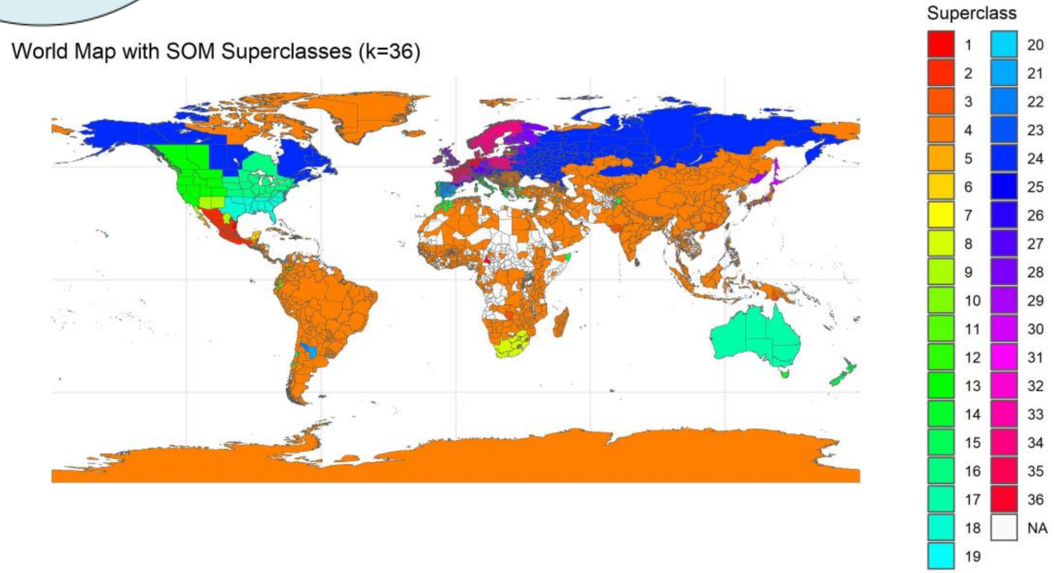
- Risk Scoring
- Regulatory Efficiency (in progress)
- Expert Knowledge Elicitation (planned)

Scan 2: Invasive Grasses





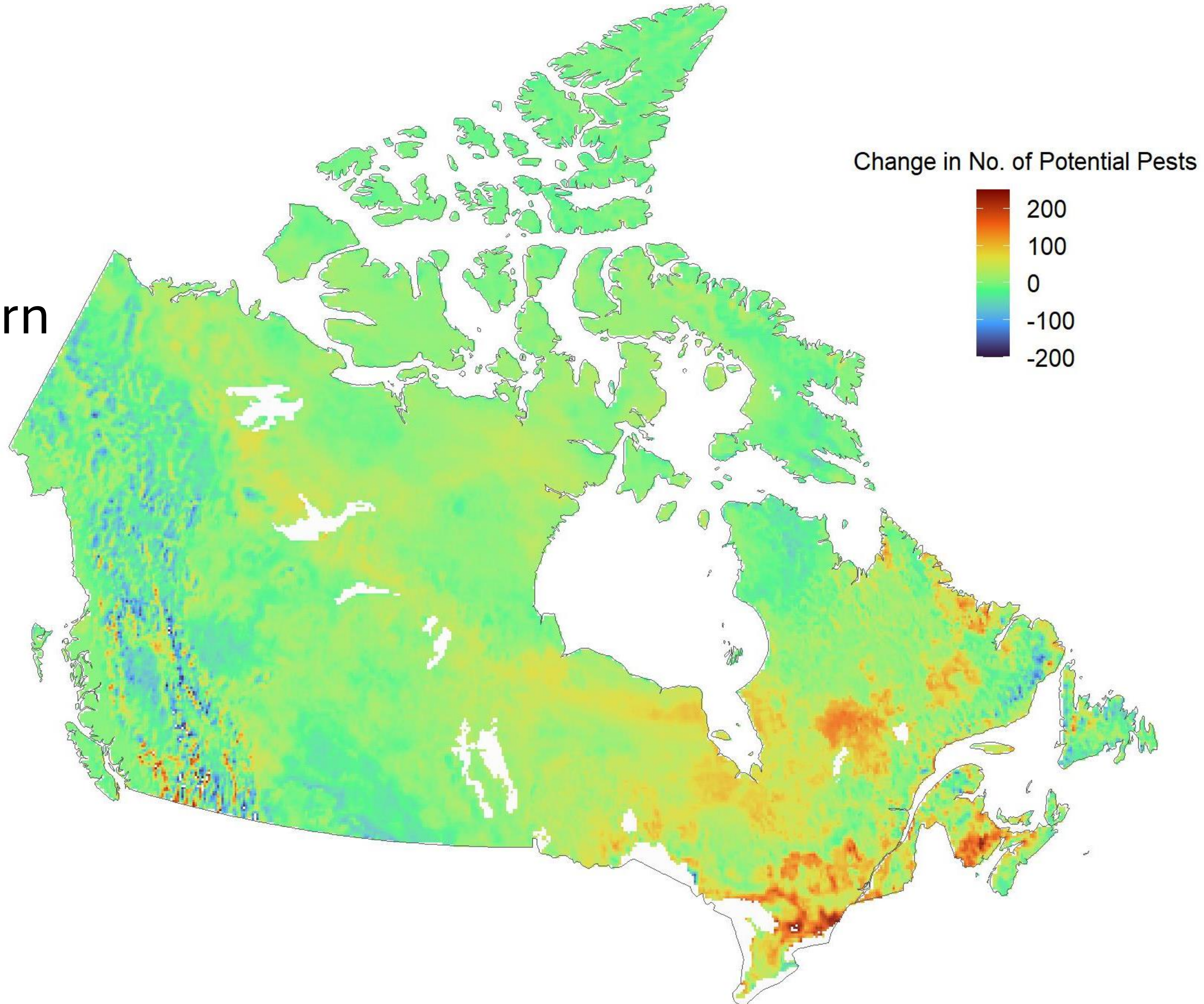




Stinziano et al., *in prep*

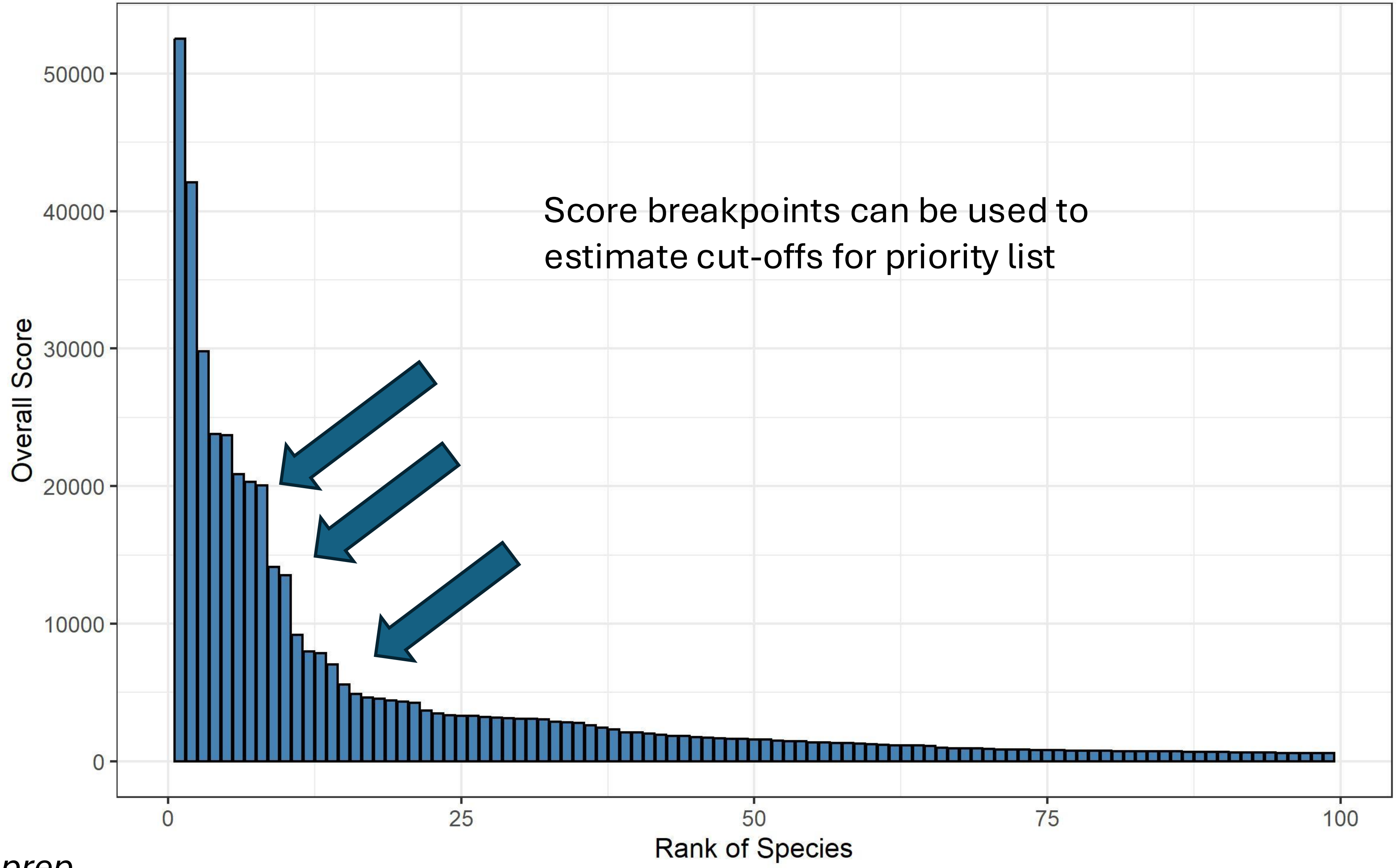
Scan 2: Invasive Grasses

- Patchiness in the impact of climate change on climate suitability for potentially invasive grasses
- Risk likely to increase in central/eastern Canada and decline in the west.



Stinziano et al., *in prep*

Scan 2: Invasive Grasses



Stinziano et al., *in prep*

Scan 2: Invasive Grasses Shortlist

Already regulated
Categorisation planned
~99.8% reduction in targets

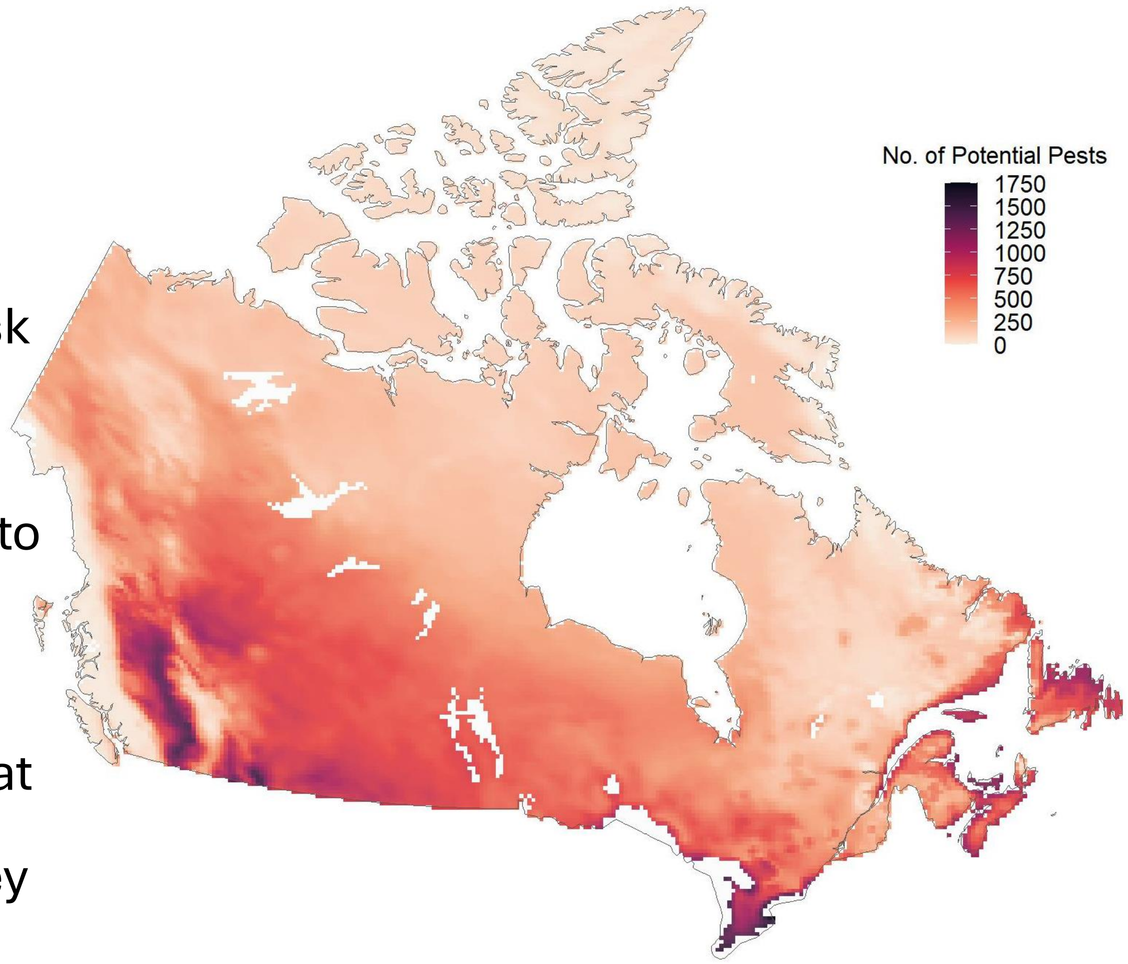
Rank	Species	Score									
		SOM	Climate	Climate Change	Trait	Invasiveness	Trade	Travel	Endemism	Global Risk	Overall
1	*Paspalum dilatatum*	1.49	1.15	1.00	3.87	2.33	4.25	4.50	1.69	4.20	52517
2	*Oryza sativa*	1.33	1.10	0.99	3.63	2.33	4.12	4.24	1.86	4.20	42086
3	*Pennisetum setaceum*	1.40	1.09	0.99	4.22	5.00	3.16	3.75	1.26	2.51	29794
4	*Paspalum distichum*	1.47	1.08	1.00	1.87	3.00	4.08	4.39	1.71	3.51	23778
5	*Paspalum urvillei*	1.20	1.01	1.00	3.90	3.00	3.86	3.57	1.43	3.40	23723
6	*Pennisetum villosum*	1.40	1.06	0.99	5.00	3.00	3.09	3.57	1.14	3.01	20888
7	*Paspalum vaginatum*	1.20	NA	NA	5.00	2.08	3.42	3.98	1.66	2.89	20318
8	*Pennisetum glaucum*	1.37	1.01	1.00	4.40	3.00	3.78	3.53	1.34	2.44	20035
9	*Pennisetum alopecuroides*	1.30	1.11	0.99	3.20	3.00	3.23	3.68	1.19	2.92	14104
10	*Paspalum conjugatum*	1.30	NA	NA	2.07	2.33	3.92	3.73	1.74	3.40	13535
11	*Paspalum notatum*	1.25	1.01	1.00	1.20	3.00	3.99	3.98	1.50	3.40	9188

Stinziano et al., *in prep*

Conclusions

- Quantitative horizon scanning can:
  - Provide priority species for regulatory review as well as a rapid risk assessment to support full risk assessments
  - Be used to identify gaps in biosecurity for a given taxonomic scope
  - Identify areas that face increased pest risks due to climate change

- Key caveats
  - Scale of quantitative horizon scanning means that there are inevitable errors
  - Availability and accessibility of data represent key limitations
    - e.g. host data availability was very low for beetles
  - Represents a 'first pass' in identifying biosecurity threats for further review

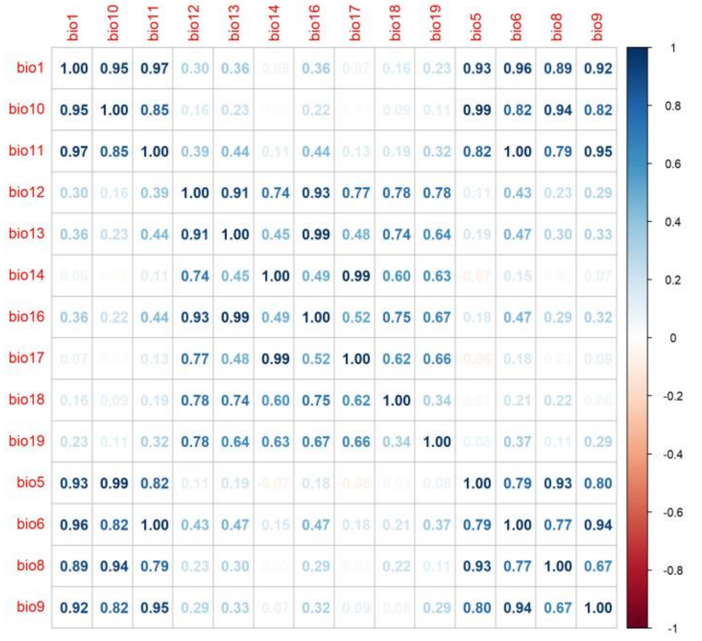


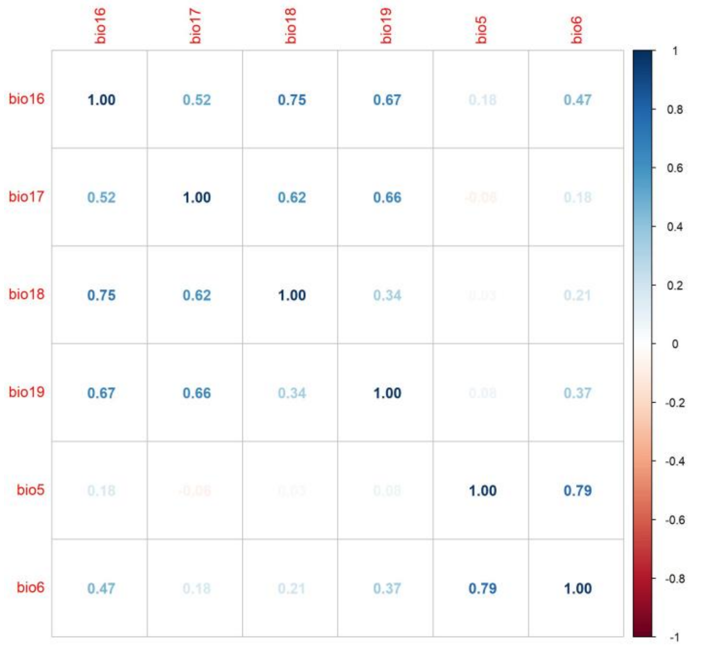
Next Steps

- Euphresco Project (Topic 2024-D-462 Quantitative horizon scanning using climatic modelling to identify species with the potential to become plant pests)
  - Work starting Winter 2025
  - Still time to sign up/participate - contact your Euphresco coordinator

Climate Variables

- Climate Data
  - o CHELSA 1981-2010 & 2011-2040
    - ▪ Variable reduction
      - Bio5 (temperature)
      - Bio6 (temperature)
      - Bio16 (precipitation)
      - Bio17 (precipitation)
      - Bio18 (precipitation)
      - Bio19 (precipitation)





Data Sources

- GBIF: species occurrence data
- CHELSA: current and future climatologies
- Statistics Canada: Canadian import volumes; international vehicular and air traffic
- IPPC: country-level pest lists
- EPPO: pest-host relationships
- Natural Resources Canada: forest inventory
- Global Compendium of Weeds: global risk scores
- TRY Database: invasive plant traits
- Plants of the World Online: plants already in Canada
- Bosquet et al. 2017 Cerambycidae of Canada & Alaska: wood-boring beetles already in Canada
- GRIIS/GRIN/GIASIP/GISD/ISC: pathways and invasiveness