Evaluating the Use of a New Risk Assessment Tool to Inform Regulatory Decisions for Aquatic Invasive Species in Ontario

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Background

- Ontario's Invasive Species Act took effect on November 3, 2016
- Provides for the regulation of species which are harming or are likely to harm Ontario's natural environment

Bill 37

Projet de loi 37

An Act respecting Invasive Species

Loi concernant les espèces envahissantes

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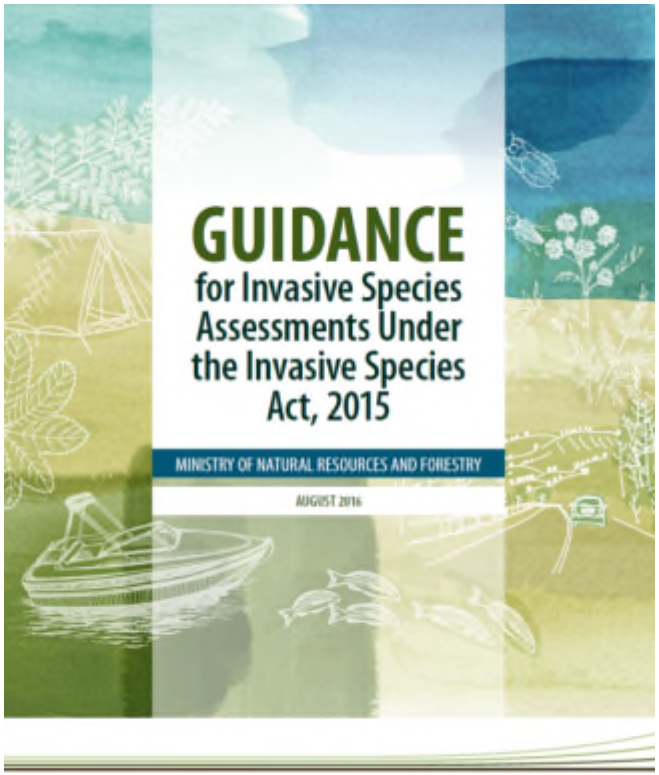
Background

- Ontario uses a risk assessment process to inform and support regulatory decisions and management actions related to invasive species.

- In 2015-2016 Ontario undertook a project to develop a more **quantitative** approach for risk assessments.



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Why Quantitative?

Quantitative: statistical approaches to estimate likelihood of invasion/ impacts and incorporate uncertainty

- Reduces subjective bias of reviewers = greater **objectivity** and **consistency**
- Considers all stages of invasion process (Arrive, Survive, Establish, Spread, Impacts)
- Estimation of **conditional probabilities**: accounts for fact that success/ failure at each stage depends on success/failure at previous stage
- Can capture and propagate levels of **uncertainty** associated with estimations of risk

New Risk Assessment Tool

Comprised of 2 “components”

- An Ontario- and AIS-specific questionnaire with standardized answer/uncertainty options, complete with specific guidance/examples

- A corresponding Bayesian Network tool to model conditional probabilities, propagate uncertainty, and derive probability distributions for overall risk of invasion and impacts

Questionnaire

Total of 24 Questions

5 Sections: (Arrival, Survival, Establishment, Spread, Magnitude of Impacts)

Questions:

- Reflect previously identified predictors of invasion success/impacts
- Incorporate questions included in other well-established risk assessment schemes
- Are comprehensive but not redundant

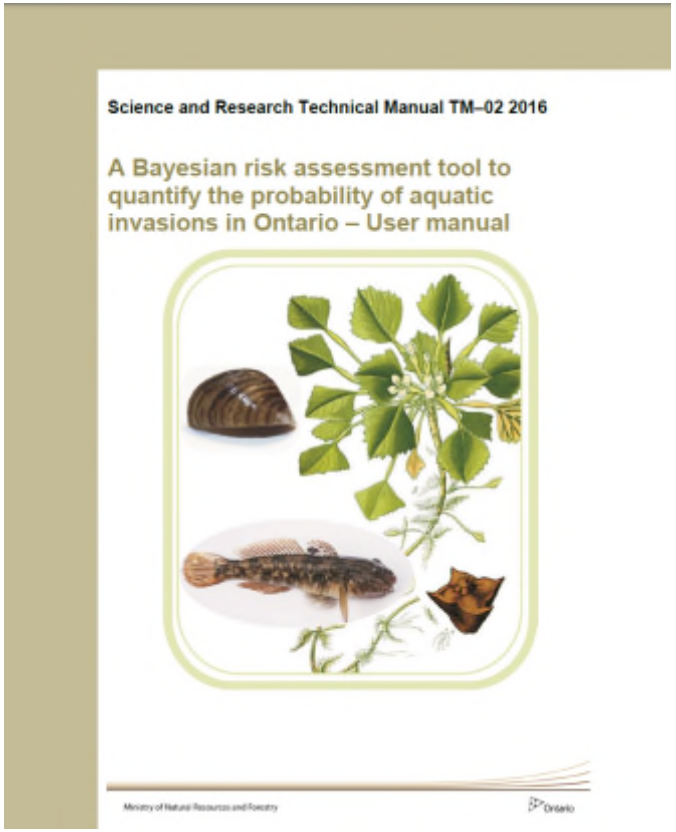
Questionnaire

All questions include:

- Ontario- and AIS-specific guidance for answer selection, with relevant examples
- General guidance on uncertainty ratings

For each question, the Risk Assessor must:

- Select one standardized answer option
- Identify level of uncertainty associated with their answer (L,M,H)
- Include justification in text for answer and uncertainty level (cite relevant literature used as evidence)



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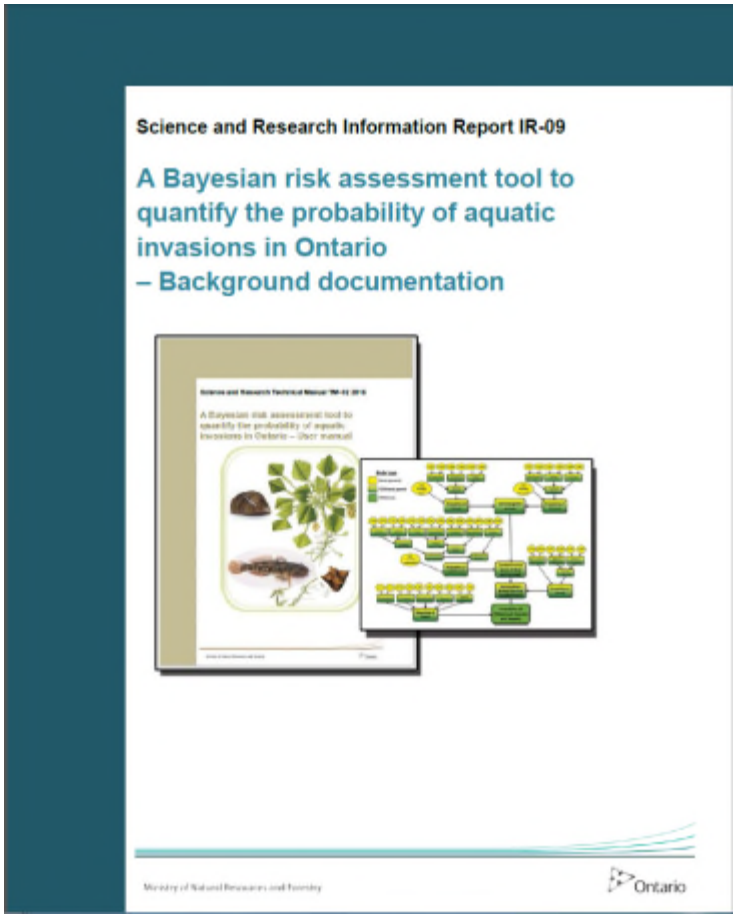
Bayesian Network to Model Invasion

Bayesian network built using GeNIe 2.1 (BayesFusion, LLC)

Documentation provided in an accompanying technical background report detailing the underlying structure/ mathematical foundations/assumptions of the modelling tool.



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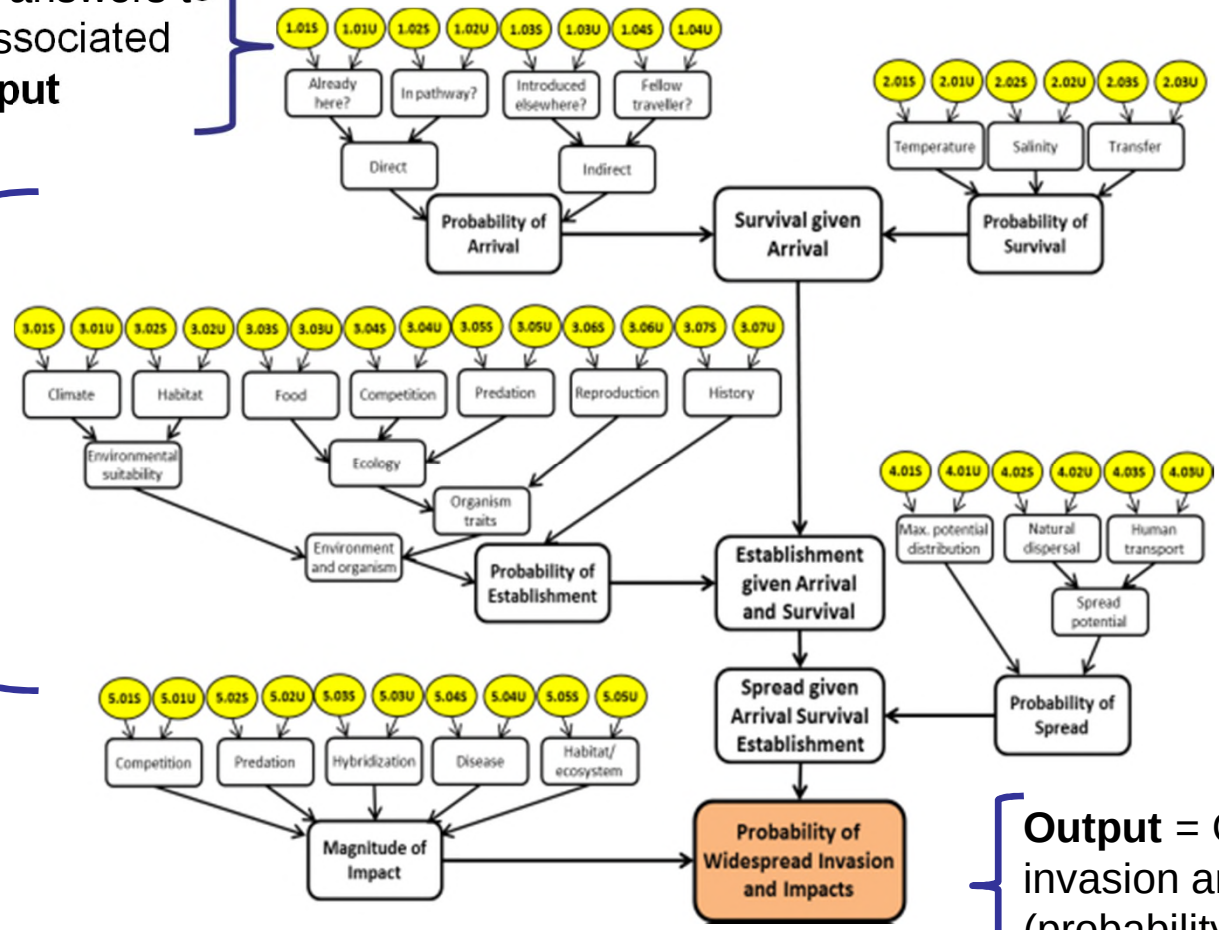
Bayesian Network to Model Invasion

Risk assessor's answers to questionnaire/associated uncertainty = **Input**

Conditional probability functions determine how factors combine and/or influence other factors AND **propagate uncertainty**



Output = Overall risk of invasion and impacts (probability distribution)

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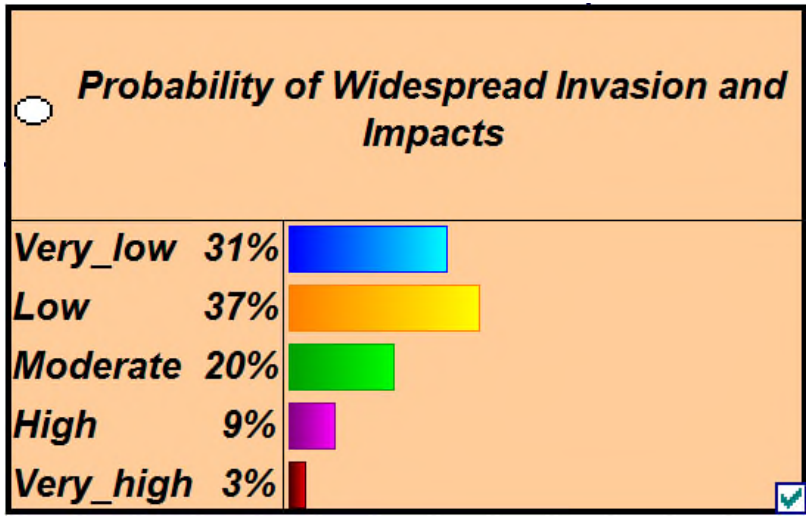
Bayesian Network to Model Invasion

Model output:



Case study: Oriental Weatherfish (*Misgurnus anguillicaudatus*)

Interpretation:

It is most likely that this species poses a low invasion risk in Ontario
(low + very low = **68**% probability)

HOWEVER

There **is a chance** that this species could pose a high risk
(high + very high = **12**% probability)

There is a 32% probability that this species would pose more than a moderate risk of invasion and impacts

Uncertainty is explicit, and transparent

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New Risk Assessment Tool

- The questionnaire/guidance document, and Bayesian Network have both been peer-reviewed.
- Tool has been beta-tested with a number of aquatic species (fish, invertebrates and aquatic plants).
- Model performed very well:
  - generated comparative results to those derived using other risk assessment protocols
  - accurately predicted risk for species known to have established and become invasive in Ontario.

Inter-rater reliability study

Purpose:

1) To evaluate the “inter-rater reliability” or consistency in risk rankings among assessors employing the newly developed Ontario risk assessment tool.

2) To evaluate the sensitivity of the overall risk rankings to different levels of inter-rater variation.

Inter-rater reliability study

Study design:

- 18 different “risk assessors” participated in the study
- 9 different potentially invasive aquatic species were assessed:

Aquatic plants	Fish
Water Lettuce	Pearl Danio
Water Hyacinth	Tench
Water Clover	Ide
Water Moss (*Salvinia* spp.)	Chinese Perch
Yellow Floatingheart	

- For each species, risk assessment questionnaires were completed by 5 randomly selected participants (with relevant taxa expertise)

Inter-rater reliability study

- Risk assessors provided with comprehensive literature review for assigned species.
- Risk assessors were instructed to complete the questionnaire based only on the information presented in the literature review as well as guidance and examples provided in the “User Manual”.
- Completed questionnaires were submitted and used to evaluate consistency in risk ratings across different assessors for the 9 different species.

Inter-rater reliability study

Inter-rater reliability (IRR) was quantified to evaluate the degree that assessors provided consistency in their scores across all questions for a given species

Data analysis:

- For each species, analyzed the similarity in weighted scores selected by 5 different assessors across 24 questions
- Inter-rater reliability: computed in R using a two-way mixed, consistency, average-measures Intra-class correlation (ICC)
- Higher ICC values indicate greater IRR: an ICC estimate of 1 indicates perfect agreement and 0 indicating only random agreement among assessors.

Results

Species	ICC	95% CI
Water Lettuce	0.915	0.846 < ICC < 0.959
Water Hyacinth	0.941	0.894 < ICC < 0.972
Water Clover	0.905	0.828 < ICC < 0.954
Water Moss	0.987	0.976 < ICC < 0.994
Yellow Floatingheart	0.943	0.897 < ICC < 0.972
Pearl Danio	0.969	0.944 < ICC < 0.985
Tench	0.875	0.774 < ICC < 0.939
Ide	0.971	0.947 < ICC < 0.986
Chinese Perch	0.953	0.914 < ICC < 0.977

Cutoffs for qualitative ratings of agreement based on ICC values (Cicchetti 1994)

Inter-rater reliability	ICC value
Poor	< 0.40
Fair	0.40 – 0.59
Good	0.59 – 0.74
Excellent	0.75 – 1.0

Inter-rater reliability study

Sensitivity of the overall risk rankings to different levels of inter-rater variation was assessed

Data analysis:

- Scores and uncertainty ratings selected in the questionnaires were entered as input into the Bayesian network model

- Overall probability of invasion and impacts was computed and compared across assessors (for each species)

Results

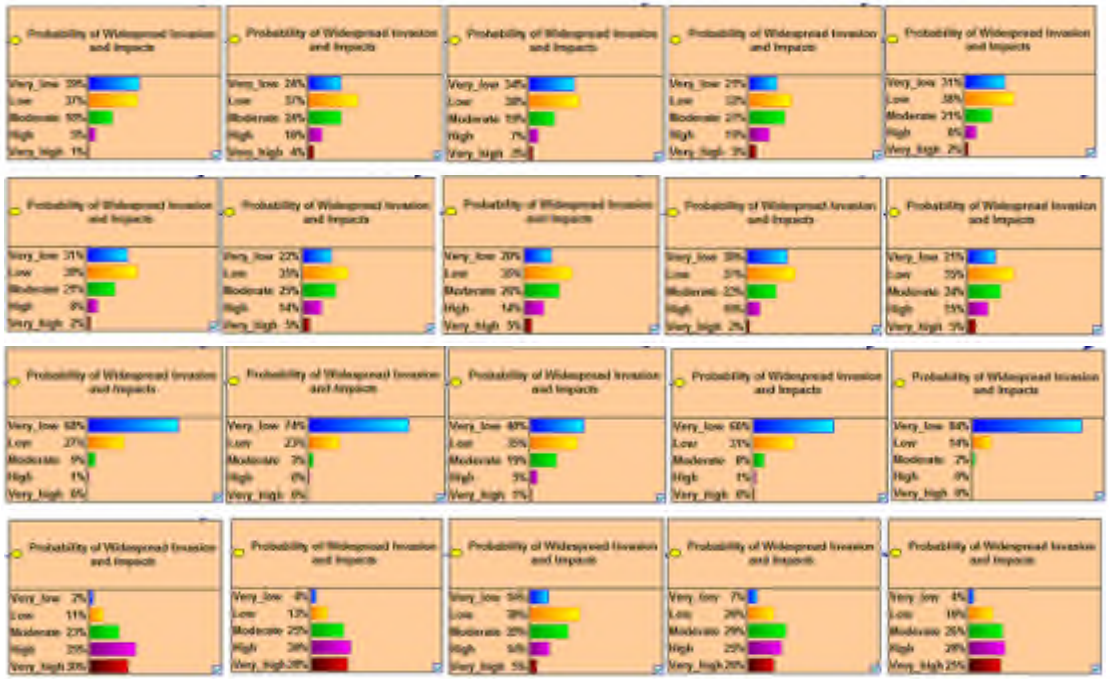
Bayesian model output: Overall risk “scores” = probability of invasion and impacts of the species in Ontario

Chinese Perch

Ide

Pearl Danio

Tench



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Results

Water Clover

Water Hyacinth

Water Lettuce

Water Moss

Yellow Floatingheart

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Lessons Learned

- Overall the new tool provides a high level of inter-rater reliability
- Model output is still sensitive to variation in assessor ratings
- Risk assessment workshops where taxa experts are convened are still warranted in order to ensure consistent understanding of questions and rating guidance and to achieve consensus on risk ratings

Conclusions

The proposed approach for quantifying invasion risk is:

- Robust, scientifically defensible, and meets established criteria for effective, detailed-level Risk Assessments.
- Consistent with/builds upon RA tools currently accepted as standards in other jurisdictions (i.e., in North America, Europe, and elsewhere)
- The first of its kind to fully incorporate and model conditional probabilities (i.e., Bayesian inference) across all invasion stages.

Next steps

- Modify/adapt the tool so that it is applicable to other taxa (beyond aquatic invasive species)

- Incorporate use of new tool in Ontario's risk assessment process to inform and support regulatory decisions and management actions related to invasive species.

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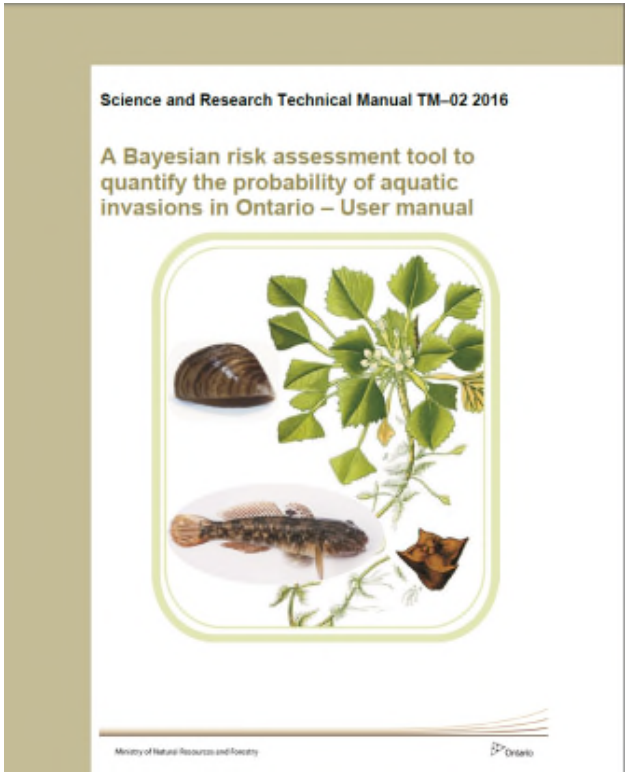
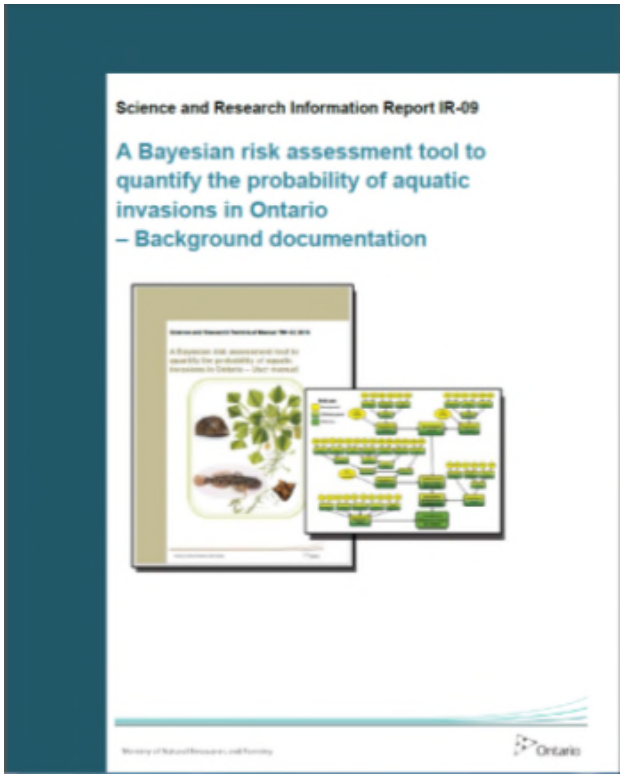
Questions?





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