Questionable Research Practices in non-hypothesis testing research:

Ecological models for conservation decision-making

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> problem

Ecological modelling has a transparency problem that remains unaddressed despite several attempts to promote thorough and transparent reporting practices. Given recent evidence revealing rates of Questionable Research Practices (QRPs) comparable to other disciplines like Psychology and Medicine (Fraser et al. 2018), it is likely that ecological modelling is also susceptible to QRPs. However, QRP literature to date has focussed almost exclusively on Null-hypothesis testing research.

How do we define Questionable Research Practices for model-based research?

What are the effects of QRPs on a model?

What are some plausible QRPs when modelling?

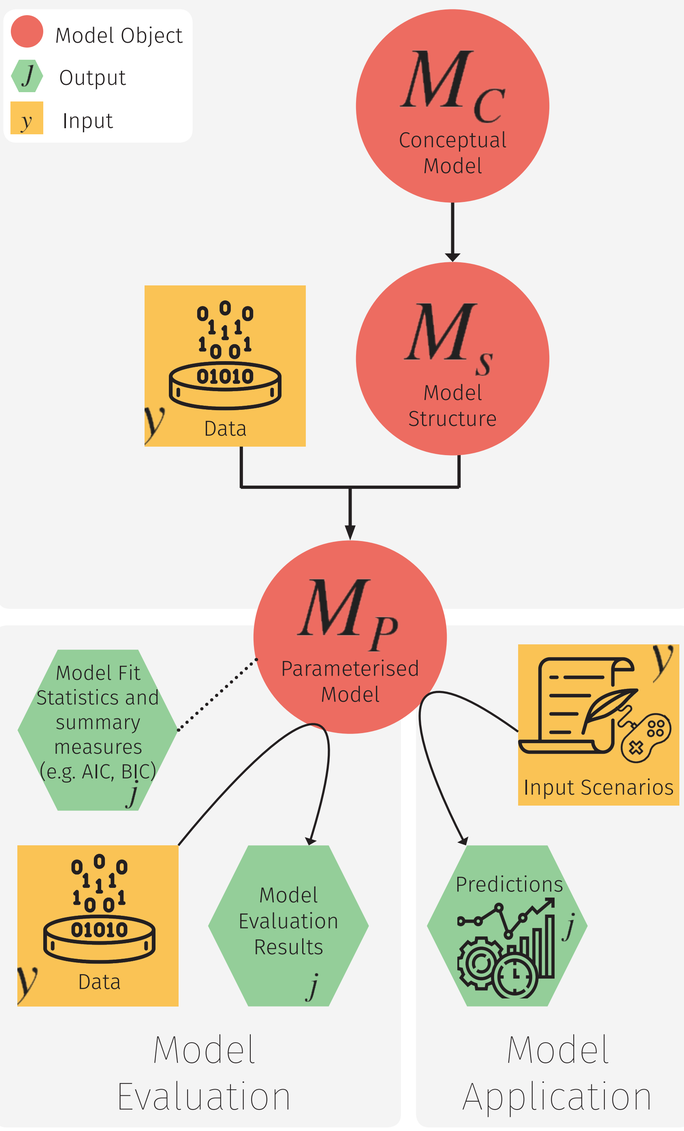
What do Applied Ecologists Model?

Models aid policy and decision-makers to make choices about how, when, and where to make conservation interventions by generating anticipatory predictions about how a target species, community or ecosystem will respond to those interventions.

Modelling frameworks and methods are diverse, varying in complexity and across landscape scale, but are often process-based or mechanistic, rather than phenomenological or correlative.

Modelling Workflows: Components and Attributes of an Ecological Model

Model Construction and Development



Towards a Conceptual Framework of QRPs in Model-Based Research

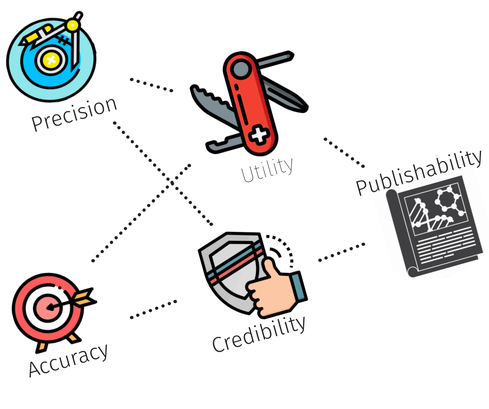
Unique Features of the Modelling Process

A sequence of many analytic decisions or choices, **C**, are made by the modeller to derive $\mathbf{M}_p$ from $\mathbf{M}_s$, from $\mathbf{M}_c$.

Some decisions are *necessarily dependent* on previous analytic decisions in the modelling workflow, e.g. an appropriate model-fitting method to derive $\mathbf{M}_p$ might depend on the specified model structure $\mathbf{M}_s$.

Modelling process results not in a single "result", but a suite of model components, which...

collectively inform the subjective attributes of a model that determine its publishability:



Process is non-linear, and iterative, with many interim versions of the model preceding publication

> define "QRP" for models

Data-dependent analytic decisions that artificially increase the accuracy or precision of a model, its predictions, and/or evaluation tests to the effect that the model is perceived to be more credible than it would be if the QRP did not occur, or practices that lead to consumers of the model placing false belief in the reliability, validity and utility of the model than would be warranted without the QRP.

A Provisional Typology of QRPs: Adapting Gelman and Loken's (2013) "Garden of Forking Paths" Theoretical Framework for Model-Based Research

It may alter:	The practice may be performed on: The Model, **M**	Any Model Output, $\mathbf{M}_j$
The Model **M**, or Model Outputs $\mathbf{M}_j$	$C(y,M;\phi(y,M))$	$C(y,M;\phi_{Mj}(y,M))$
Model Credibility or Utility, by selective reporting or "fishing":	$C(y,M;\phi^{best}(y,M))$	$C(y,M;\phi^{best}_{Mj}(y,M))$
No QRP, pre-specified analytical decisions:	$C(y,M;\phi)$	$C(y,M;\phi_{Mj})$

1. Problem Formulation	2. Define Conceptual Model	3. Specify Model, Model Structure	4. Model Fitting, Model Checking	5. Model Evaluation	6. Scenario Analysis, Projection
Define model purpose, scope, resources; Data collection and collation	Identify predictor, response & intermediate variables, specify assumptions	Choose model class, family; Choose method for finding structure, parameter values; Choose performance criteria and technique for parameter, structure estimation	Model Checking; Fit Model; Specify priors	Choose Model Validation Scheme; Choose Validation Performance Criteria; Sensitivity Analyses, Robustness Analyses	Choose Scenarios and Performance Criteria; Run Analyses, Simulations
S Failure to a priori specify stopping rule and data-peeking. HARKing Changing the stated purpose of the model after fitting and evaluating the model, and/or running scenario analyses.	S Changing the predictor or response variables after model fitting, checking and evaluation, without reporting.	Failing to report all methods for estimating model structure and parameters. HARKing Changing the method for parameter and structure estimation- after, fitting, checking and/or evaluating the model. Failing to report all model fit measures or changing the technique and criteria after fitting, checking or evaluating the model.	Fail to check and report influence of prior. S Fail to ensure Prior measured on same scale as likelihood. HARKing Data-peeking "SPARKing": specifying priors after results are known Failure to undertake and report all model checking results. Failure to check and report all assumption violation tests.	S Hacking the model evaluation measure until it meets some threshold for model accuracy, precision or credibility. Changing the model evaluation performance criteria after results are known. HARKing Failing to report all model evaluation measures, or robustness analyses undertaken.	Failing to report all scenario analyses implemented. Choosing to report only the best performing scenario that make model seem fit for purpose. HARKing Changing the model purpose after running scenario analyses. S Hacking analyses until desired result obtained.

Legend

- Cherry-picking
- S "S-hacking", or statistic hacking
- HARKing Hypothesising, setting expectations or purpose after results are known
- Selective reporting

QRP Roadmaps: Mapping the occurrence and type of QRP onto the modelling process, Bayesian preditive modelling.

> key findings: roadmap

> Many opportunities for undisclosed "Researcher Degrees of Freedom" in model-based research

> QRPs can occur at multiple decision points, multiple QRPs possible at each modelling step

> Direct analogues between NHST and non-NHST research, but also some specificities

> Open Questions and Next Steps

> What is the prevalence and extent of QRPs in the published ecological modelling literature?

> What technical solutions other than pre-registration may mitigate QRPs?

> Is pre-registration an appropriate solution to model-based QRPs? What form would it take?

Gelman, A., & Loken, E. (2013). The garden of forking paths: Why multiple comparisons can be a problem, even when there is no "fishing expedition" or "p-hacking" and the research hypothesis was posited ahead of time. https://osf.io/n3axs/download

Fraser, H., Parker, T., Nakagawa, S., Barnett, A., & Fidler, F. (2018). Questionable research practices in ecology and evolution. PLoS One, 13(7), e0200303. doi:10.1371/journal.pone.0200303