Using Bayesian Networks to improve understanding of survey data;

A case study of adoption of conservation practices by landholders

Jenifer Ticehurst, Allan Curtis and Wendy Merritt

Natural Resource Management (NRM)

- **NRM Regions of Australia typically report their achievements as 'outputs' rather than '*outcomes*'**
  - *e.g. "2km of river frontage was fenced off from stock at a cost of $40,000", rather than "sediment loads in river were decreased on average by 100kg/yr"*

- **Australian Government pushing for '*outcomes*' to be reported to justify their investment**

Addressing the 'Outcome'

- **Two key factors:**
  - Biophysical: *"What is the likely outcome (i.e. change in natural resource condition) from that change in action/management?"*
  - Social: *"What change in action/management are likely to be adopted by land managers, and why?"*
- **Landscape Logic** ***(www.landscapelogic.org.au)*** **is exploring these questions.**
  - Water quality in Tasmania
  - Native vegetation condition in Victoria

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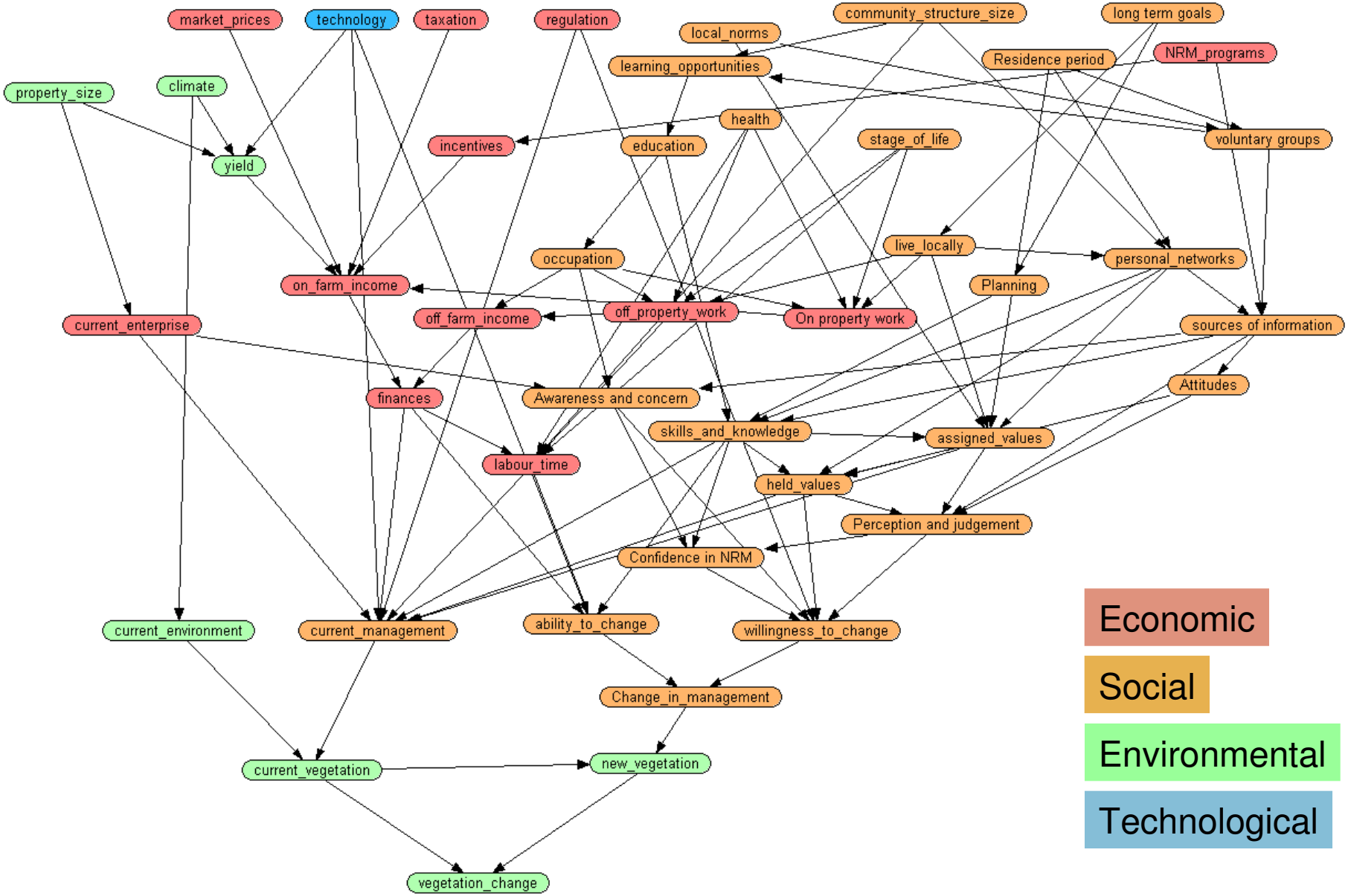
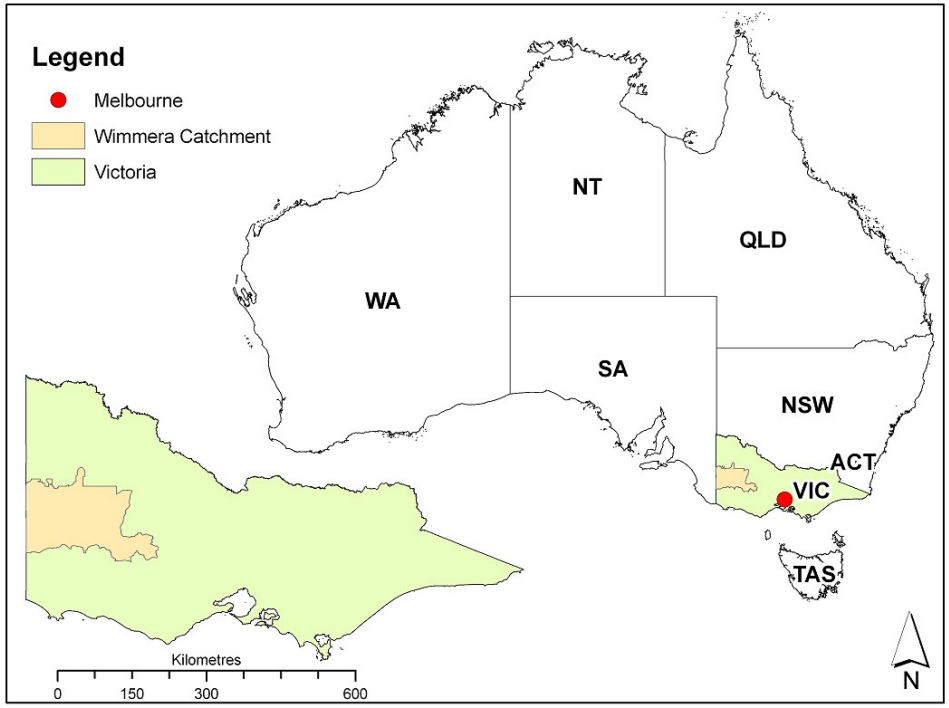
Draft Conceptual Model for Social Drivers in Changes in Native Vegetation Condition



Wimmera CMA Social Survey

- **Conducted by SAME social research team at CSU**
- **Survey completed in 2006 - 2007**
- **Survey data included:**
  - Issues affecting the property and district
  - Values attached to the property
  - Level of confidence in Current Recommended Practices (CRPs)
  - Long-term plans for the property
  - Background socio-economic and property data (e.g. property size, age, occupation, etc)



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Pilot Study

- **CSU study**
  - Generated detailed social dataset
  - 503 respondents (out of 1000 surveys)
  - Included information on the management of native vegetation (CRPs)
  - Data already analysed using conventional approaches

- **Presented an opportunity**
  - Explore the usefulness of Bayesian networks in analysing and presenting social data
  - Focus discussions and Bn development on CRPs
  - Facilitate discussions between integrationists and social scientists

Conventional Social Data Analysis

- **Techniques include:**
  - Social psychological models e.g.
    - Theory of planned behaviour (Azjen, 1991)
    - Conceptually map people's expected behaviour
  - Statistical approaches e.g.
    - Regression Modelling: *Multiple linear, Multiple logistic*
    - Other Statistics: *Spearman rank order correlations, Pearson's Chi square, Kruskal-Wallis Rank sum*
    - Statistics show the strength of a relationship between two variables, but do not account for the process understanding (i.e. pairwise comparisons).

- **Bns have the potential to do both**

Conventional Analysis

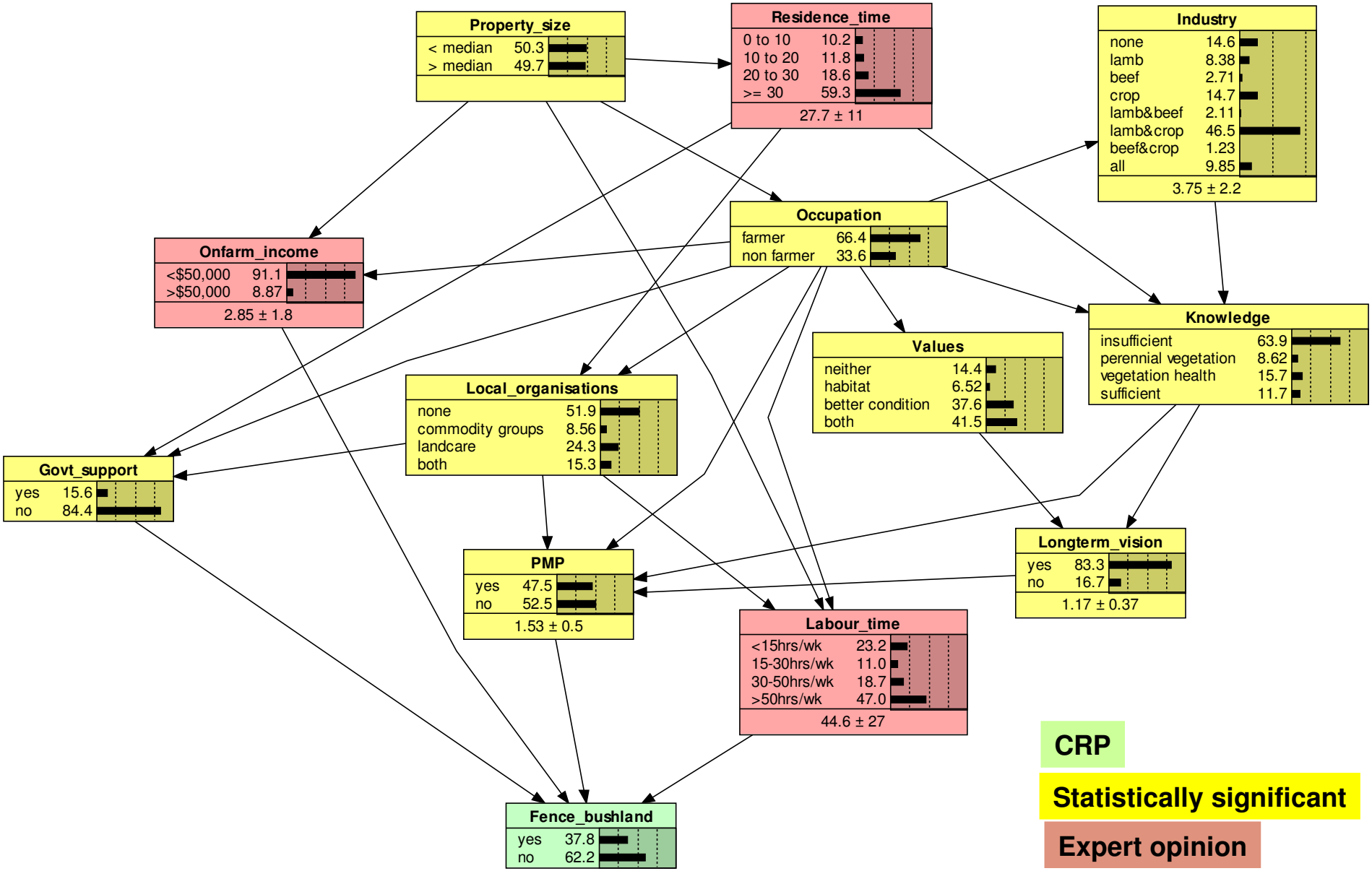
Selected one Current Recommended Practice (CRP) relevant to the management of native vegetation: “Fencing of native remnant bushland to manage stock access”.

CSU ran a pairwise comparison using statistics to see which variables were significantly related to the fencing of bushland.

Conventional Analysis findings

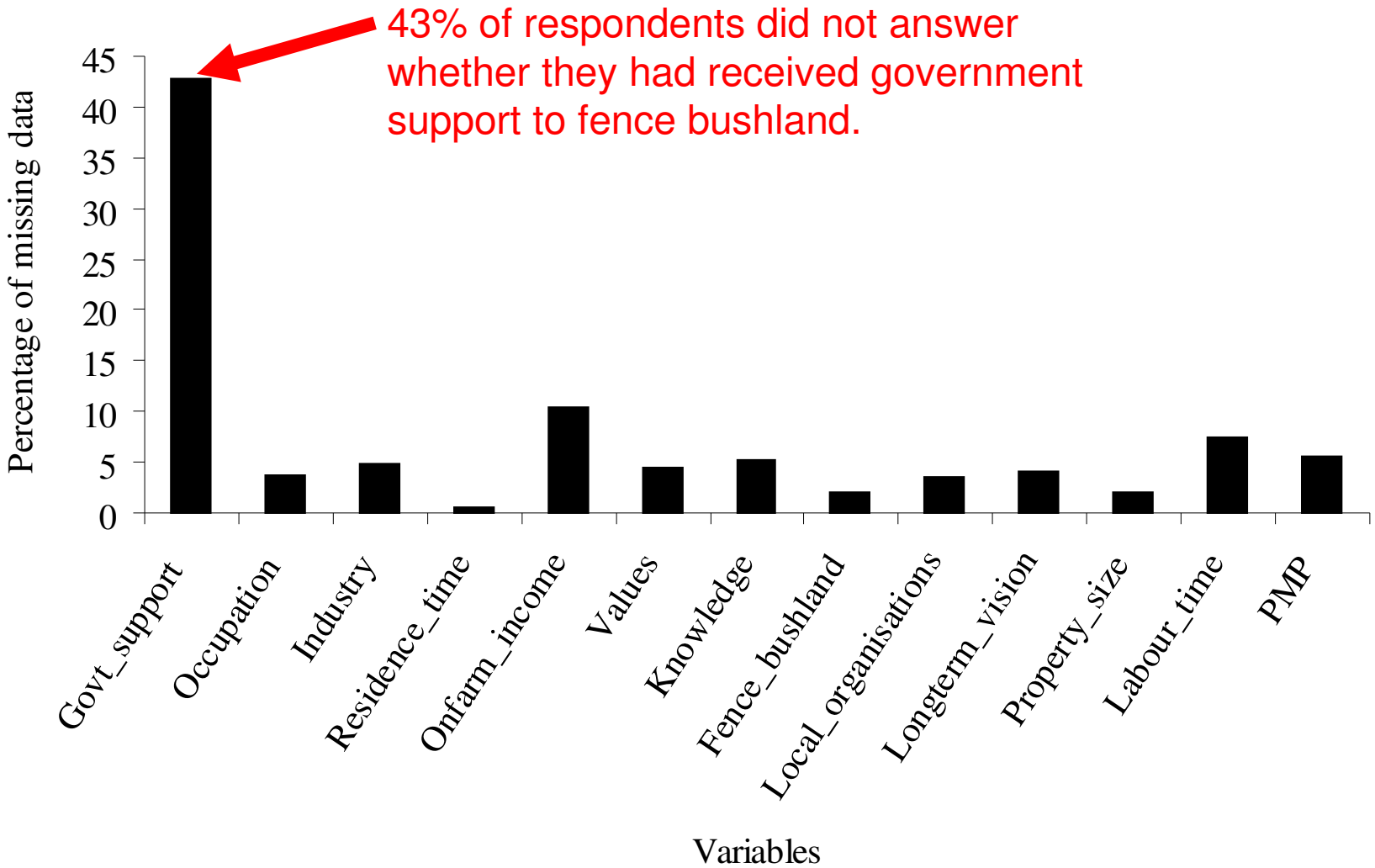
Variable	p-value
A higher rating to 'native vegetation on my property provides habitat for native animals'	4.5×10^{-3}
A higher rating to 'being able to pass the property on in better condition'	6.9×10^{-3}
Higher self-assessed knowledge of the ability of perennial vegetation to prevent water tables rising	6.6×10^{-4}
Higher self-assessed knowledge of how to protect and improve the health of native bush areas	2.0×10^{-4}
Involvement in whole farm planning	1.9 x 10-4
Having a long-term plan or vision	4.5×10^{-6}
Landcare membership or involvement	1.1×10^{-4}
Membership of a local commodity group	3.6×10^{-4}
Larger property size	2.6×10^{-10}
Identifying as a farmer by occupation	1.2×10^{-2}
Support from government	1.1×10^{-16}
Beef cattle producers	1.7×10^{-1}
Sheep meat producers	2.1×10^{-2}
Have patches of native bush	N/A

Resultant Bn



Populating the Bn

- Survey data used to populate Bn



Learning algorithms in Netica

1. **Counting (*incorp casefile*)**

   Tally to make conditional probability tables

1. **Counting + missing data**

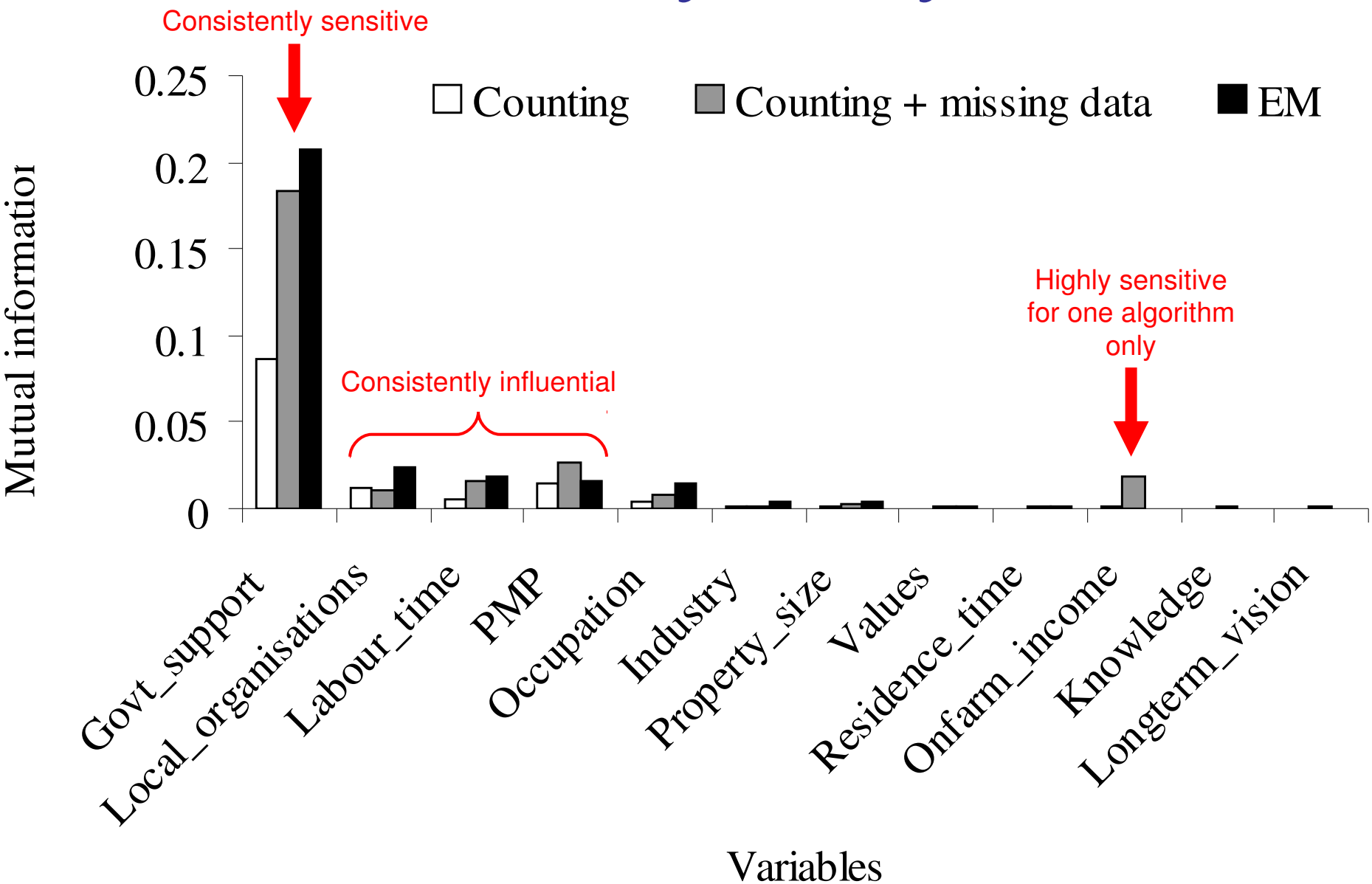
   As with 'Counting' but 'missing data' is explicitly included as a state for each variable

1. ***Expectation Maximisation (EM)***

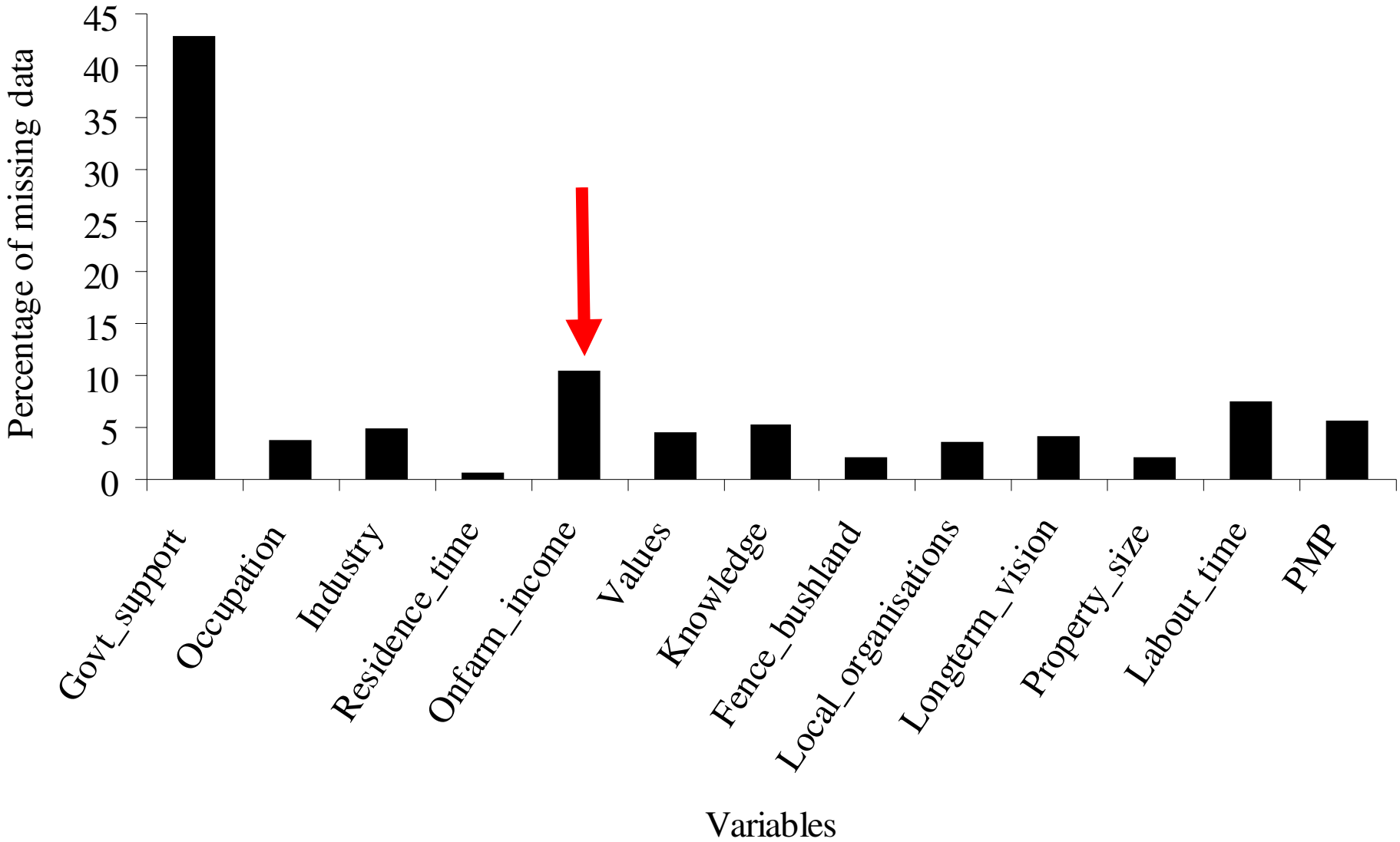
   Each state is initially given an even probability and these are adjusted according to the data being imported

   Missing values are interpolated from the existing data

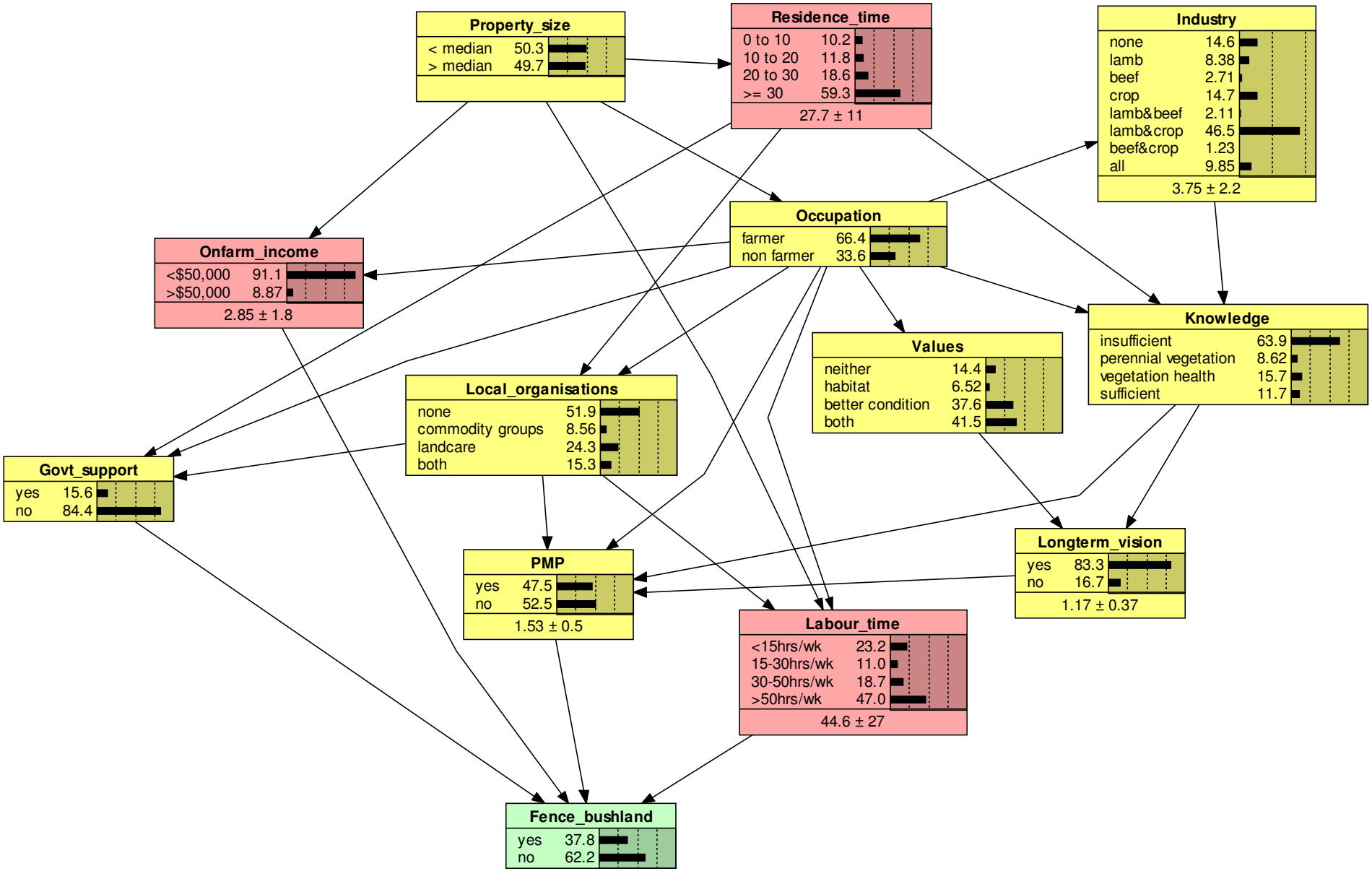
Sensitivity Analysis



Missing data



Reviewing the Bn Performance



GeNIe to learn the structure

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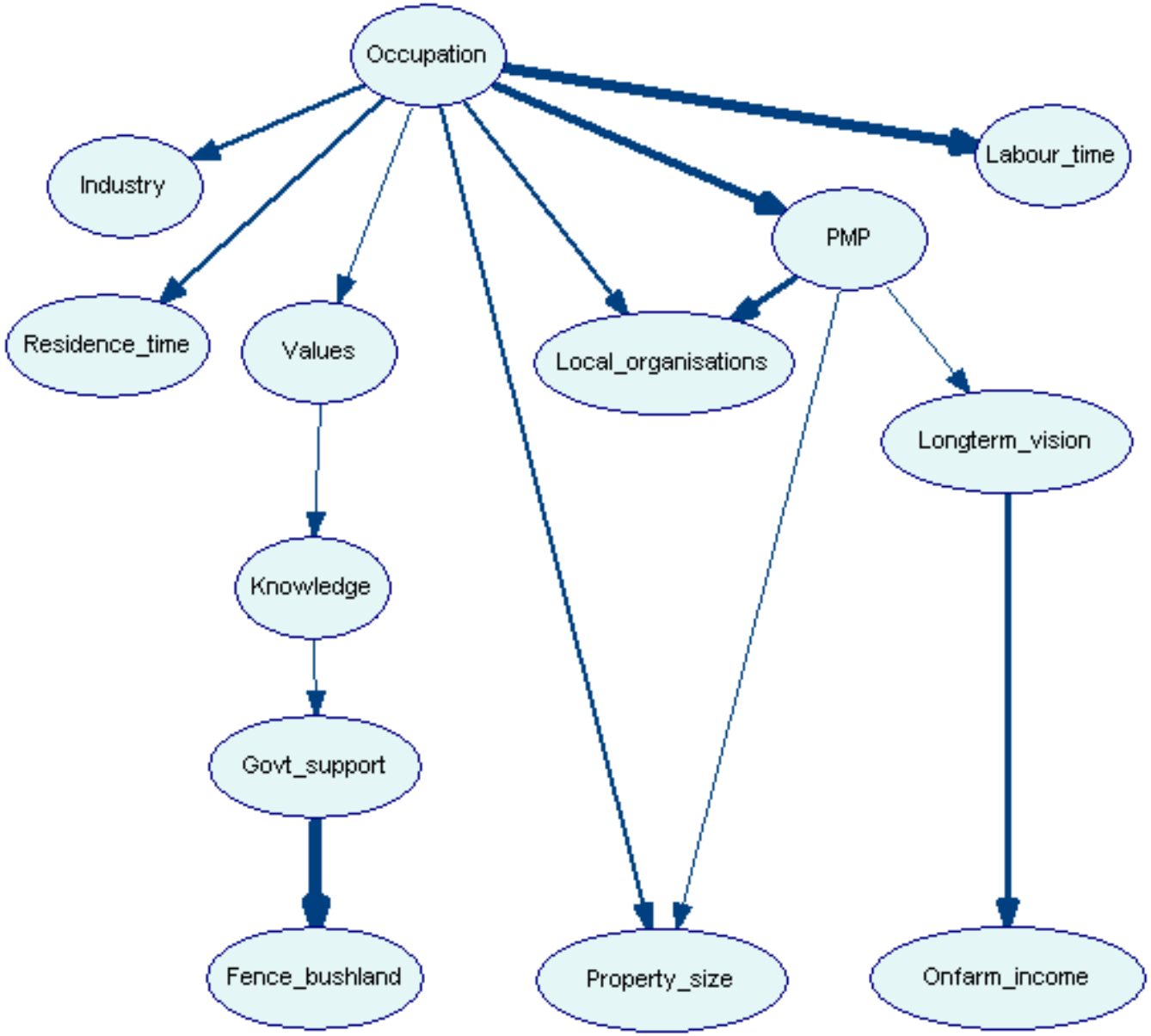

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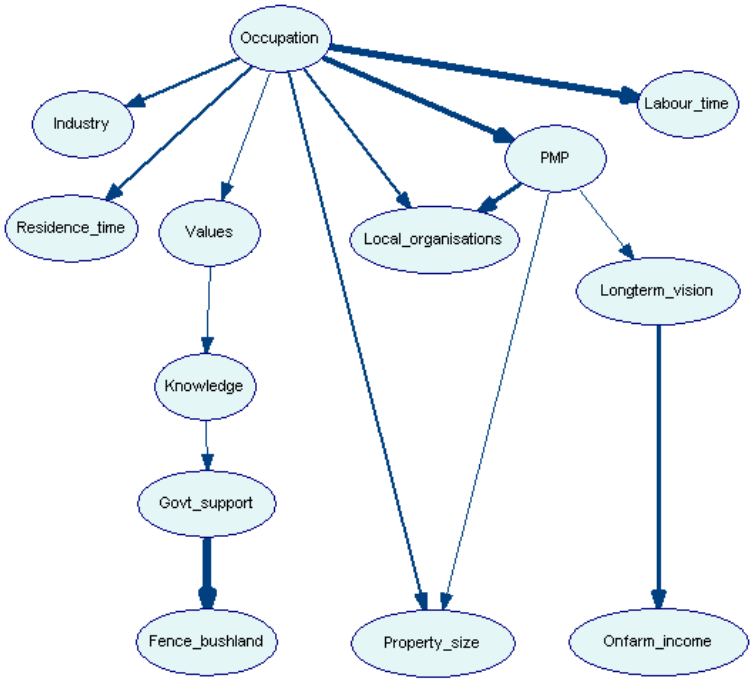
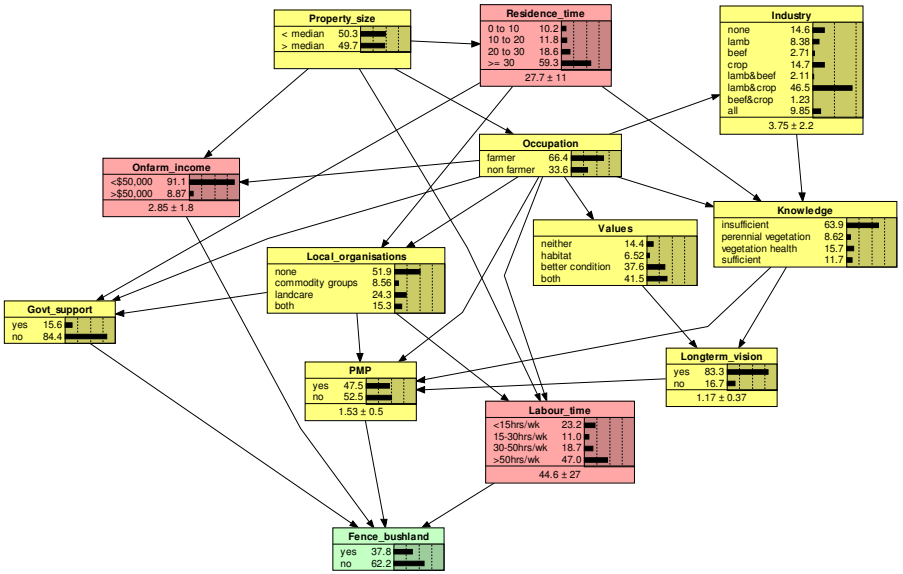
Importance of expert opinion

Learned



Constructed



- Ensure that the causal relationships (i.e. conceptual structure) make sense
- Enables variables to be included that were not shown to be mathematically important. "*Not all important information can be captured in a survey*".
- Example: enabled 'the time spent working on the property' (*Labour_time*) to be included which was found to be highly influential.

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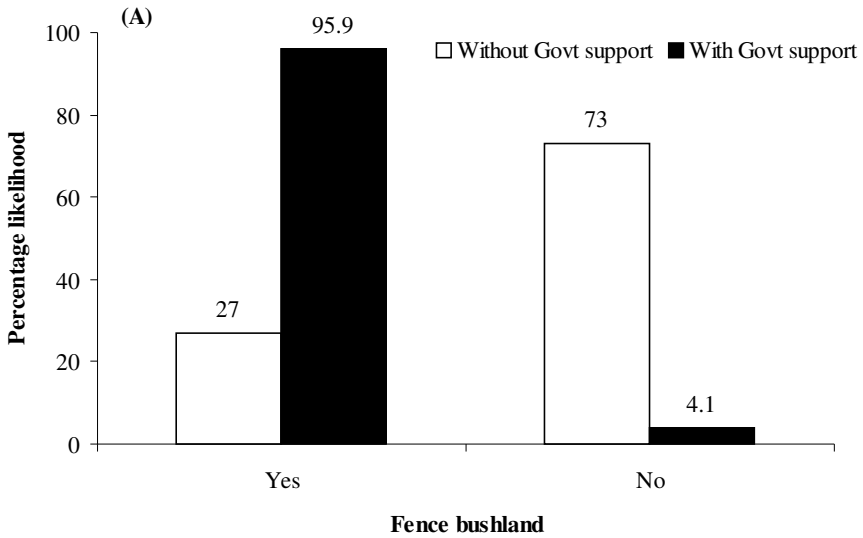
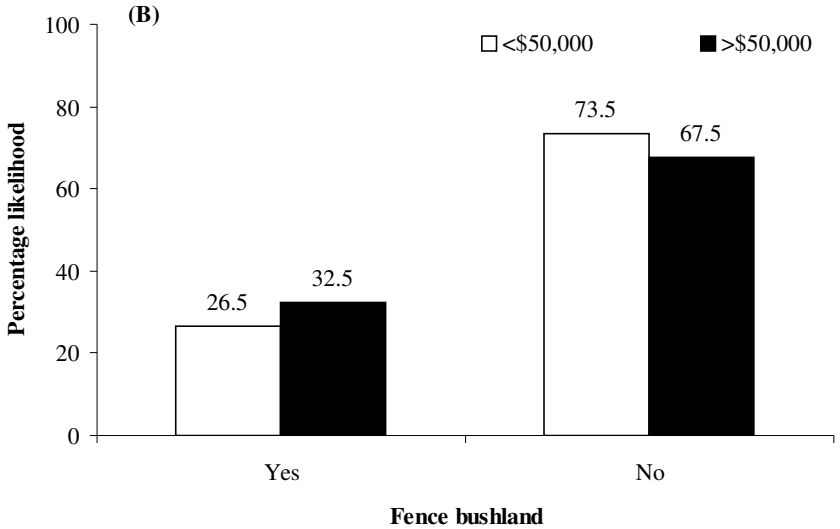
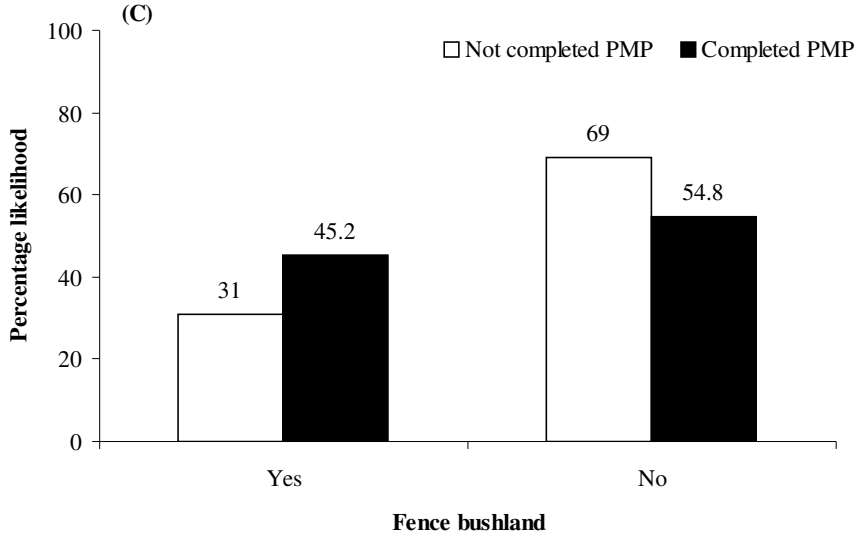
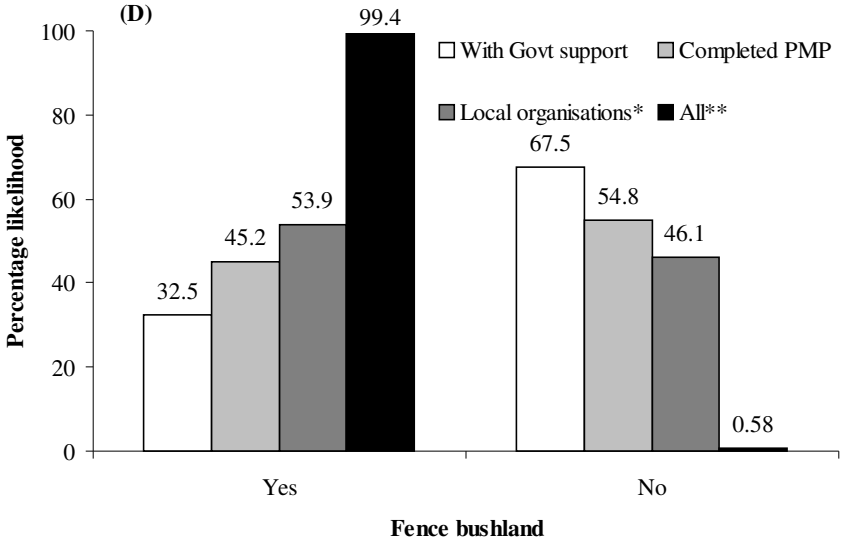
Adoption findings using EM Bn









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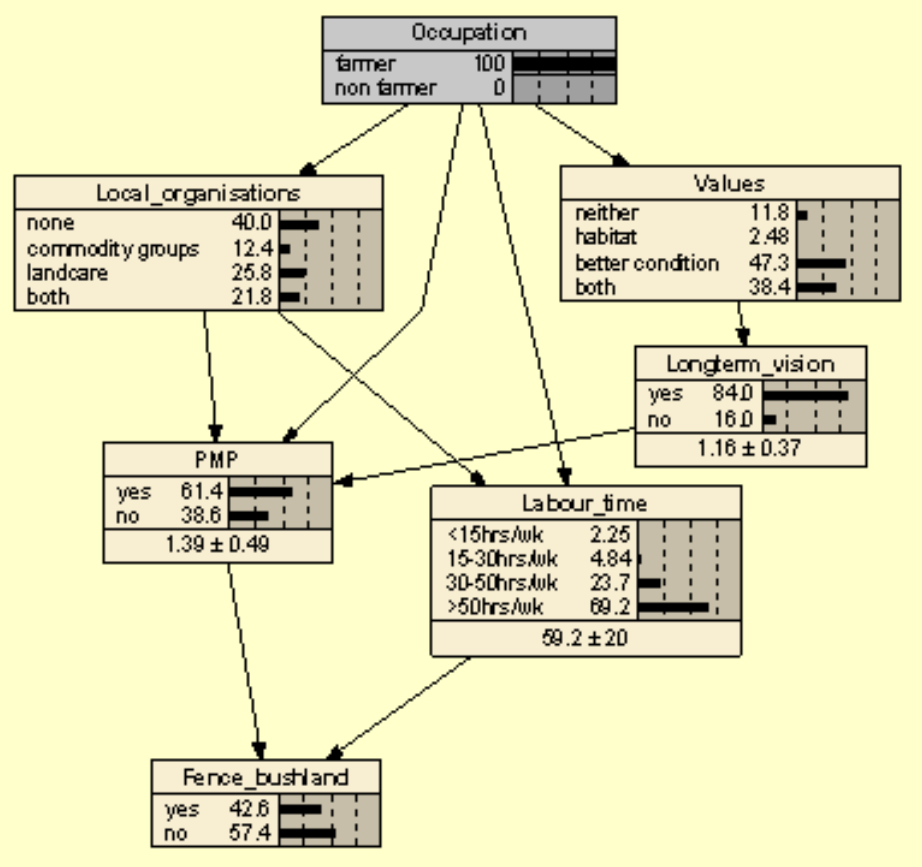
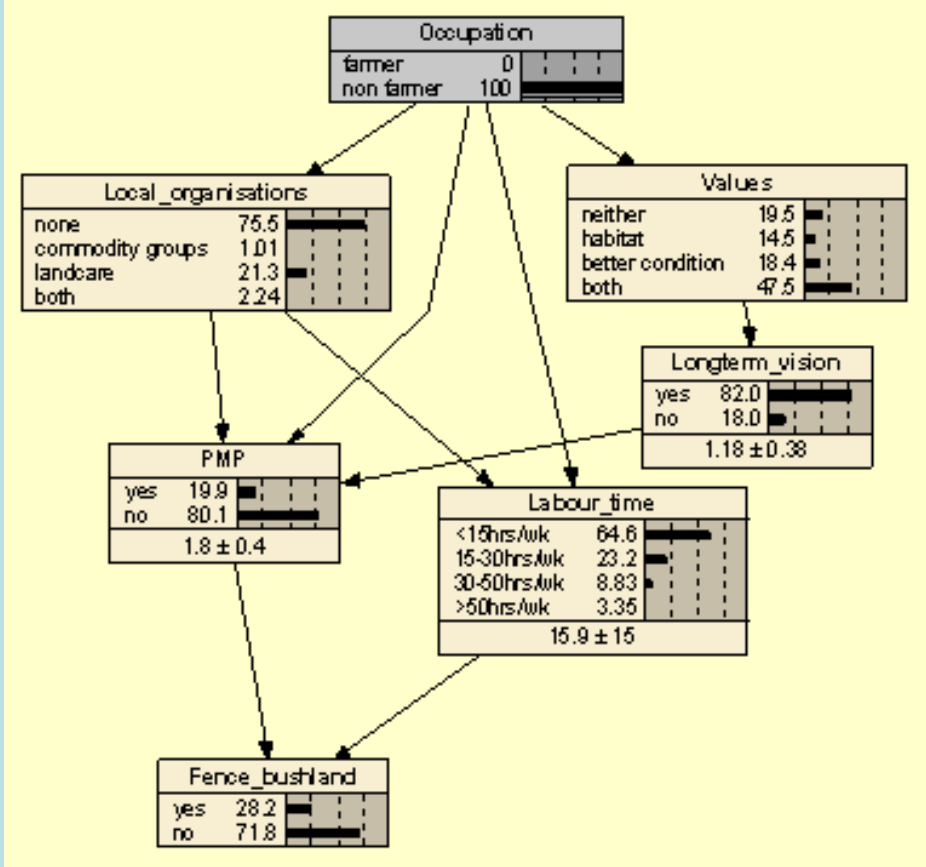
Occupation

Farmers



- 2.48% value bushland for habitat
- 60% belong to Landcare or commodity group
- 61.4% completed PMP course
- **42.6% fence bushland**

Non - Farmers



- 14.5% value bushland for habitat
- 24.5% belong to Landcare or commodity group
- 19.9% completed PMP course
- **28.2% fence bushland**

Summary

Key Findings:

- **Government support had most influence over fencing of bushland**
- **Compared to non-farmers, farmers were more likely to:**
  - belong to a Landcare or commodity group,
  - have completed a PMP course and
  - fence native bushland

Analysis comparison:

- **Pre-existing analysis of the survey data facilitated BN development**
- **Expert opinion is very important for the development and refinement of the Bn structure, and to interpret the results**

- **Compared to the conventional analysis the BN approach:**
  - is more explicit and open to scrutiny
  - easier to communicate to stakeholders
  - was useful to explore causality

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