U.S. Department of the Interior
U.S. Geological Survey

Bayesian network models as a framework for forecasting wildlife response to GCC

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Initial thoughts: *challenges ahead*

- We'd like to incorporate both empirical & experiential info
  field data **expert knowledge**
- Graphical framework whose **transparency** allows dev't & evaluation by many user groups
- Causal relationships among variables may articulate **mechanisms**
- **Uncertainty** inherent in ecosystems leads to use of **probabilities**
- We'd like to know what factors model is most **sensitive** to

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What to monitor… & what it tells us

- Conservation practitioners have wrestled with the question of what to track, given limited funds

  - Umbrellas
  - Flagships

  - Keystones

  - Key envir. correlates, Key ecological F(x)s (ICBEMP)
  - Focal spp. (Lambeck 1999)

  - Indicator spp.
  - Guilds
  - Rare vs. common spp. (Scott et al. 1995)

Unfortunately, there simply are no silver bullets…

Bayesian network models: *Basics*

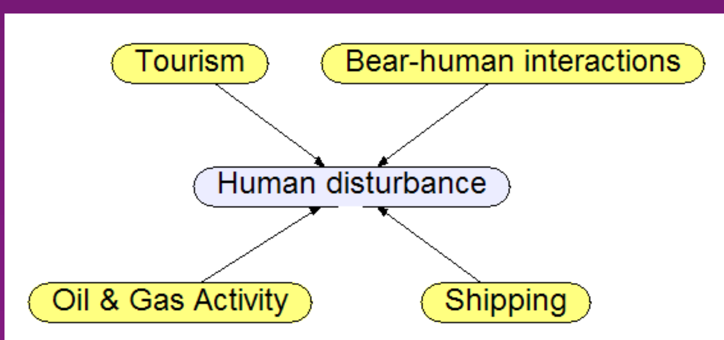
- Relate to *prior* and *posterior* probabilities

- Rely on Bayes' theorem
  - $$P(\mathrm{S} \mid \mathrm{H}) = \frac{P(\mathrm{H} \mid \mathrm{S}) * P(\mathrm{S})}{P(\mathrm{H})}$$

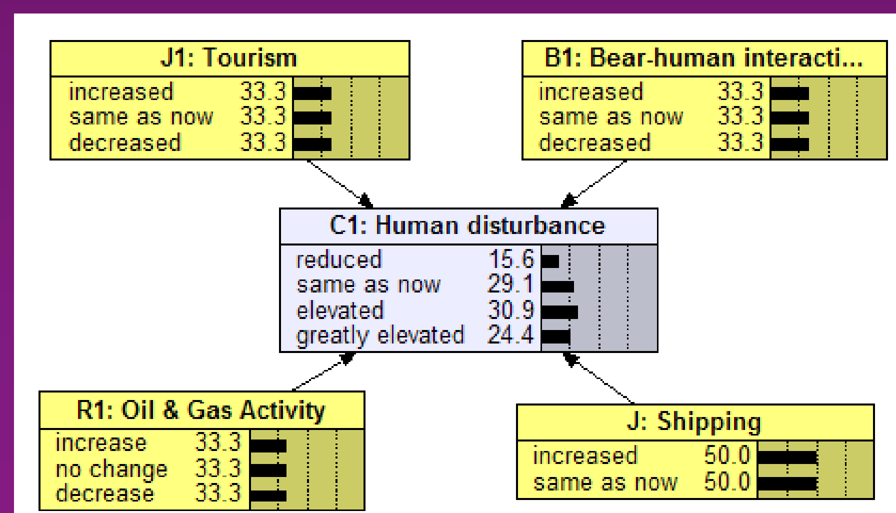
S = species abundance, presence
H = habitat conditions

- **Explicitly show probabilities of each state in each node**

Influence diagram (graphical)



With probabilities (quantitative)



Bayesian network models: *Strengths*

- **Allow combining of data of differing quality, level of certainty**

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- **Can use informed (hypothesis- or data-driven), or uninformed (equal prob) prior probabilities**

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'in'

'out'

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- Others ?

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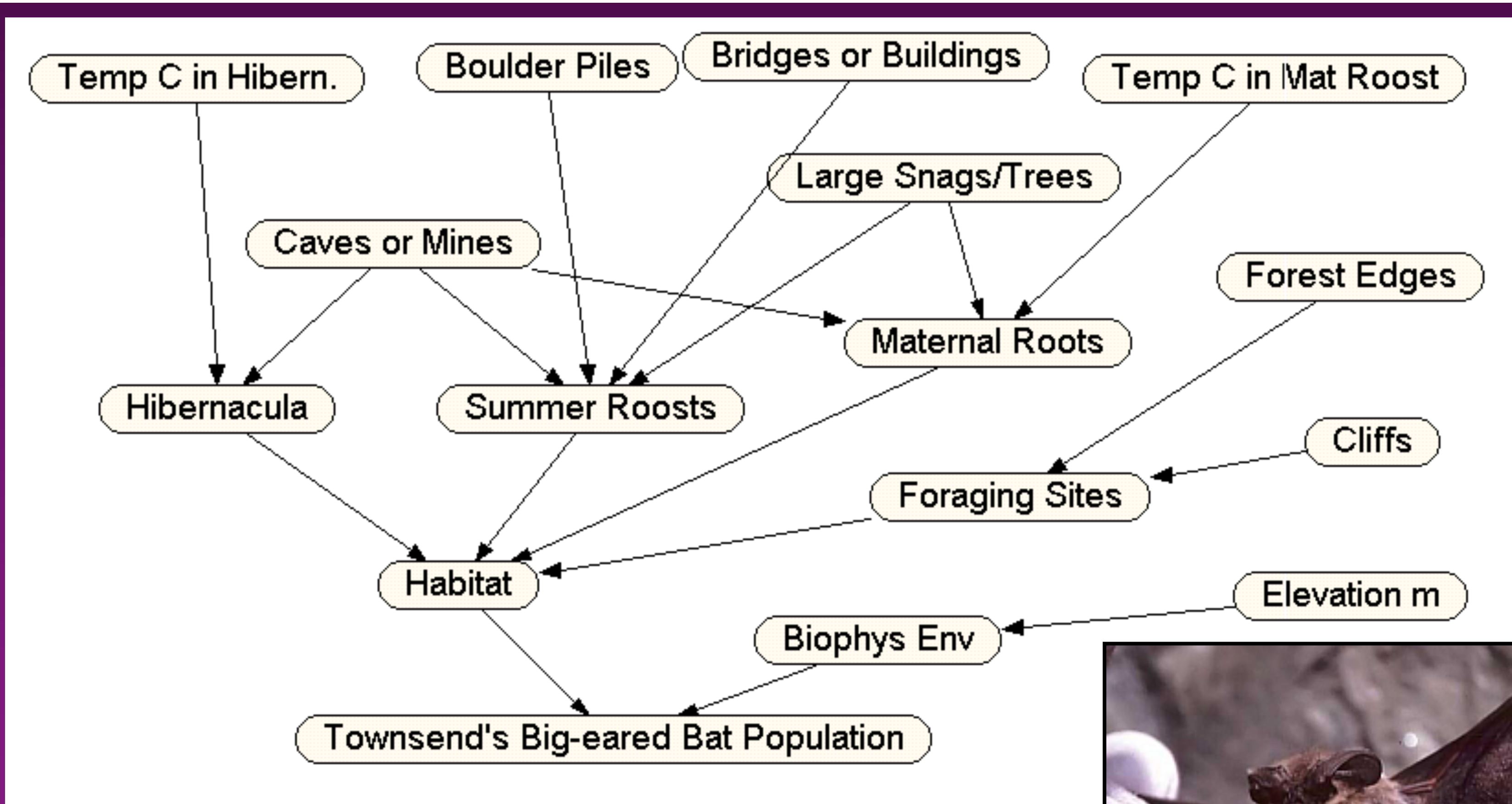
Relationship to conceptual models

- **CMs directly convertible to Bayes networks; allow Id. of testable hypotheses**

Conceptual model (=influence diagram)



Source: Marcot, B. G., et al. 2001. Forest Ecology and Mgmt 153(1-3):29-42.

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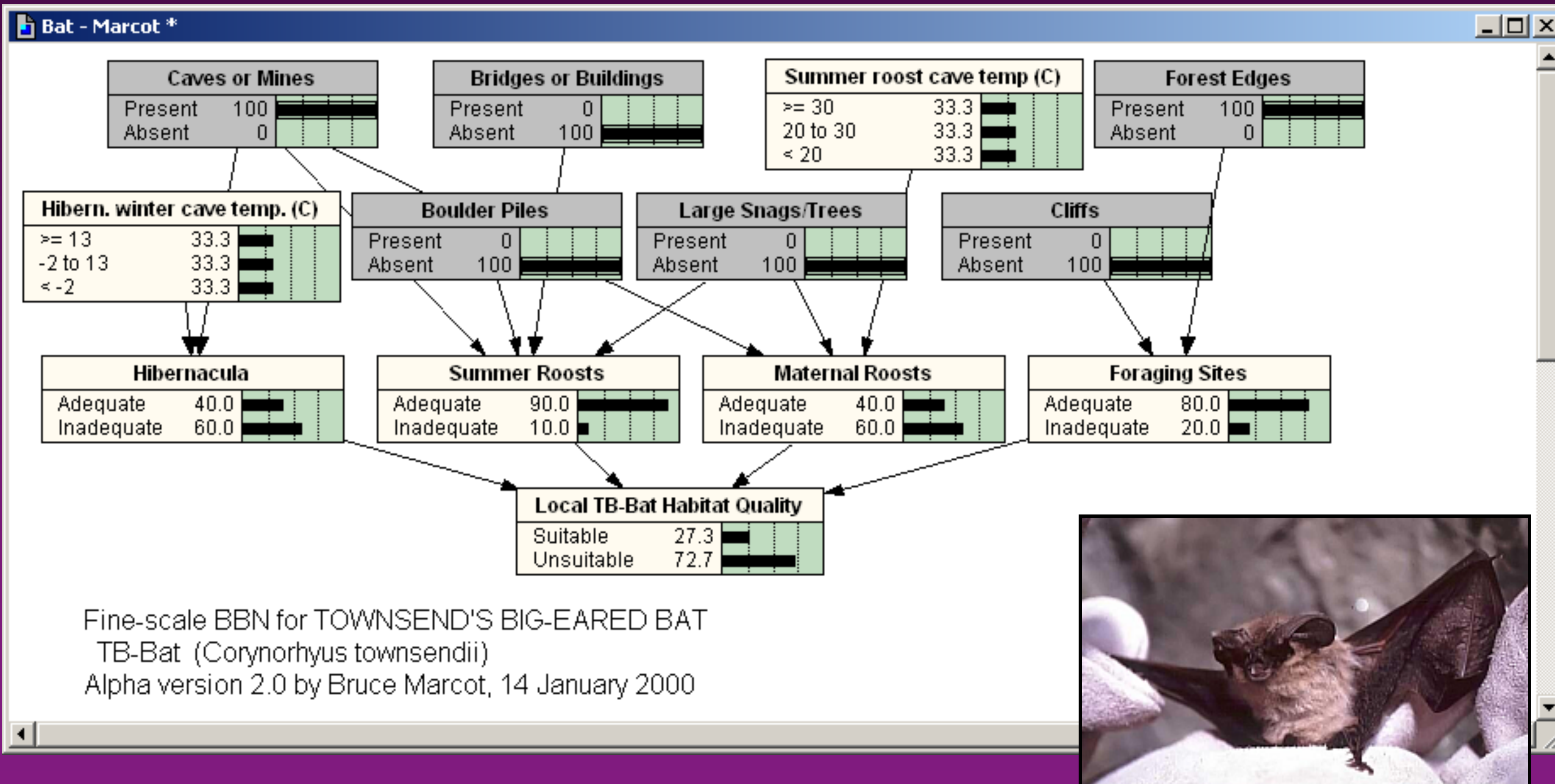
Relationship to conceptual models

Bayesian Network Model



Programs for creating conceptual models

- PowerPoint
- Mindjet MindManager Pro
- Inspiration
- Personal Brain
- Netica
- cMap *
- FreeMind *

* = freeware

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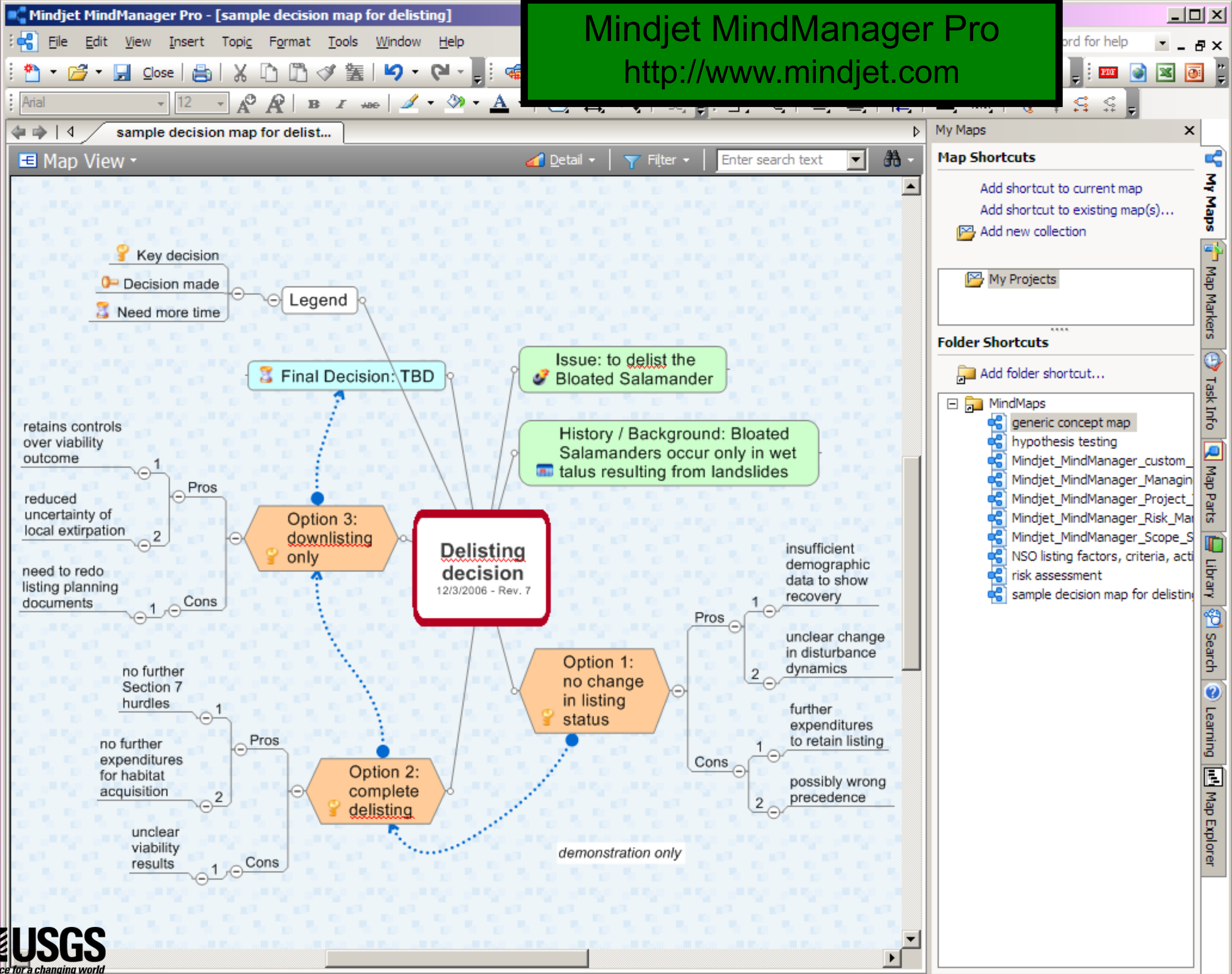
Mindjet MindManager Pro
http://www.mindjet.com



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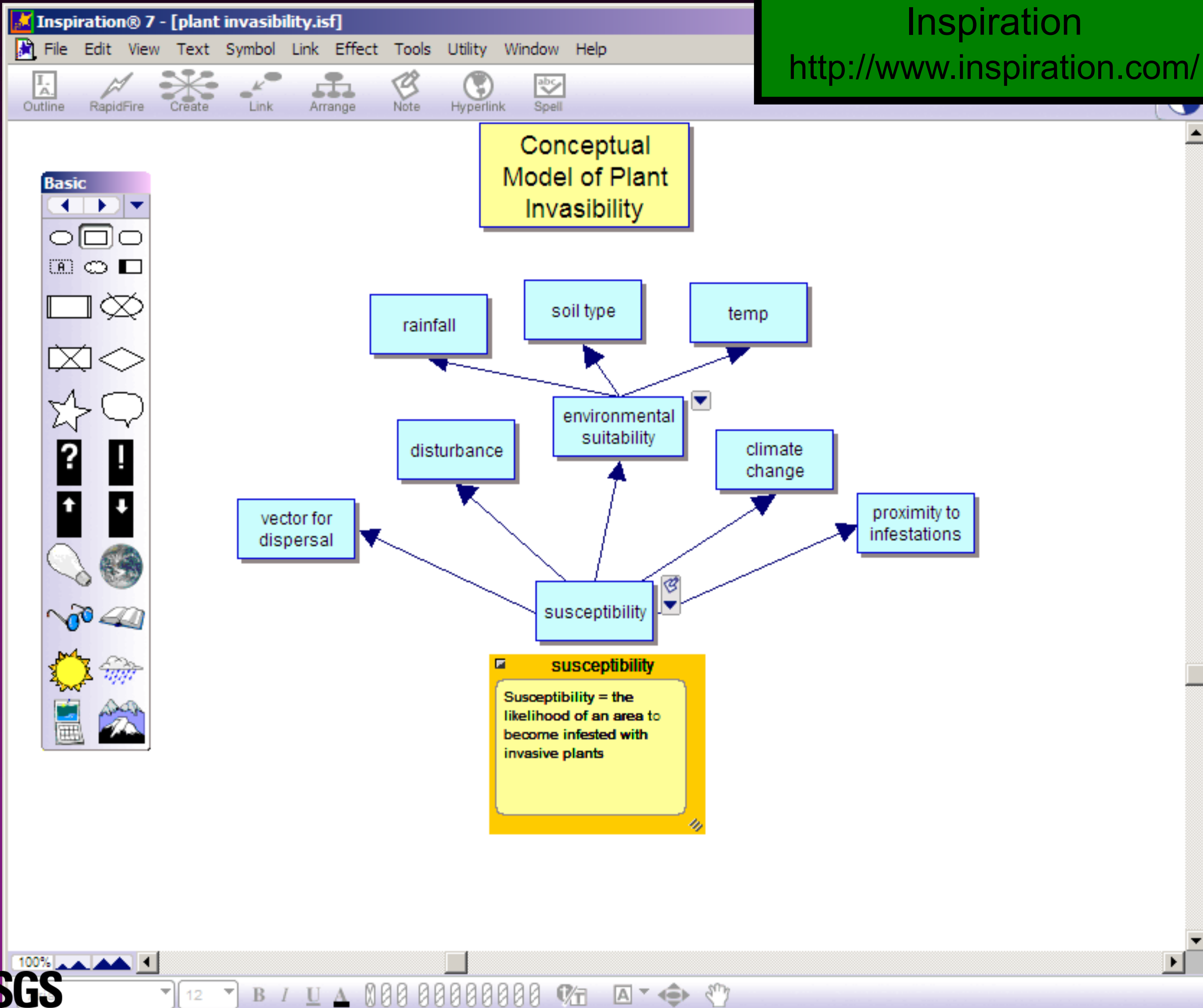
Inspiration
http://www.inspiration.com/



Bayesian Network model: *stressors on polar bear pop's*

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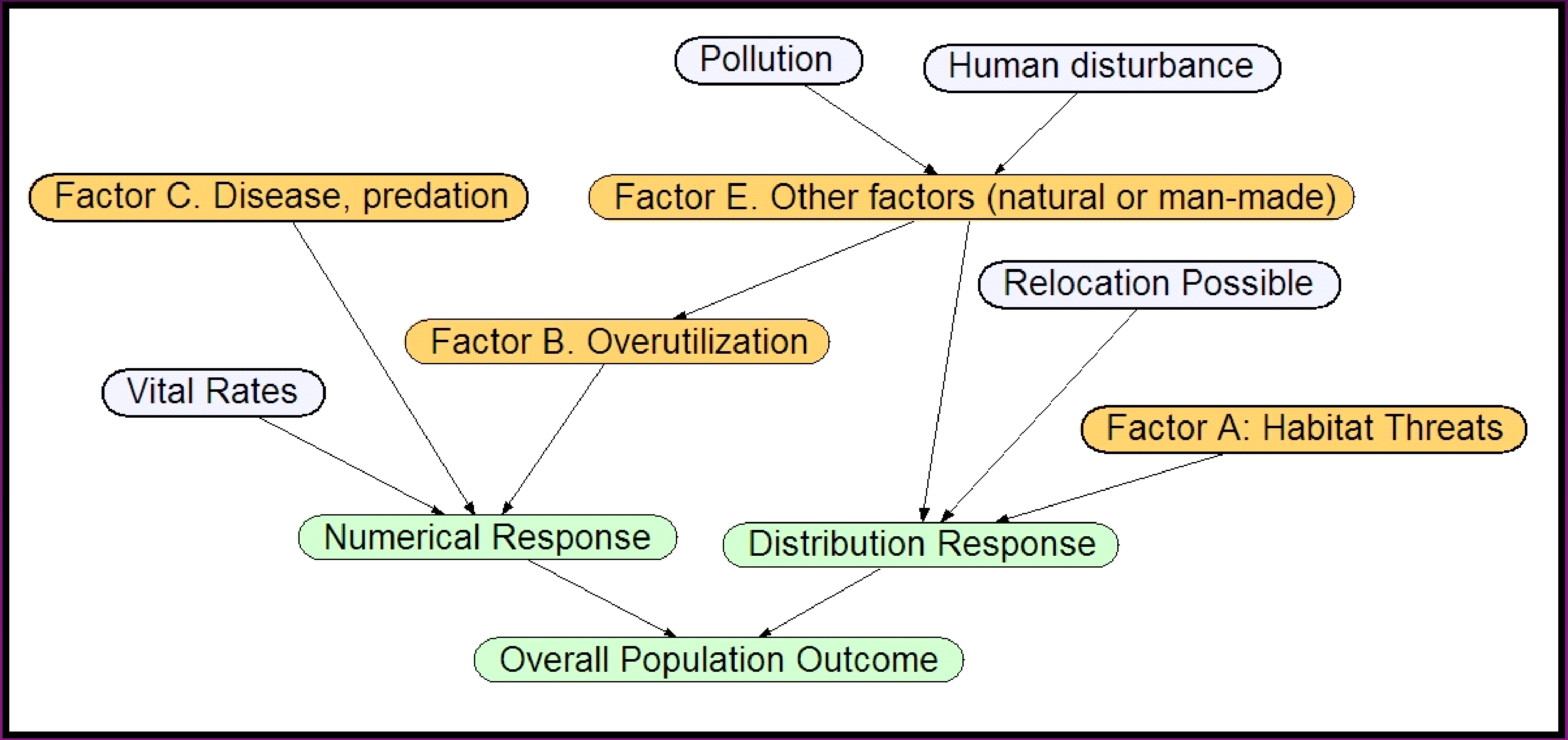

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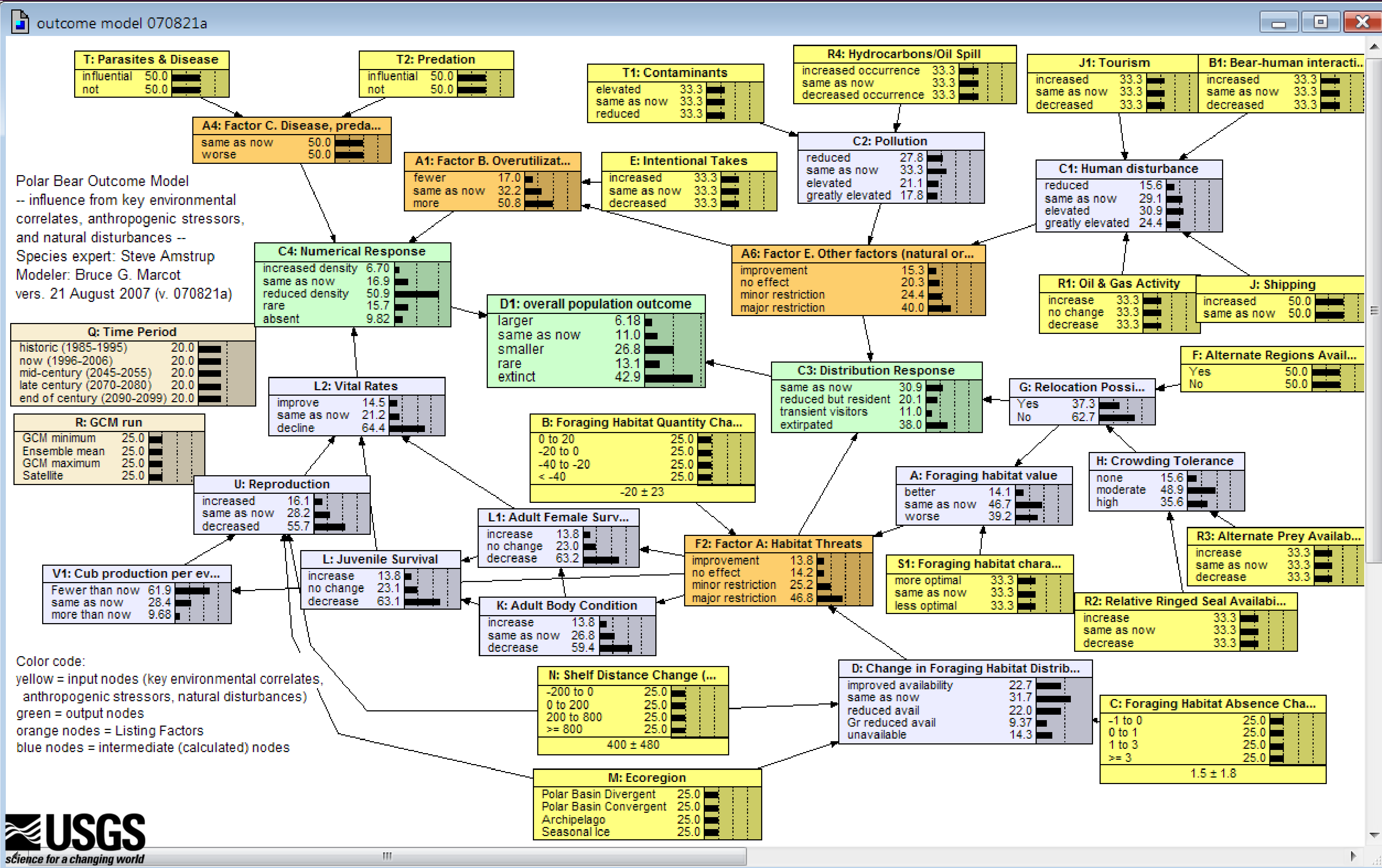

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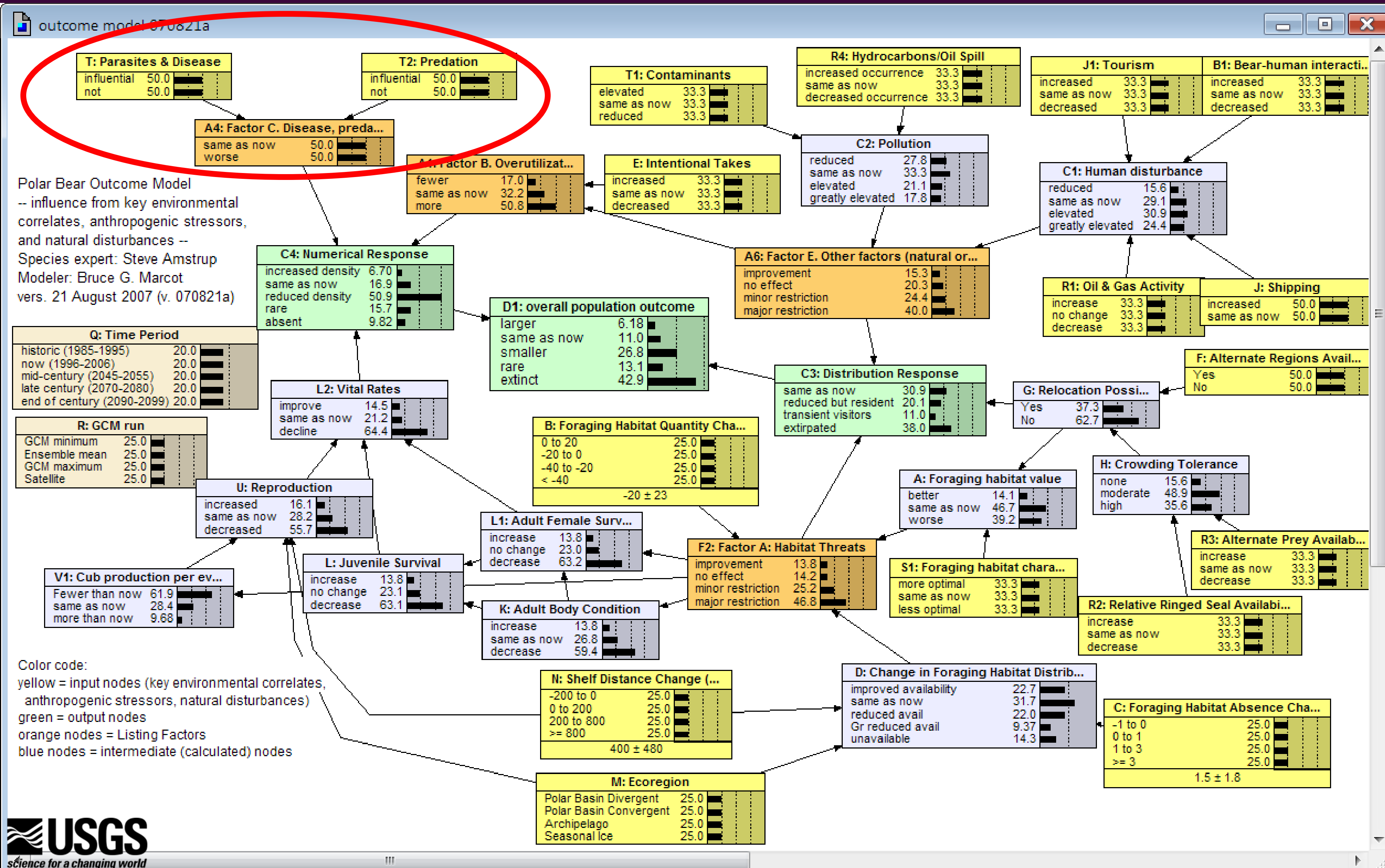
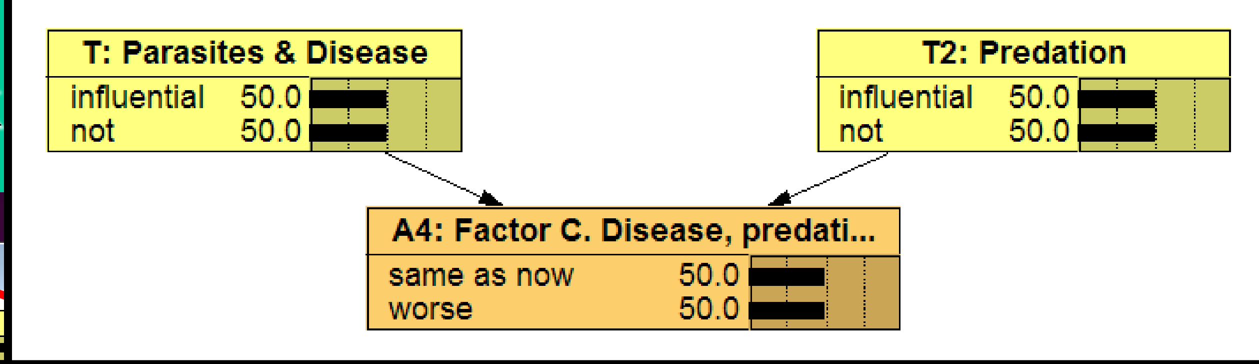
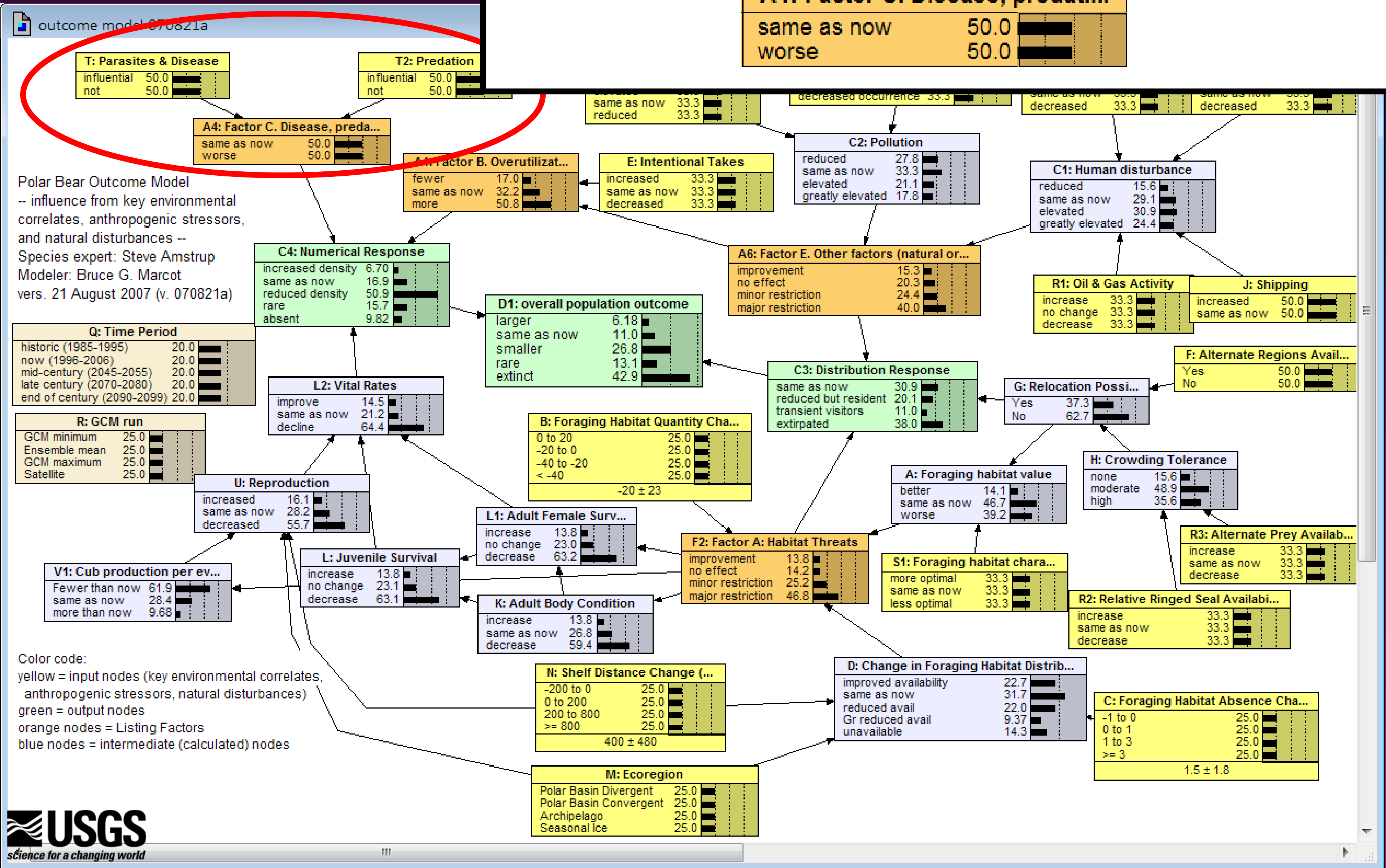


Bayesian Network





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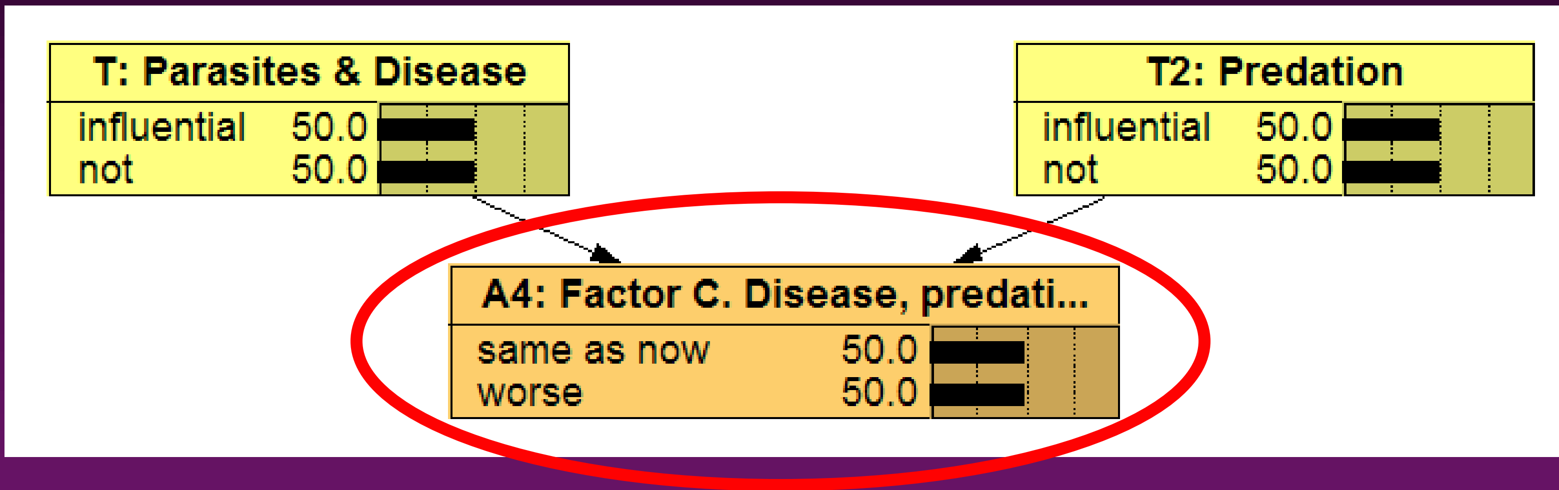
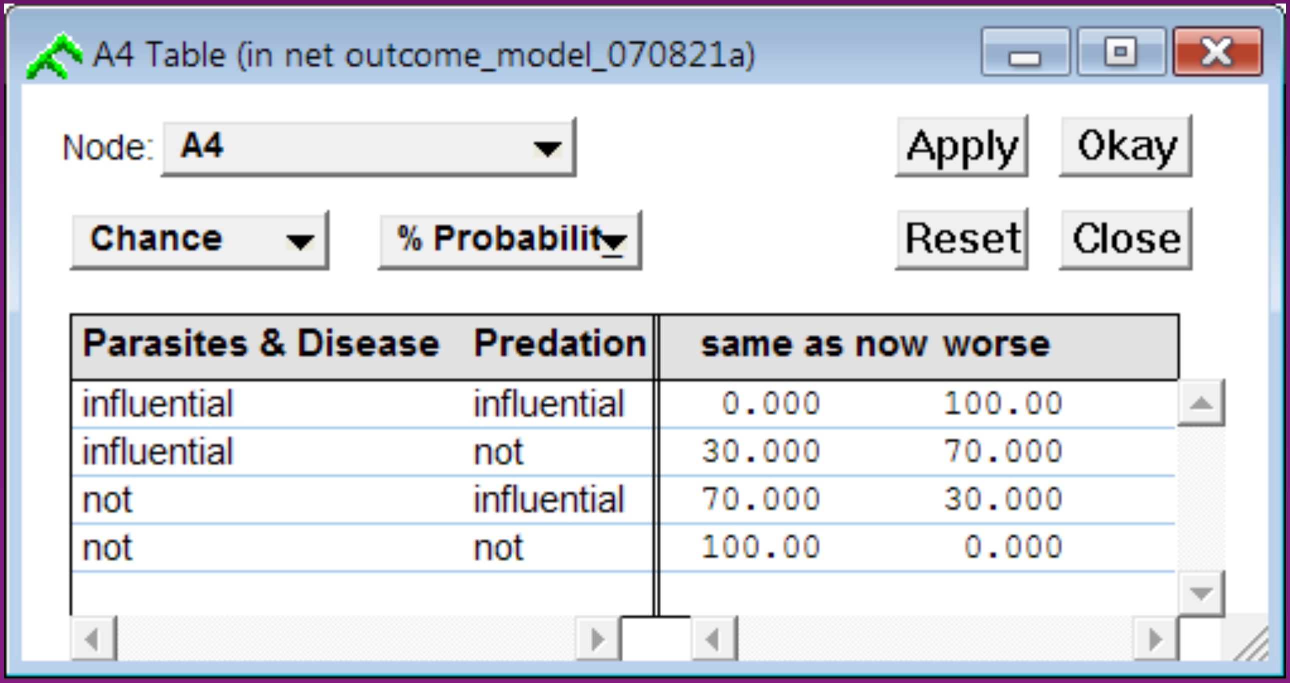


Conditional-probability table



Parasites & Disease	Predation	same as now	worse
influential	influential	0.000	100.00
influential	not	30.000	70.000
not	influential	70.000	30.000
not	not	100.00	0.000

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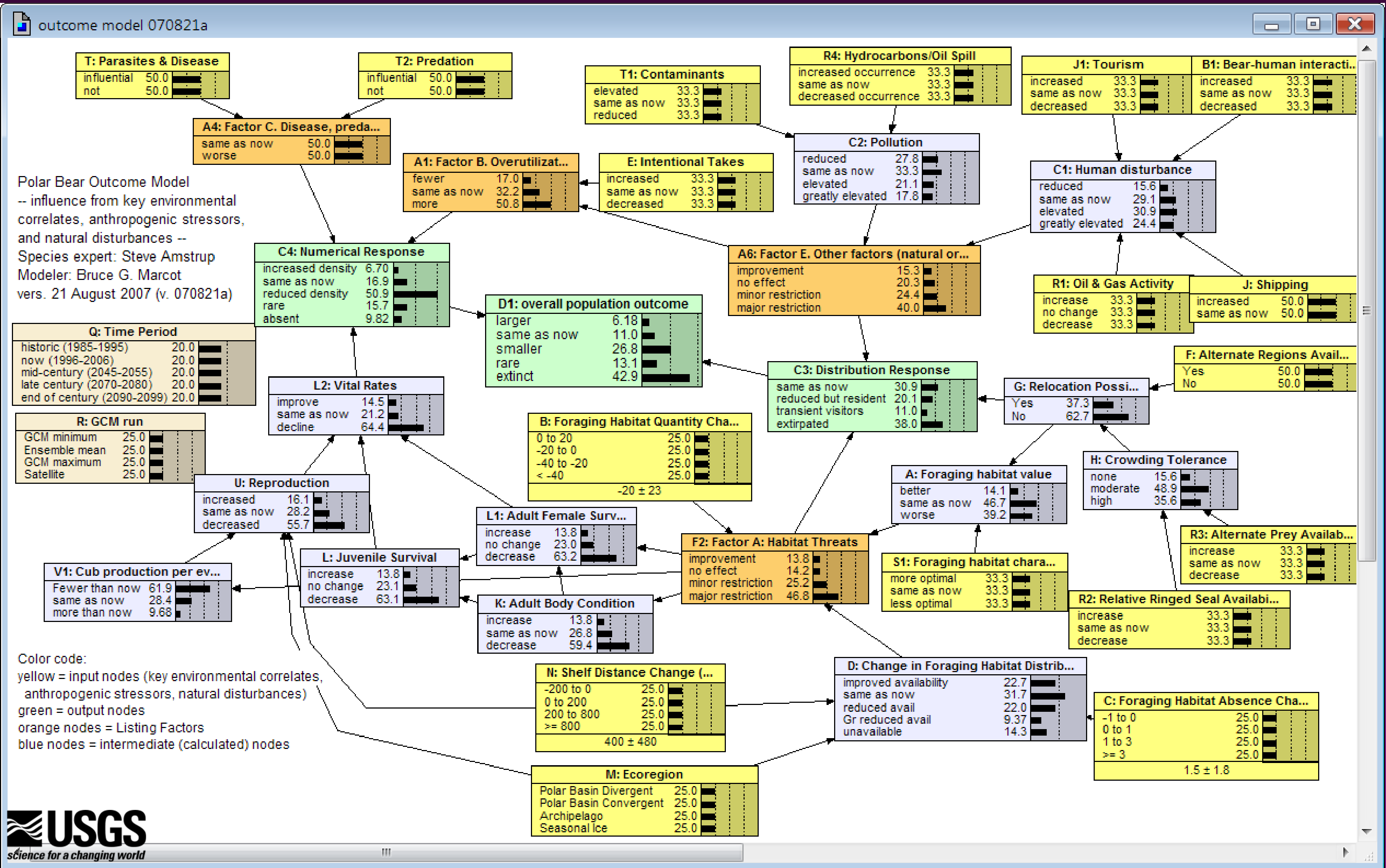

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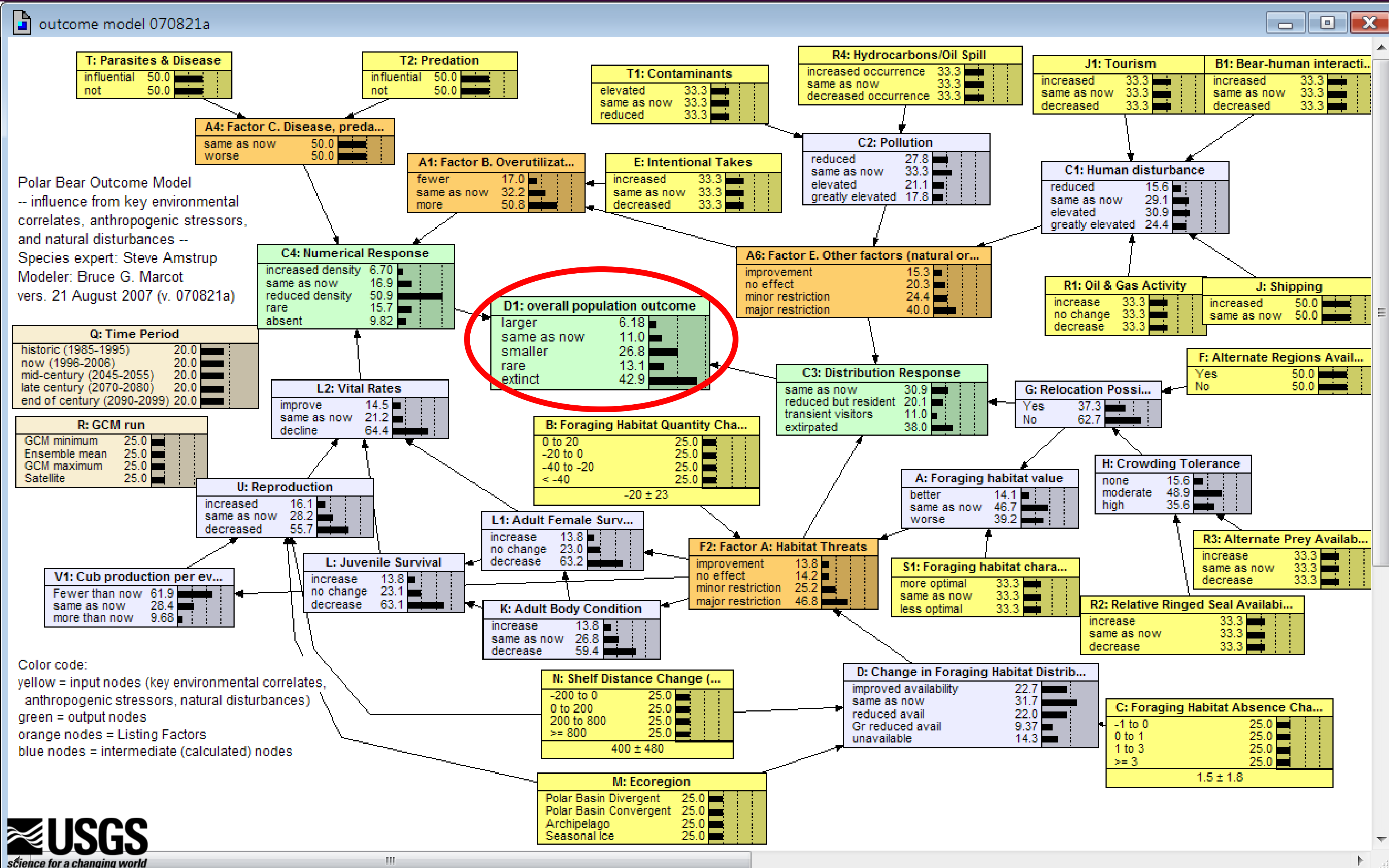

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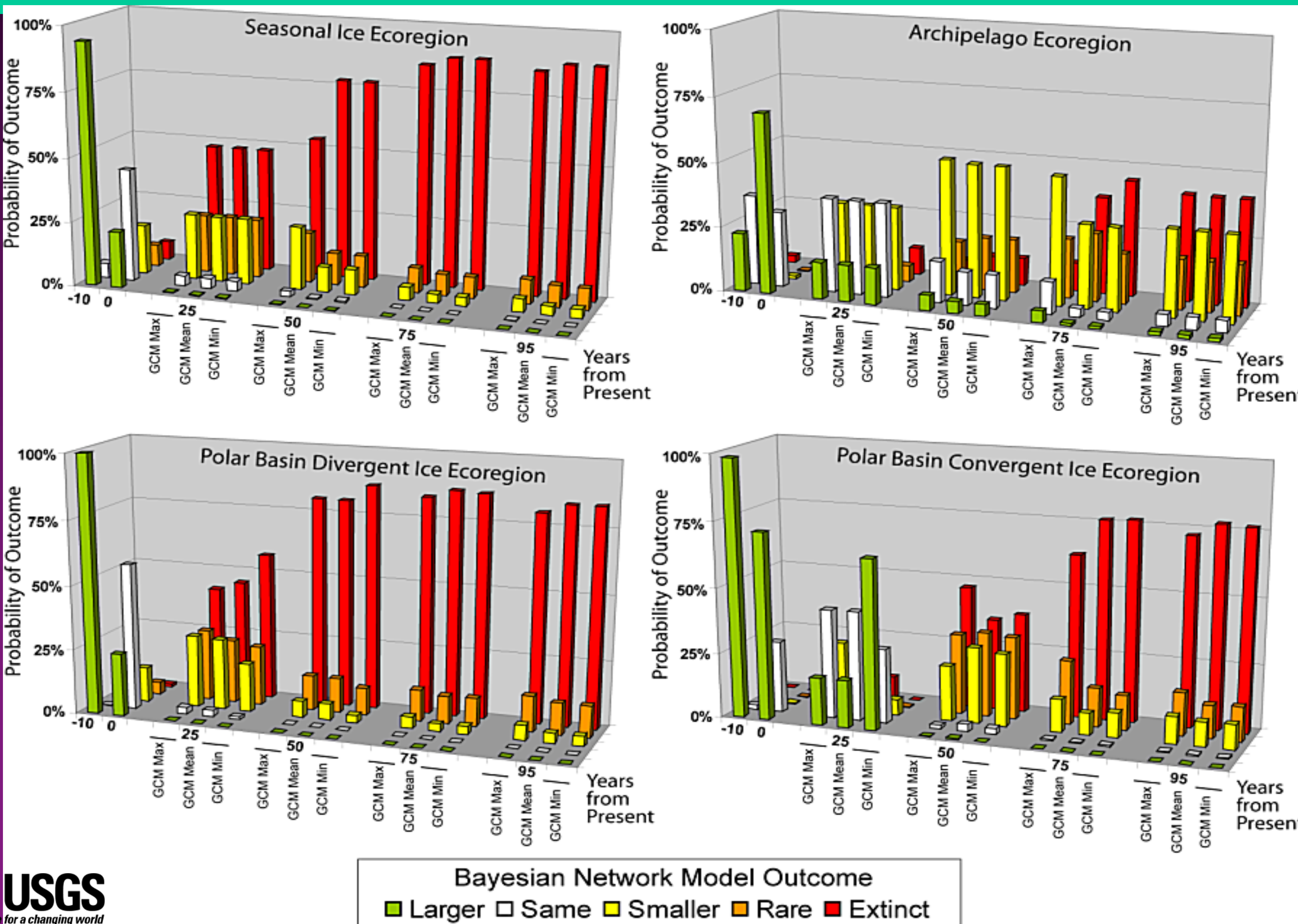

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Some of the devil(s) …

- Complicated dynamics modeled tractably with sub-models
  - Coherency across spp., regions ??
- Spatially-explicit change requires more-intensive modeling effort, but the two can be linked by transition probabilities
- How do we handle the different dynamics of pulse *vs*. press disturbances? unknown trajectories of dev't? feedbacks, non-linear synergies, threshold dynamics, emergent properties?
- Varying resolutions of constituent data may mean reverting to coarsest scale among data sources
- **Indep. of BBNs**: The degree to which spp. are obligately tied to any available habitat variable differs, among spp.

Decision-support models: *useful model attributes*

- probability-based
- can still provide results when missing data
- provides for sensitivity testing
- provides management hypothesis (adaptive management)
- incorporates new data to update model functions, probabilities, structure
- allows rapid prototyping
- combines expert judgment w/ empirical data; multiple experts.

Take-home messages

- Work more like the human brain, compared to null-hypothesis testing
- Require specialized expertise, program(s) to build and refine (e.g., Netica, Amos?), but it’s possible to learn
- Provide a transparent means by which to probabilistically bound uncertainty

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