Basics of Belief Nets

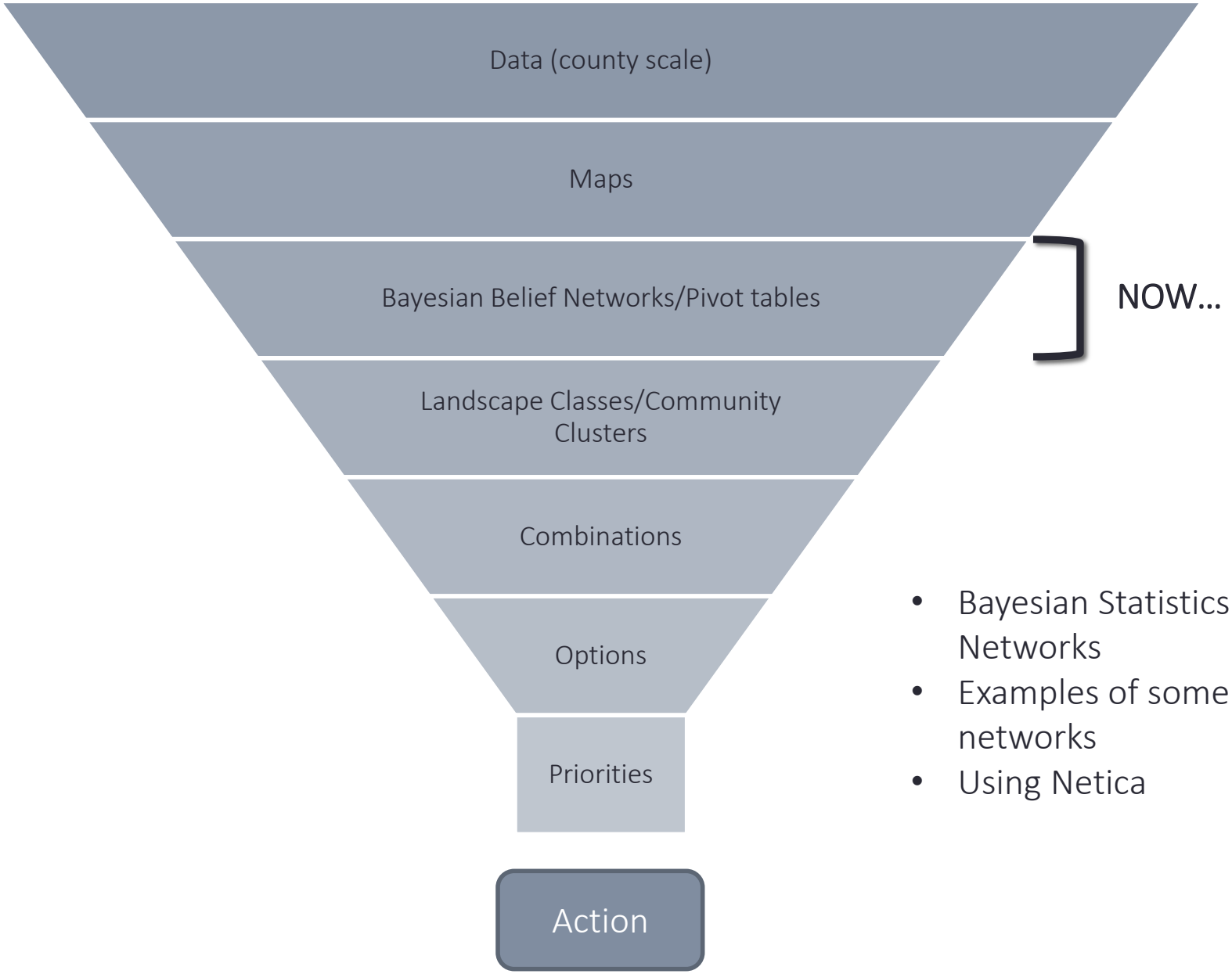
National Cohesive Wildland Fire Management Strategy

Science Analysis Report: Application to the Southeast Region

January, 2014

Agenda

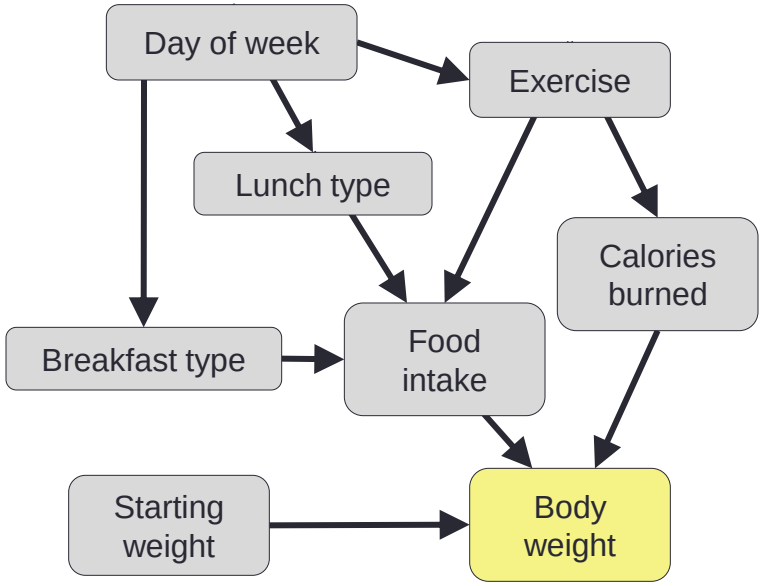
- Today:
  - The National Science Analysis
  - Preparing Data for Analysis
  - Application of Products
  - Basics of Belief Nets
- Tomorrow:
  - Exercise #1: Pivot Tables
  - Exercise #2: Naïve Networks
  - Exercise #3: Bayes Networks
  - Wrap-up



- Bayesian Statistics and Belief Networks
- Examples of some interesting networks
- Using Netica

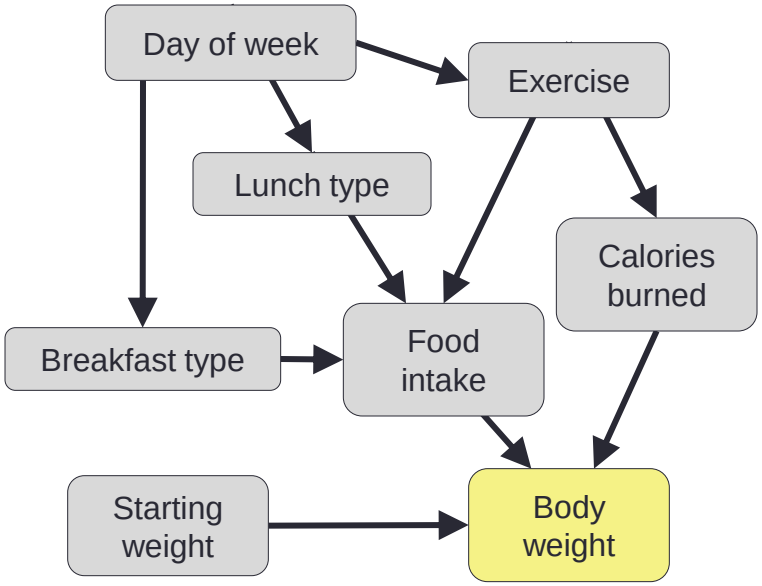
What are Bayesian models?

- A model that reflects the state of some part of the world and how they are related by probabilities.
- Examples: your house, or your car, your body, your community, an ecosystem, a stock-market, etc.



What are Bayesian models?

- States of the model represent all the possible worlds (or scenarios) that can exist
- Your body can be sick or healthy, you can exercise or not, you can eat well or eat junk food.
- Some states occur more frequently than others when other states are present.



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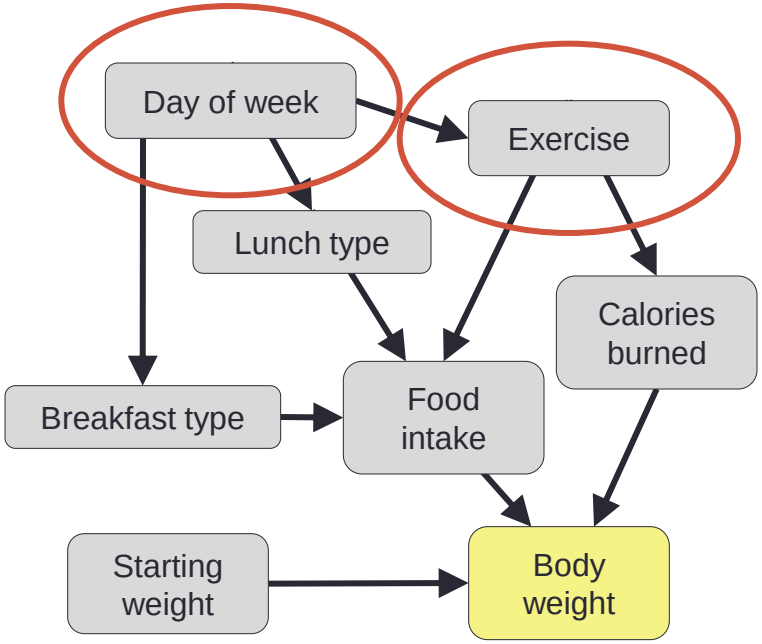
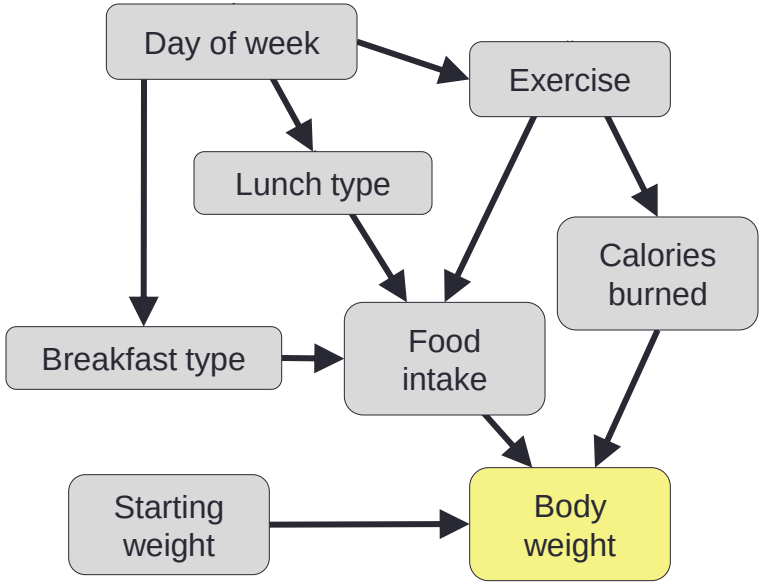
- **Some states occur more frequently than others when other states are present**.
- Monday = less exercise



What are Bayesian Statistics?

- A field of statistics that explores evidence about the "true" state of the world
- *Expressed in terms of probabilities or "degrees of belief"*



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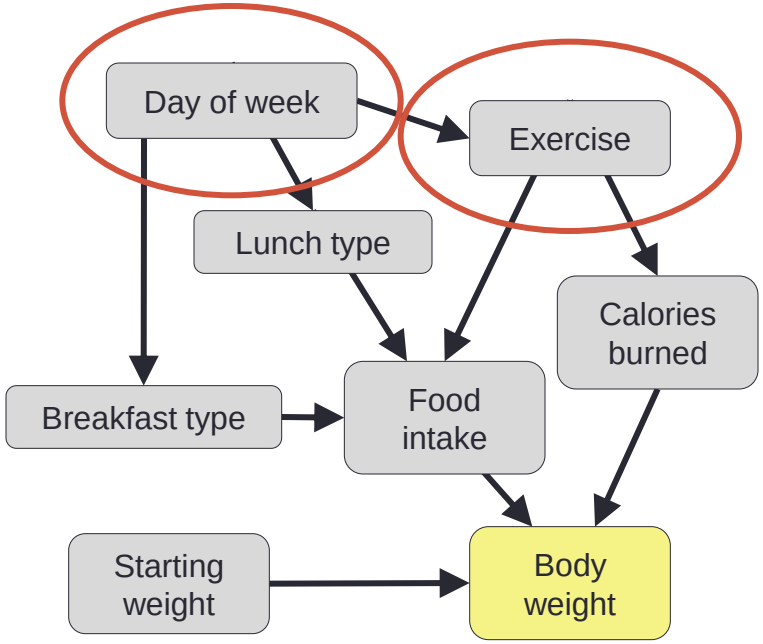

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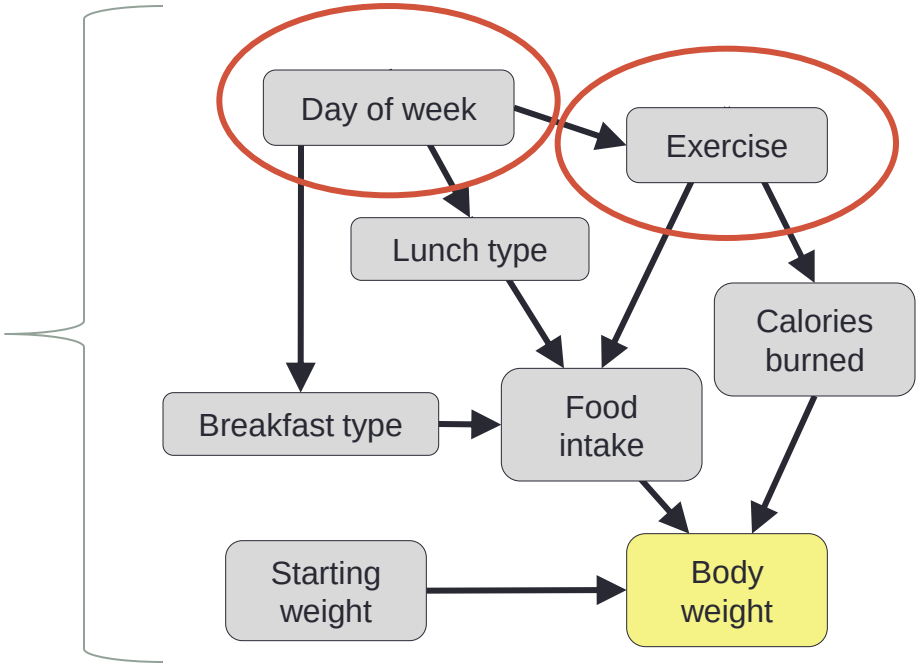
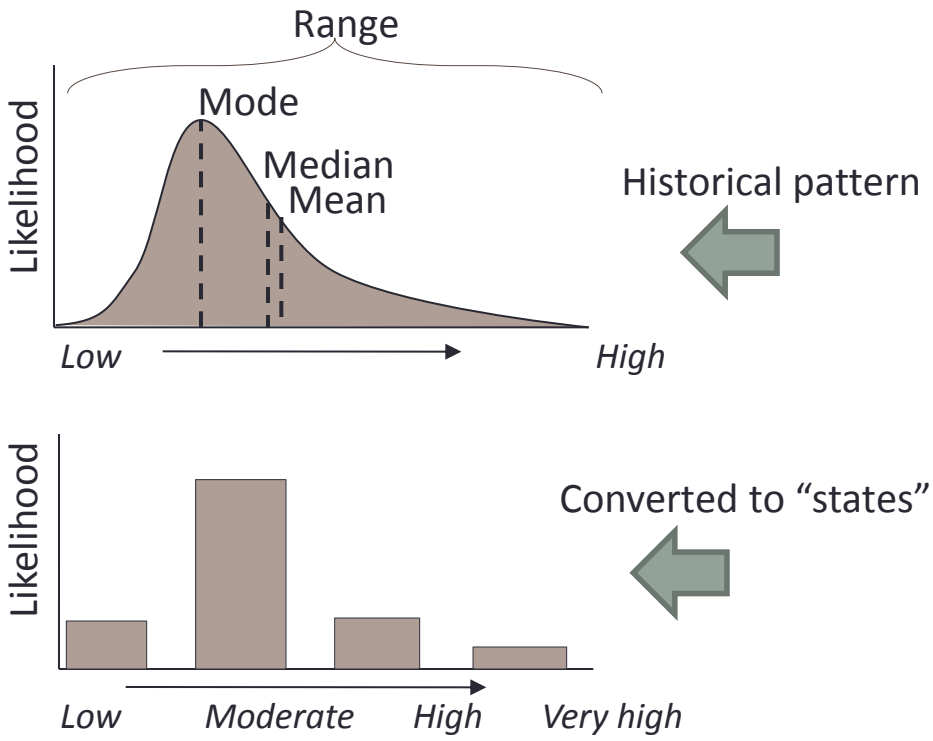
Expressed using conceptual models and arrows to indicate cause and effect linkages



How are probability models expressed?

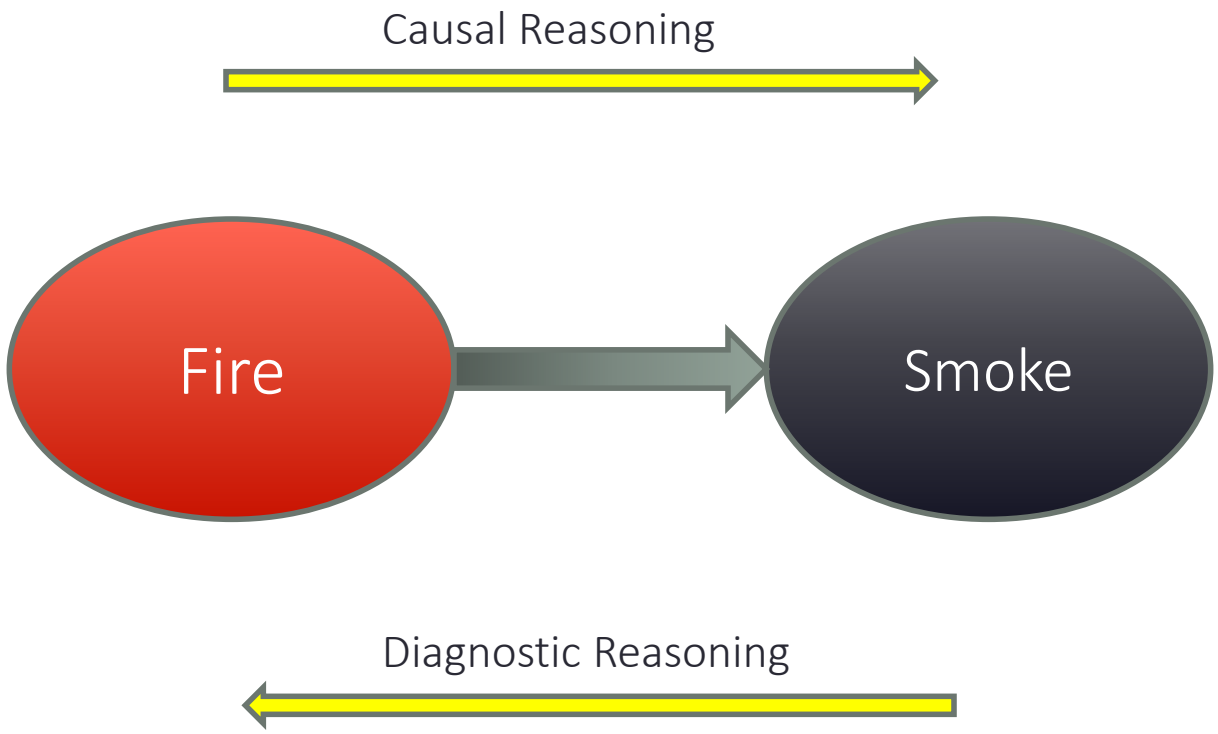
- Historical data provide a starting point of probabilities across a range of states or some gradient
- Considered as states, any portion of the distribution can be thought of and modeled as a scenario
- When there is no reliable data to start with, states can be assigned a uniform distribution.



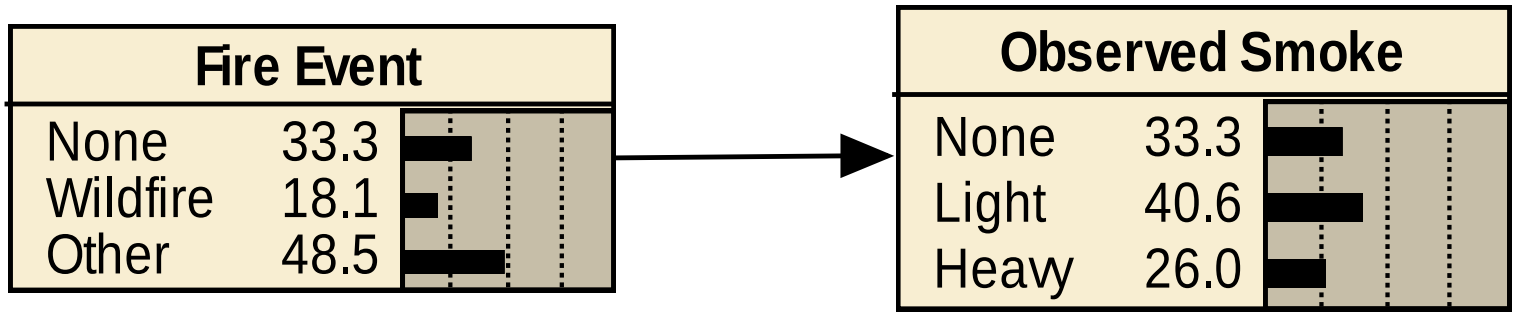
Historical Footnote

- Thomas Bayes (1701-1761). First articulated what is known as Bayes Theorem in a paper published after his death in 1762.
- What is the probability of "A" when a new piece of evidence about "B" appears?
- This is the basic concept behind Bayesian Statistics that started growing in the 1950's and have recently expanded with the advent of advanced computational methods and computers.
- In the 1980's and beyond, Judea Perl and other computer scientists adopted and expanded Bayes theorem to develop analytical models of cognitive reasoning, which gave rise to Bayesian networks.

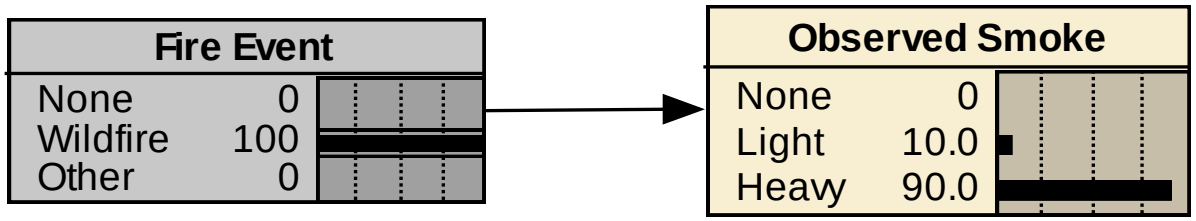
Basic concepts



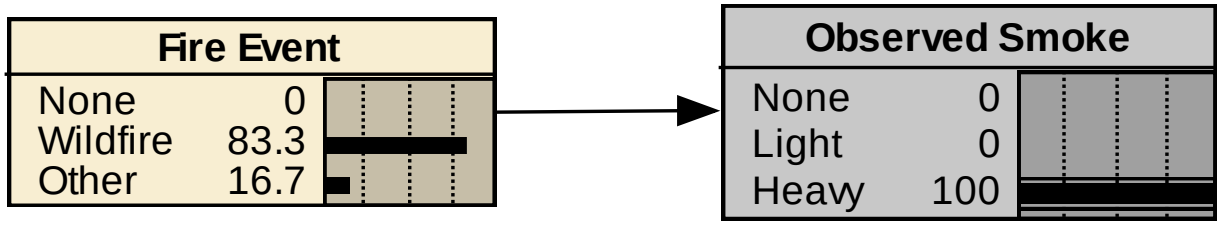
Add probability histograms and conditional linkages



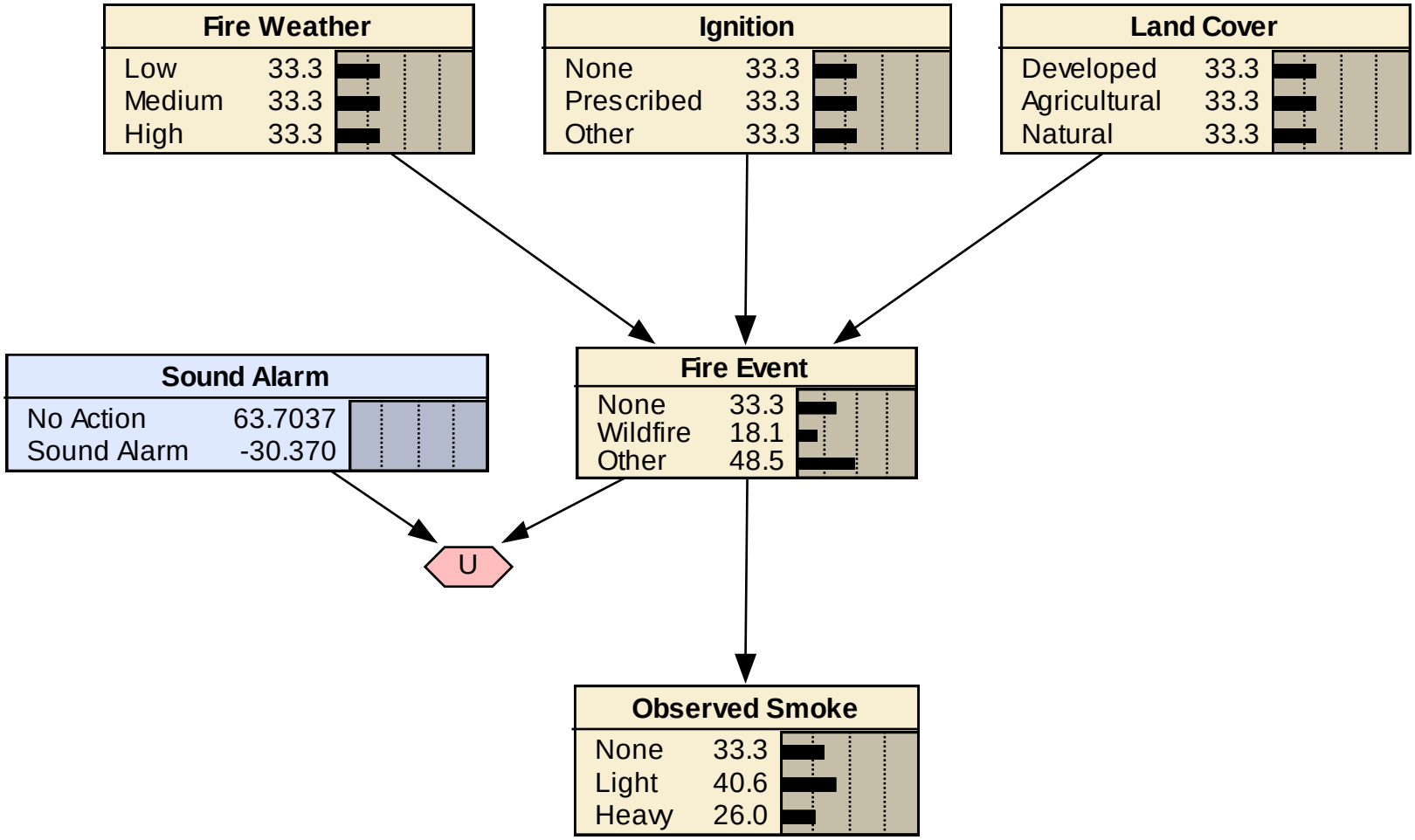
Causal Reasoning



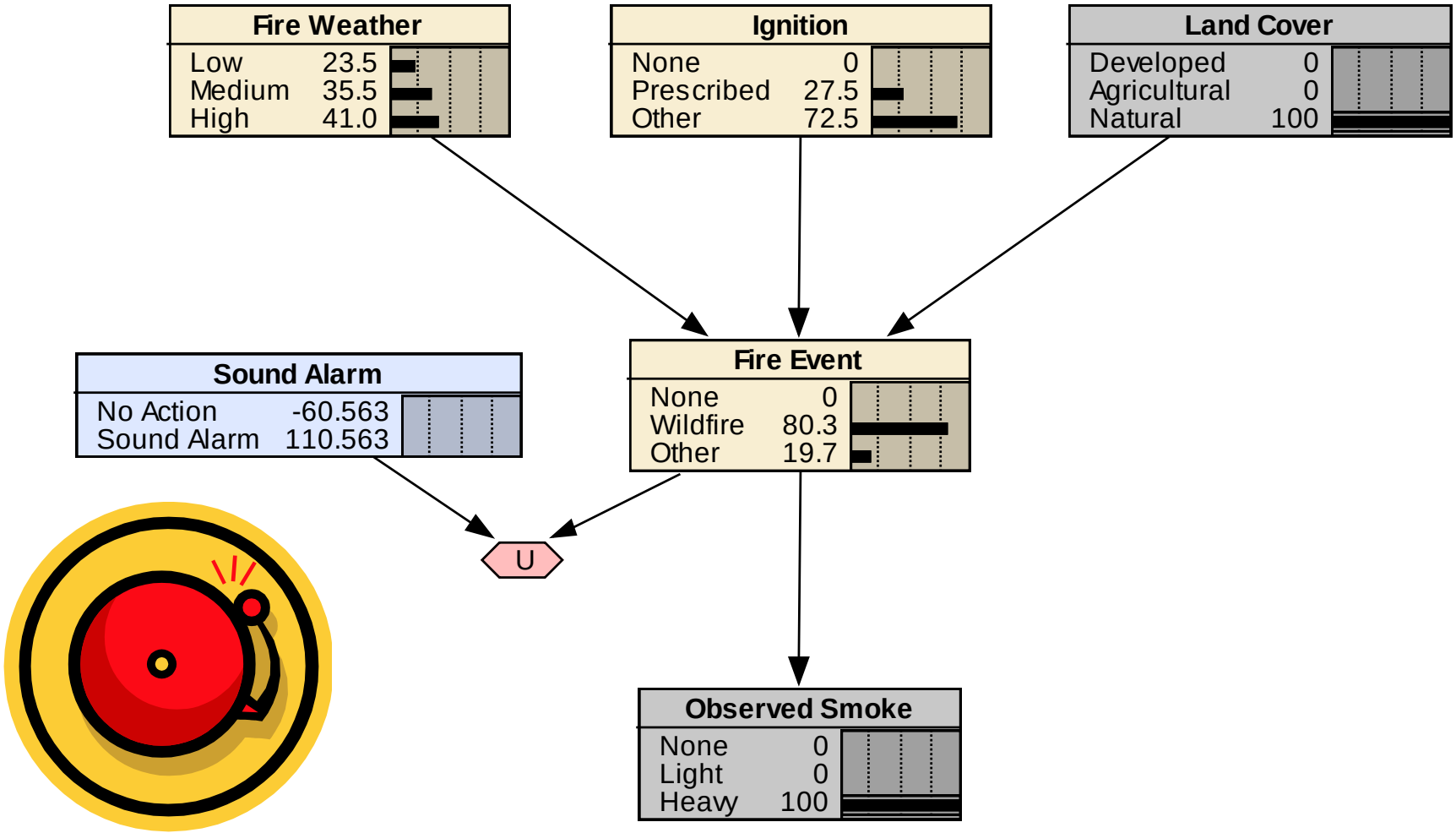
Diagnostic Reasoning



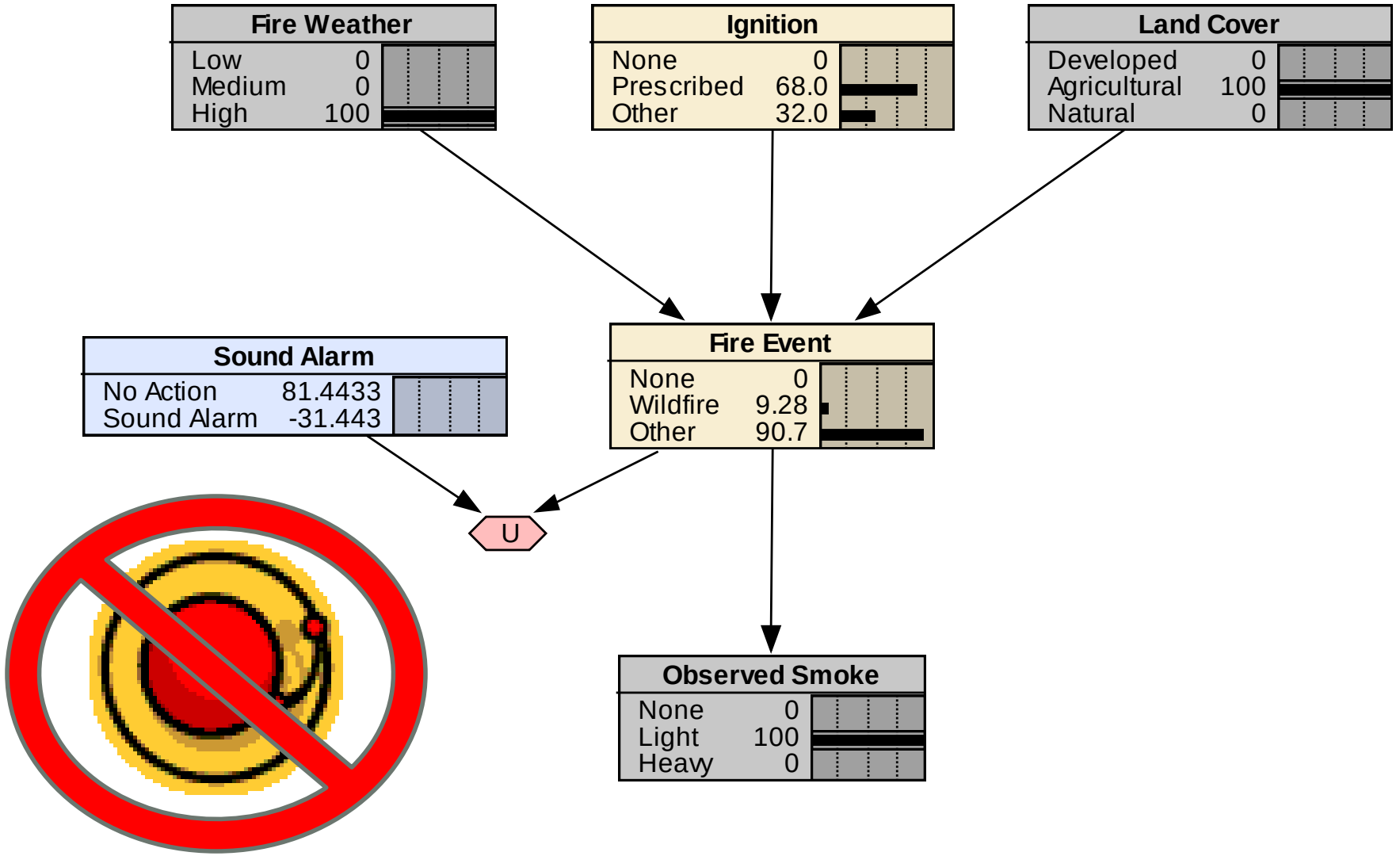
Add complexity for Fire Lookout



Example 1: heavy smoke in forest

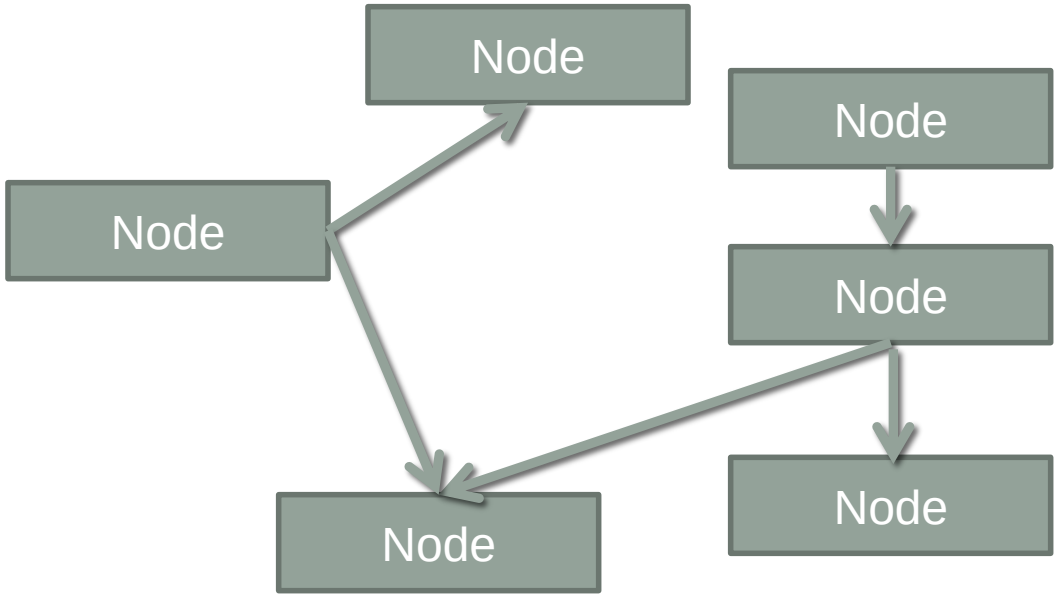


Example 2: Light smoke in croplands

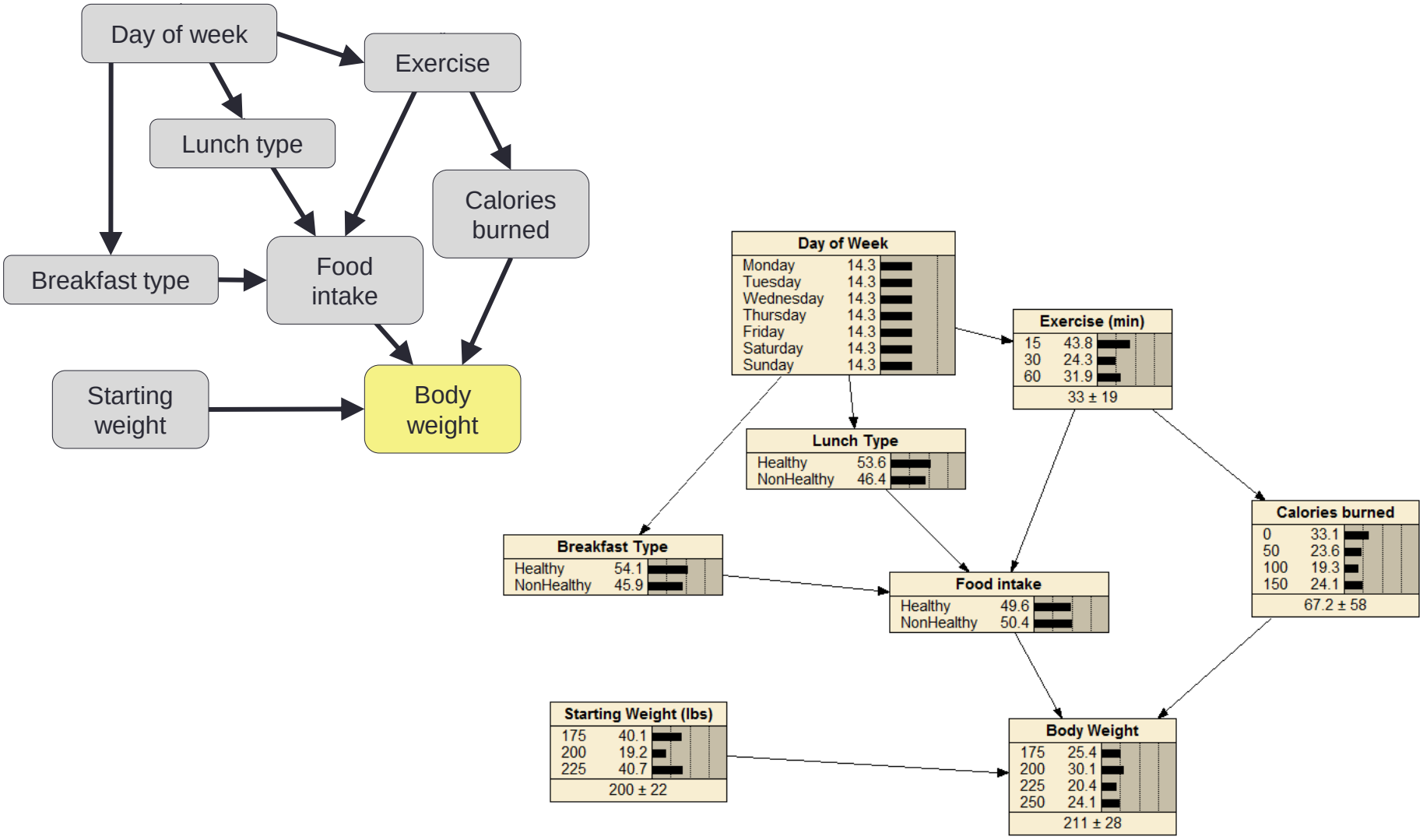


Bayes Network

- A type of structure for a network
- Assumes that nodes have conditional dependencies on each other that are shown in an acyclic graph. That is, the graph has no cycle or start point.
- There are cause and effect relationships among many nodes



Bayes Network: Body Weight



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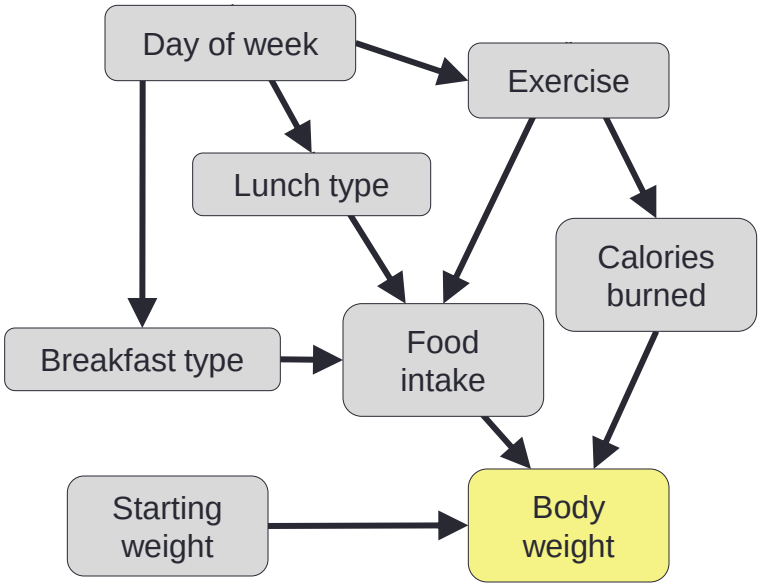
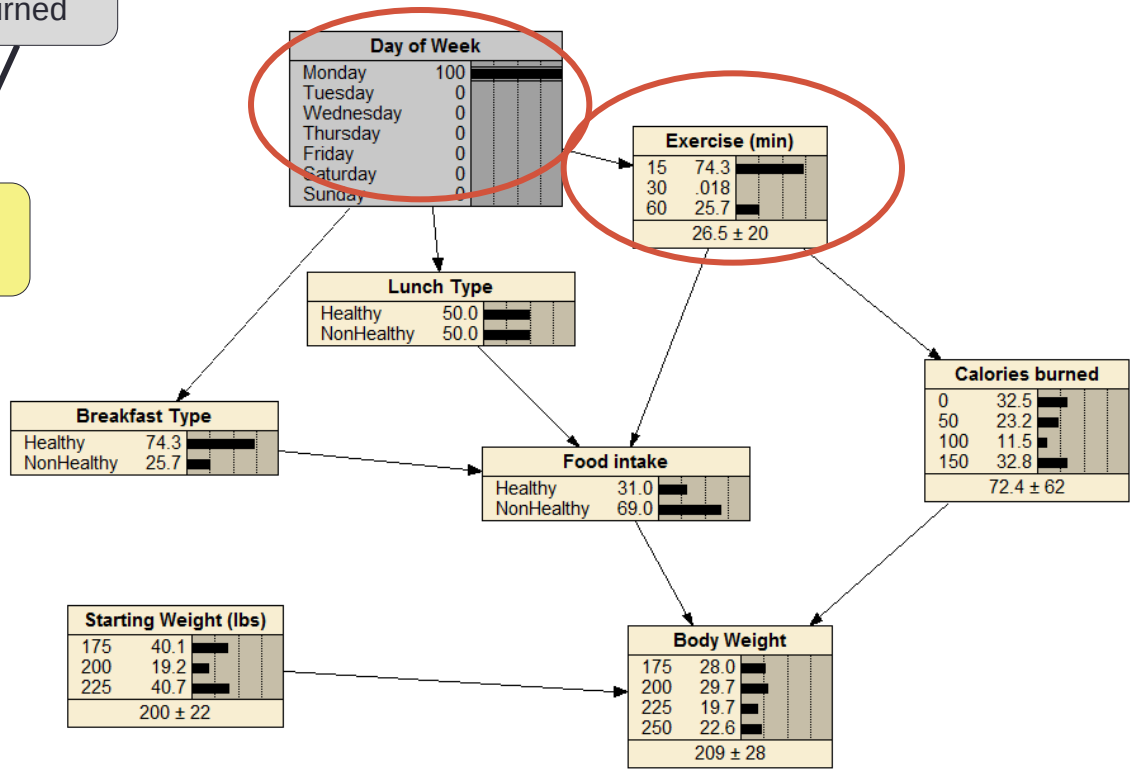
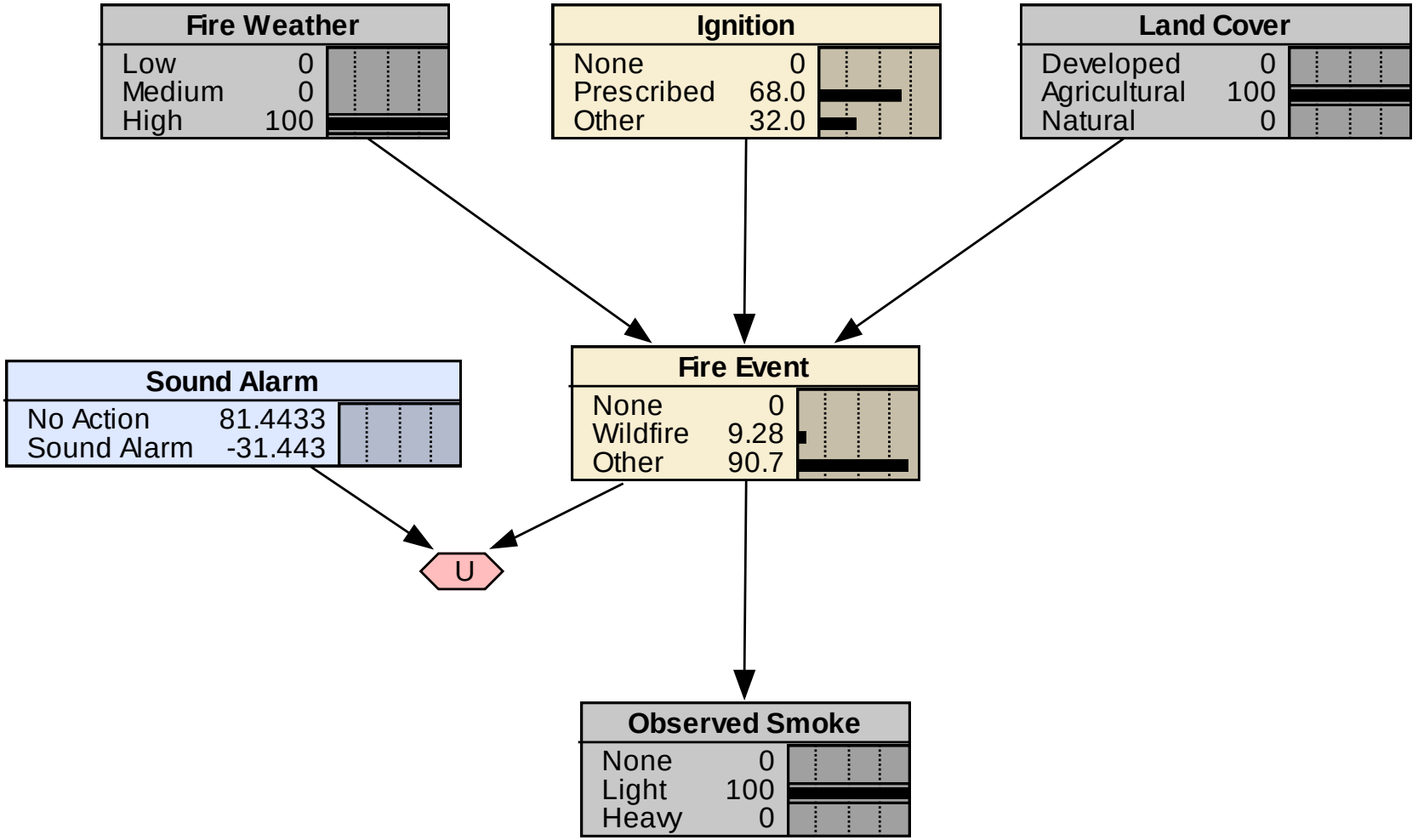
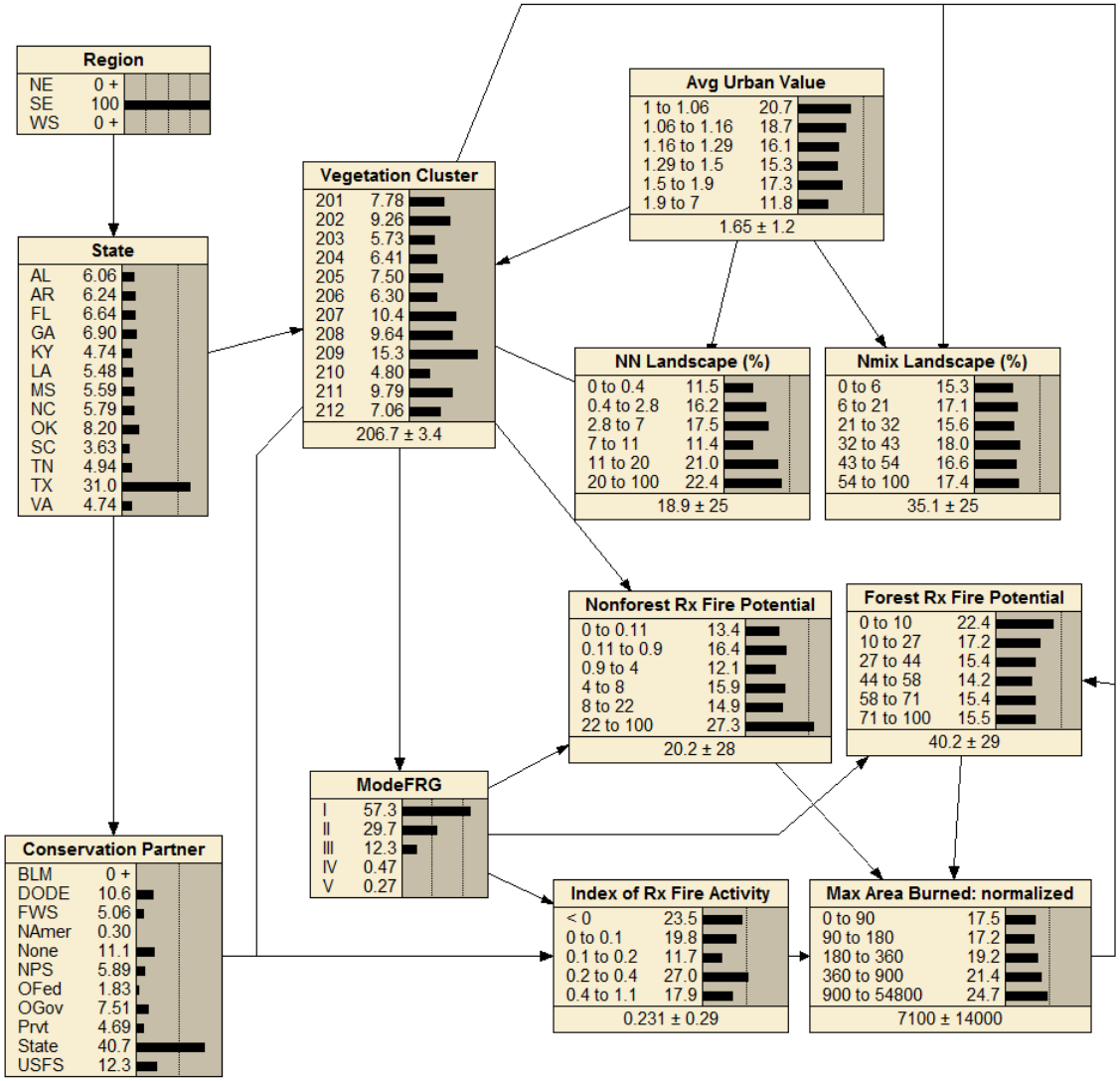




Bayes Network: Fire Lookout

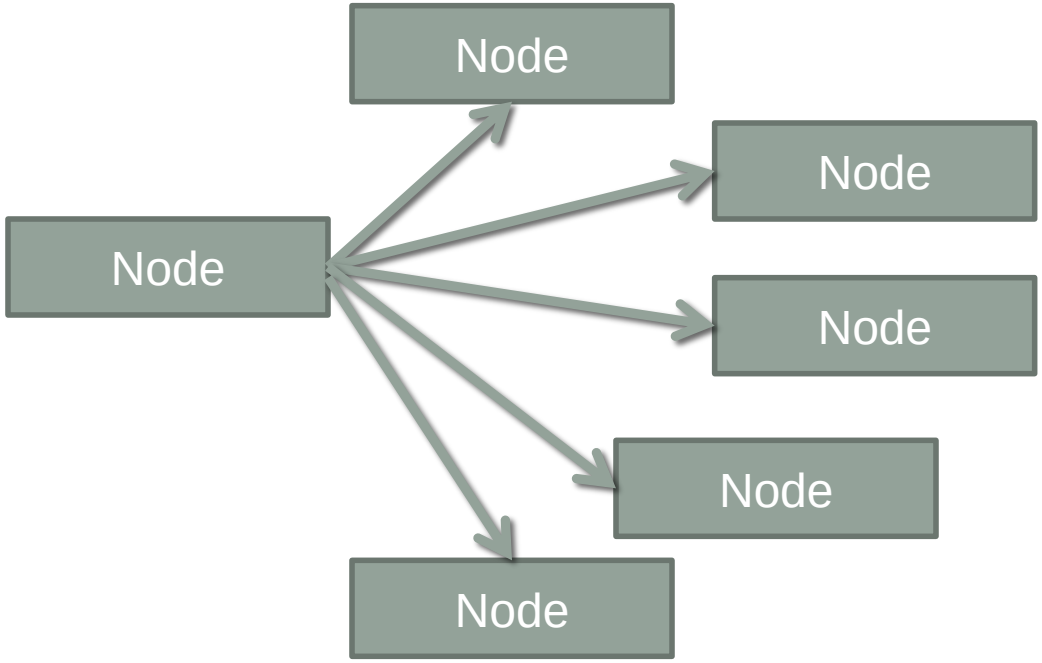


Bayes Network: Prescribed Fire Network for Science Analysis



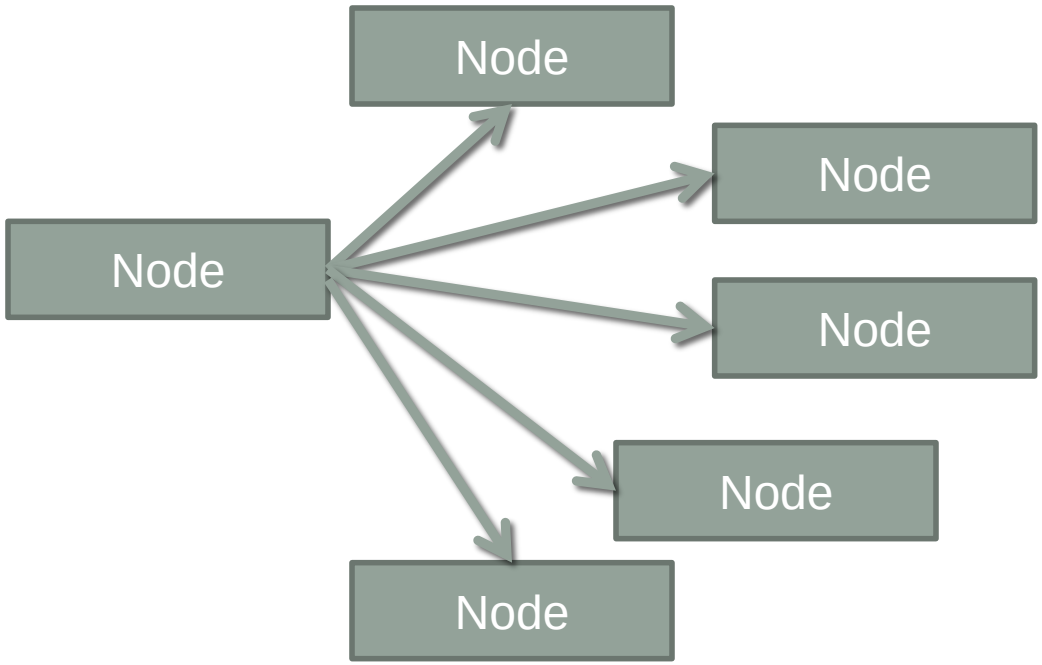
Naïve Network

- A type of structure for a network
- Assumes that all nodes (or data variables) are independent and that the presence or absence of a node is unrelated to the presence or absence of another node
- There is no cause and effect relationship among all nodes



Naïve networks

- Each node contributes independently to the network
- Particularly useful for exploring large datasets



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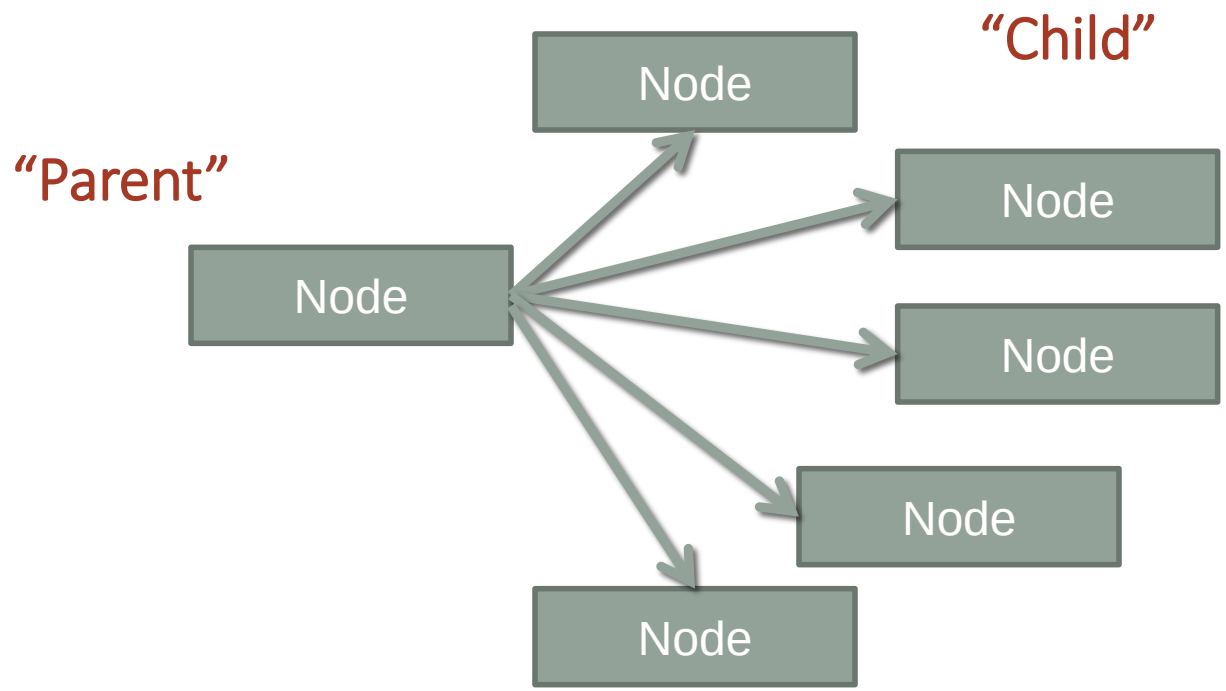
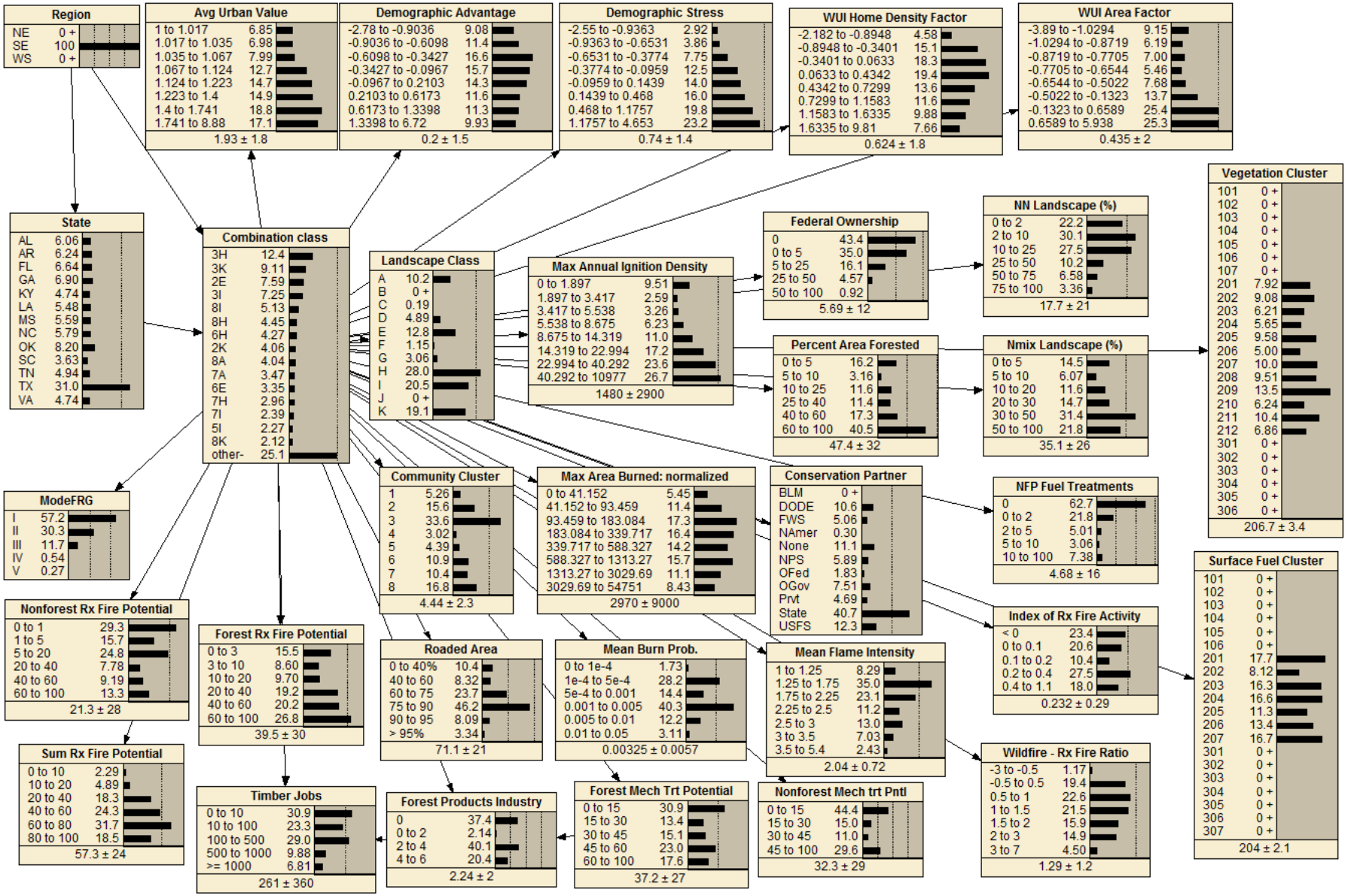


Naïve Network: Science Analysis



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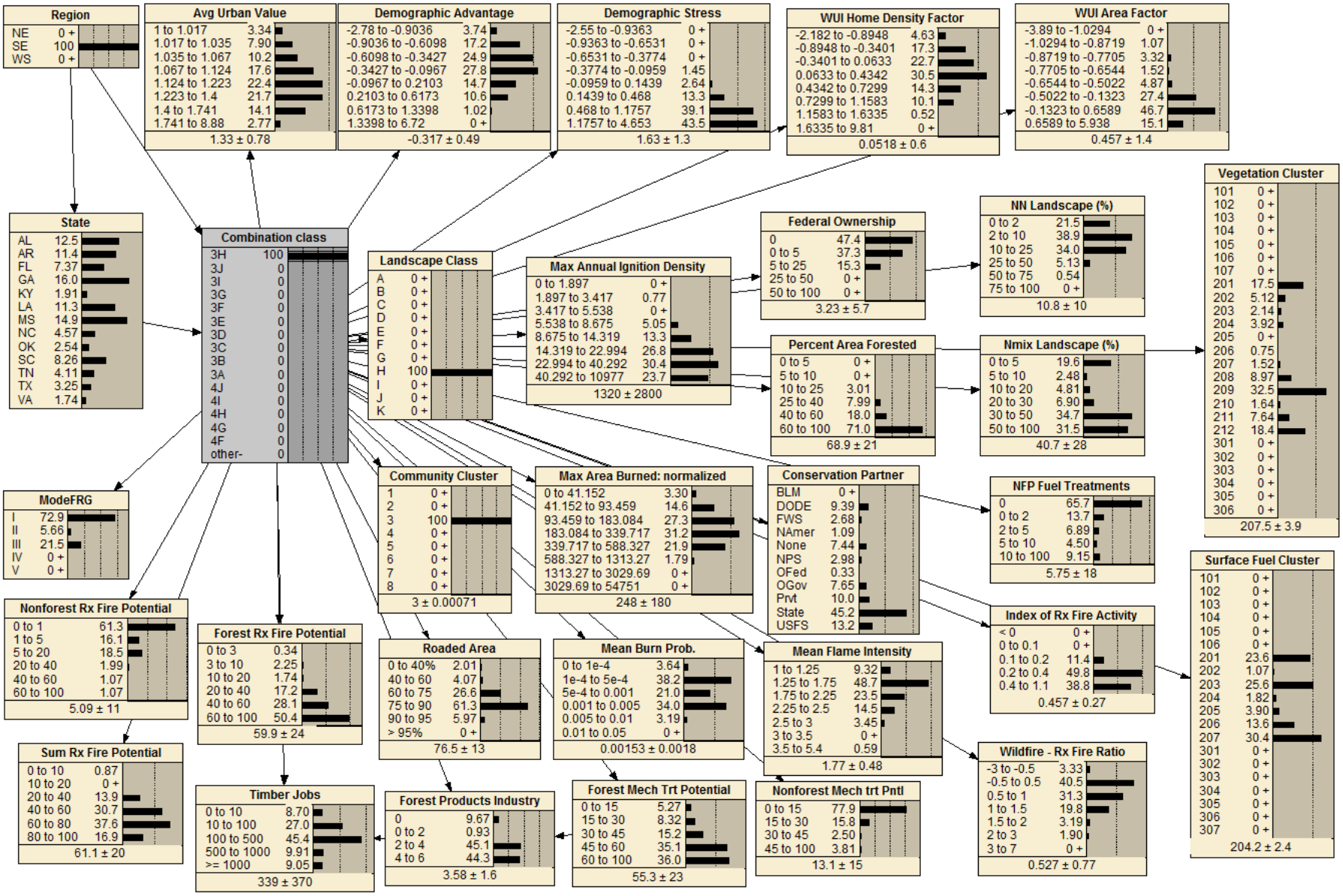

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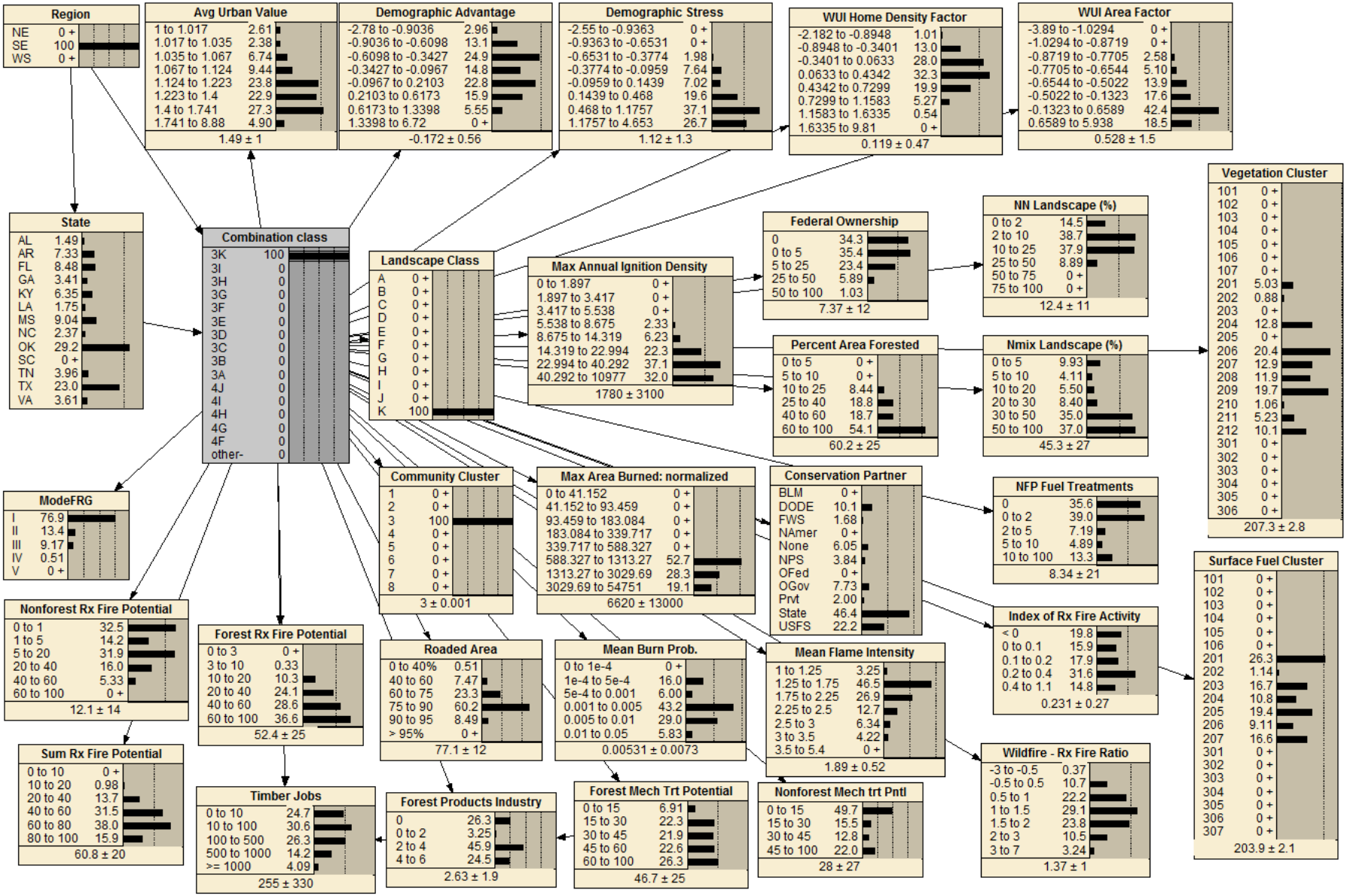

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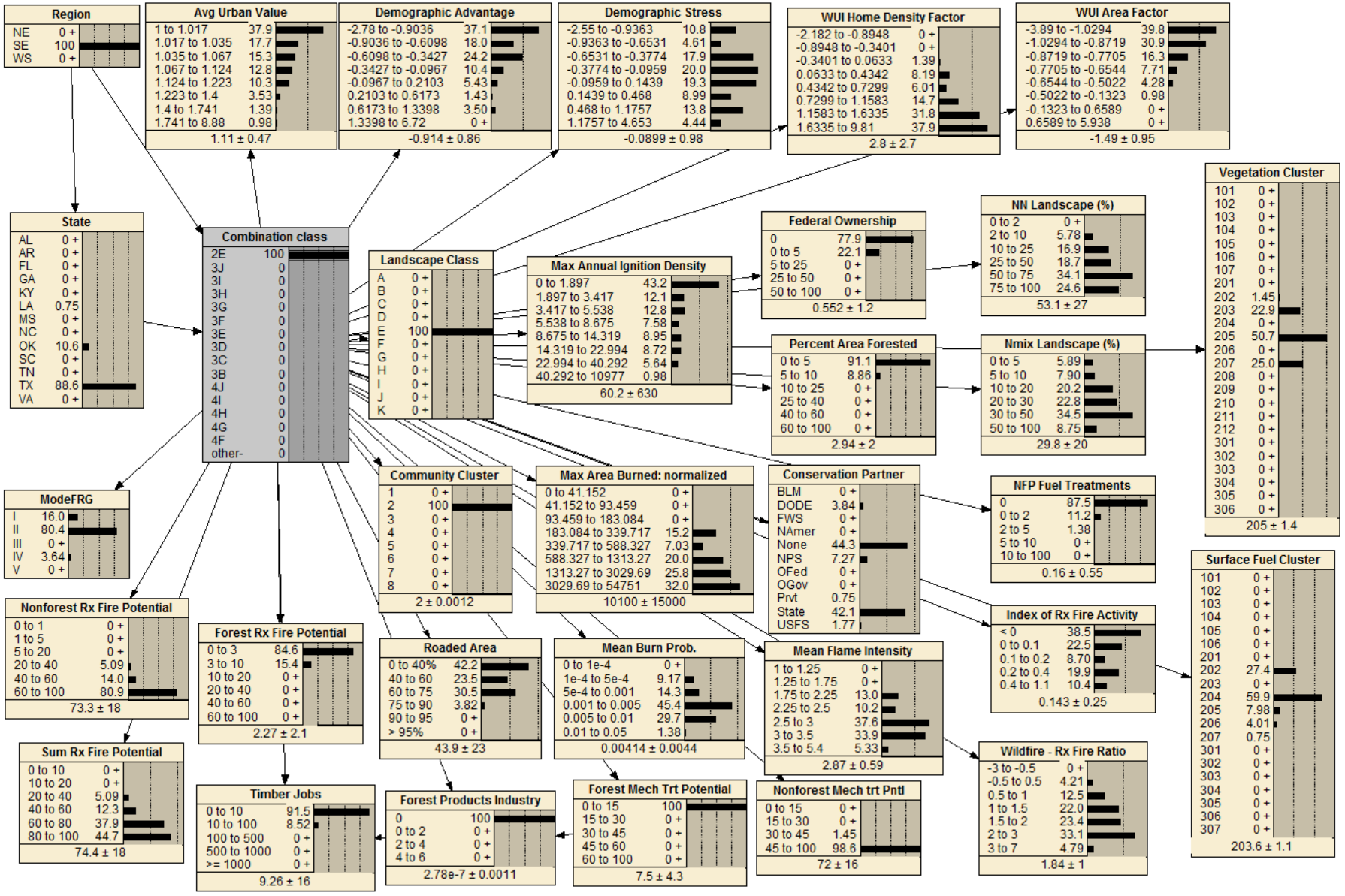
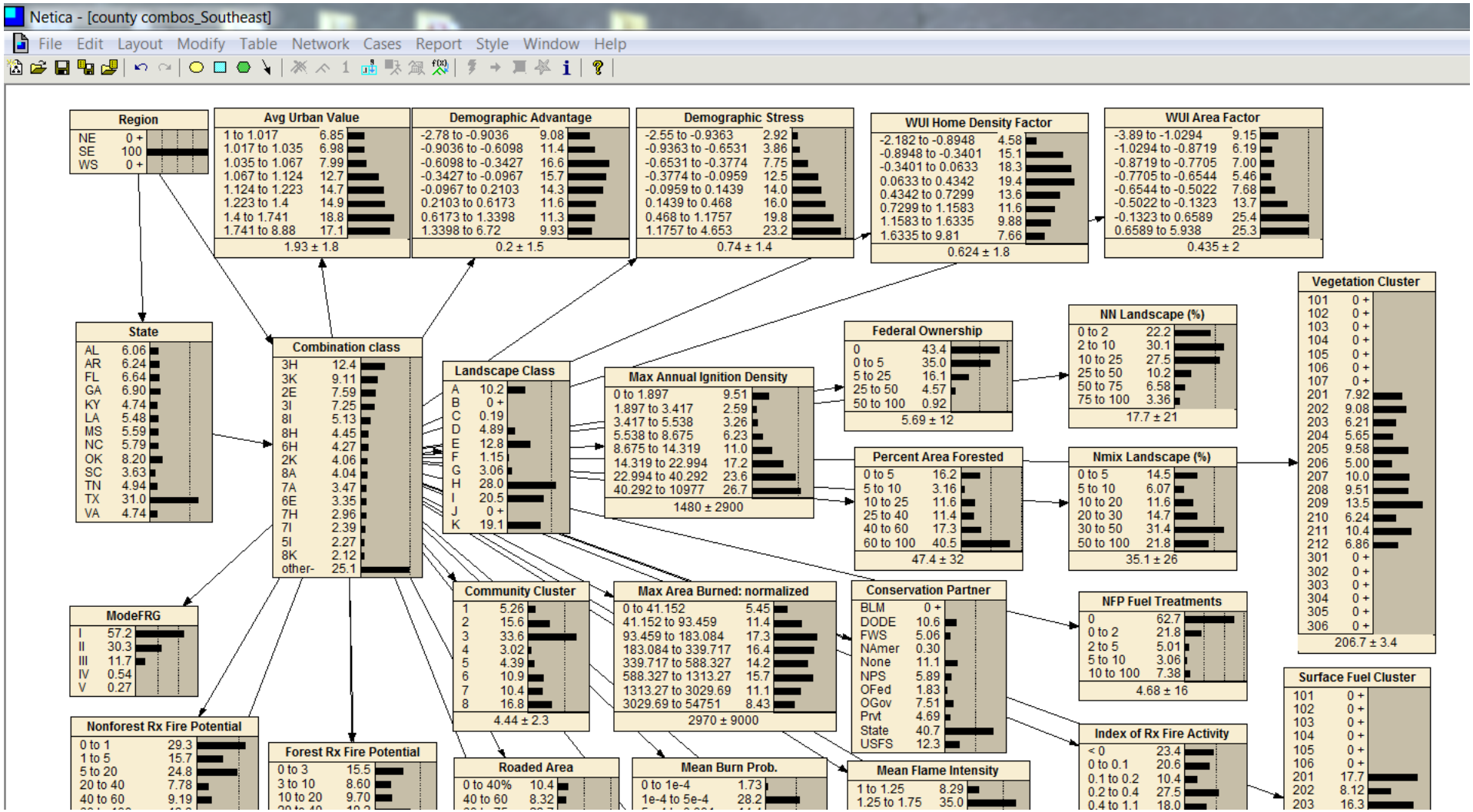
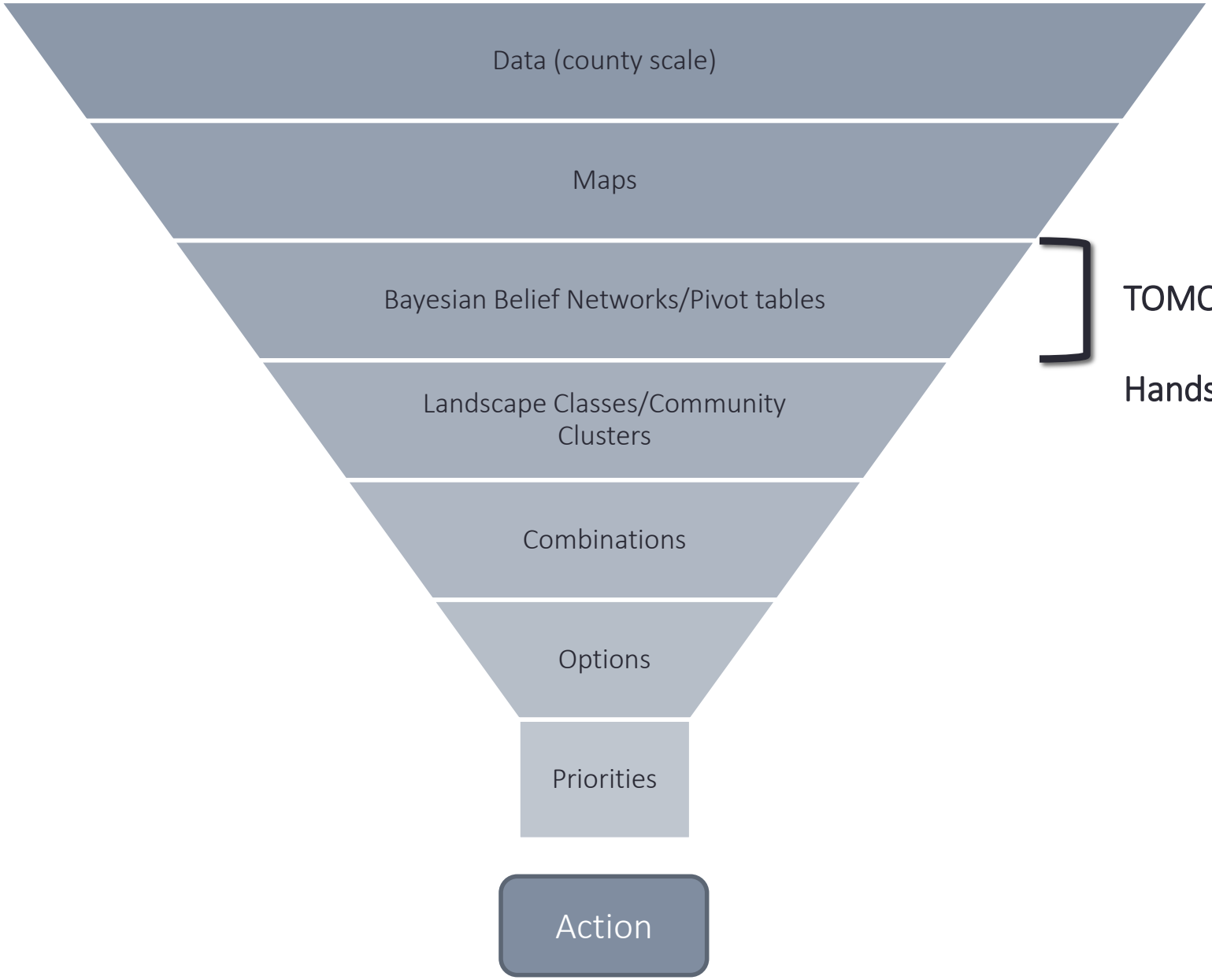


Why Use Belief Networks?

- Provides **reasoning** for the information you have (and uncertainties); does not provide answers.
- Automated and graphical way to display (and even interact with) related information.
- To seamlessly integrate other models, expert knowledge and datasets within a single platform
- Ability to **update** understanding **with new information**.
- Highly flexible.

Tomorrow: Interact with a Network Using Netica





TOMORROW:

Hands-on exercises