

BAYESIAN NETWORKS FOR ENVIRONMENTAL RISK ASSESSMENT: **ASSESSING WILDFIRE CONSEQUENCES**

Semijon Mujan

25. Mai 2023

ENVIRONMENTAL RISK ASSESSMENT

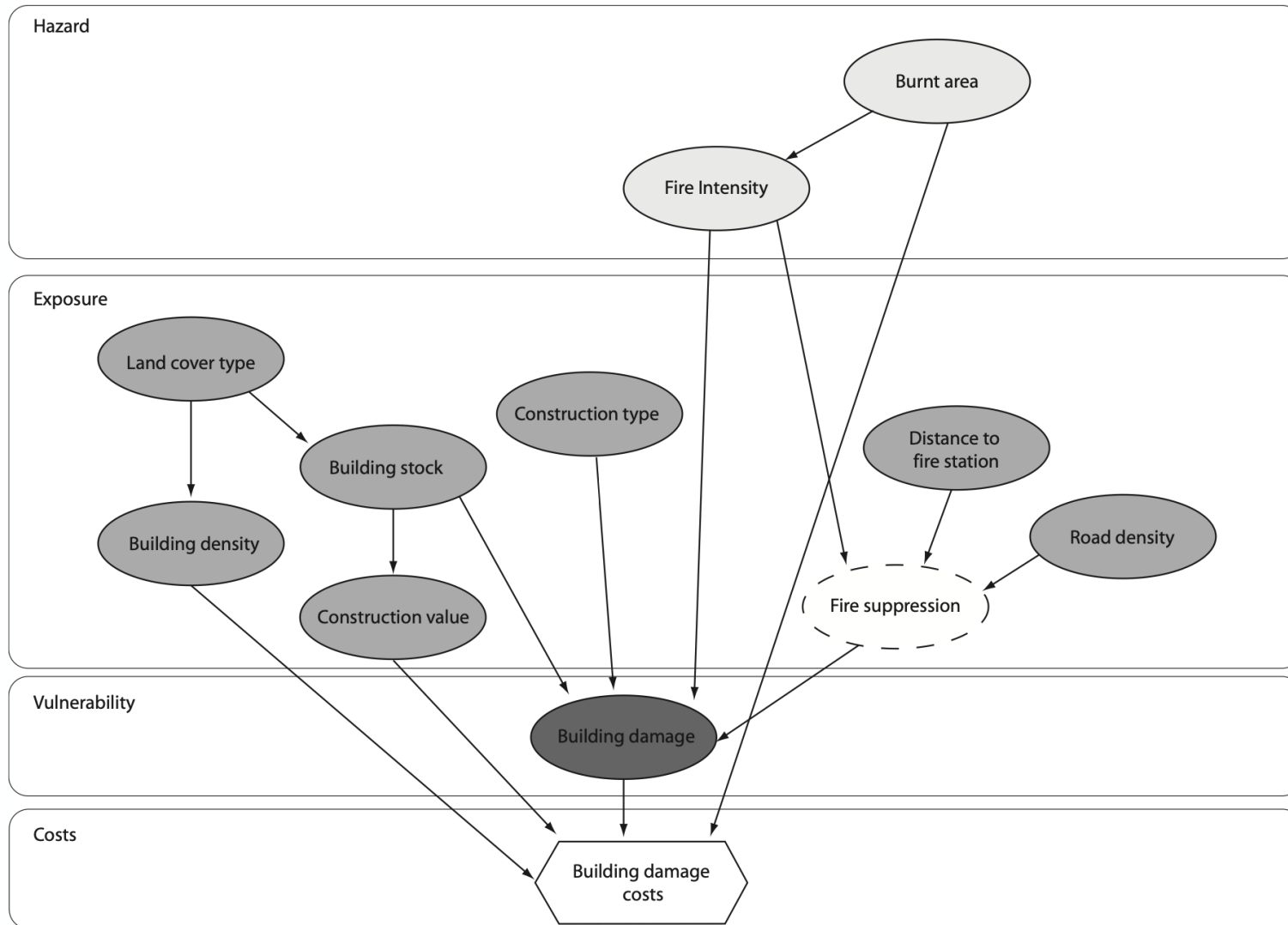
- short: ERA
- systematic process for identifying and evaluating the potential impact of a proposed activity, product, or substance on the environment
- Steps:
 1. Problem identification
 2. Exposure estimation
 3. Effect estimation
 4. Risk assessment
 5. Risk management and communication

CASE STUDY: ASSESSING WILDFIRE CONSEQUENCES

1. **Identification of the problem:** Wildfires are a significant environmental risk
2. **Exposure estimation:** Bayesian networks: probability of various fire events and their potential impacts on buildings
3. **Impact assessment:** various factors that can affect the impact of fire on buildings
4. **Risk assessment:** estimate of expected building damage for different fire types

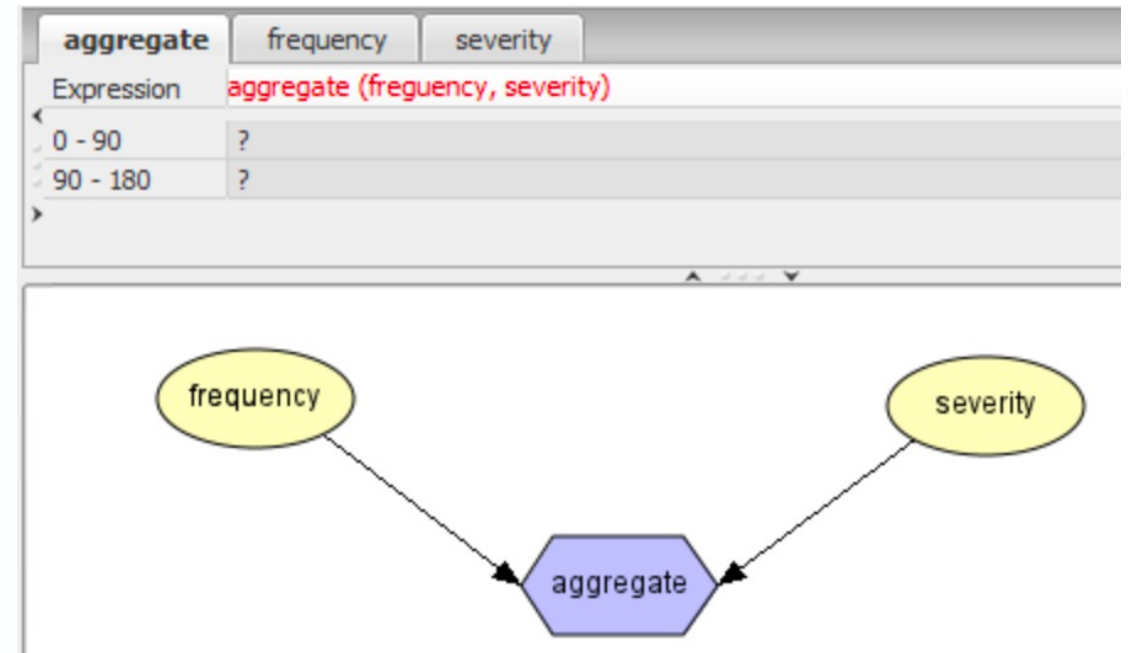


BN FOR BUILDING DAMAGE CONSEQUENCES DUE TO WILDFIRES



DISCRETE FUNCTION NODE

- Table of discrete function → marginal distribution
 - can be a function of the values of the parents
 - is specified by using an expression
- Parent nodes can be:
 - Boolean
 - Numbered
 - Interval
 - Continuous

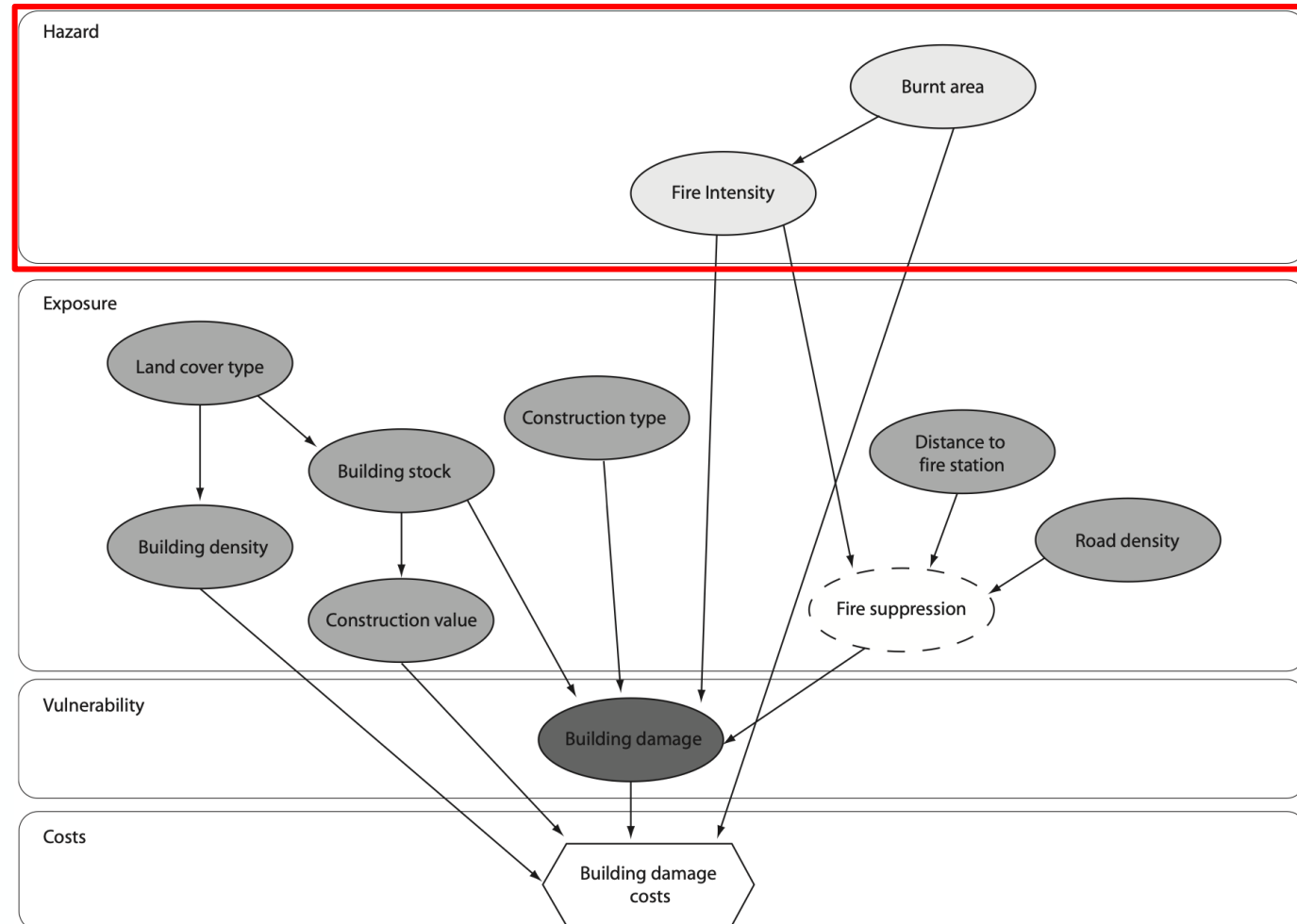


BN FOR BUILDING DAMAGE CONSEQUENCES DUE TO WILDFIRES

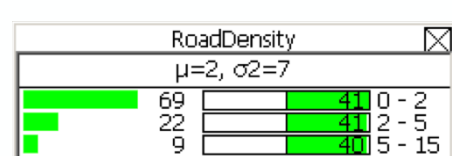
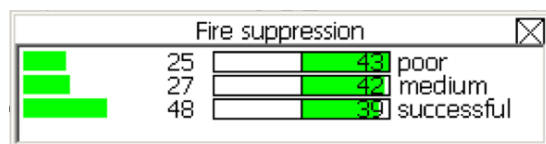
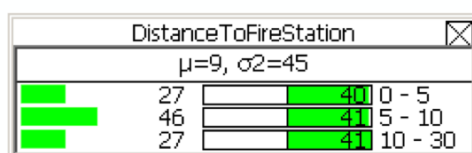
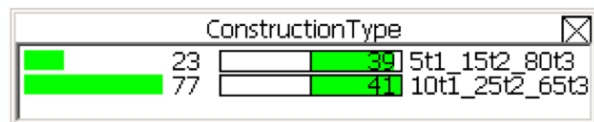
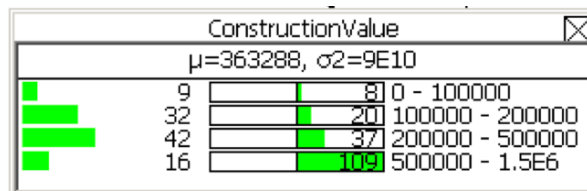
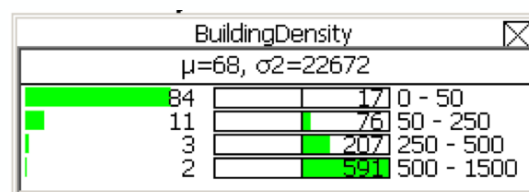
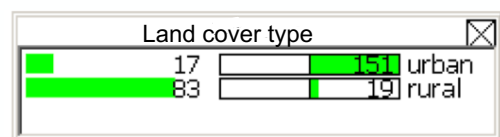
- hazard: characterized by the resulting burnt area and fire intensity
- fire intensity: rate of energy or heat release
- wildfire severity expressed by the resulting burnt area

BurntArea			
$\mu=5E-3, \sigma^2=3E-21$			
100	41	*	0 - 0.01
0	0.00		0.01 - 0.1
0	0.00		0.1 - 0.5
0	0.00		0.5 - 1
0	0.00		1 - 5
0	0.00		5 - 10
0	0.00		10 - 20

Fire Intensity			
$\mu=173, \sigma^2=7E-12$			
100	41	*	0 - 346
0	0.00		346 - 1730
0	0.00		1730 - 4000
0	0.00		4000 - 10000

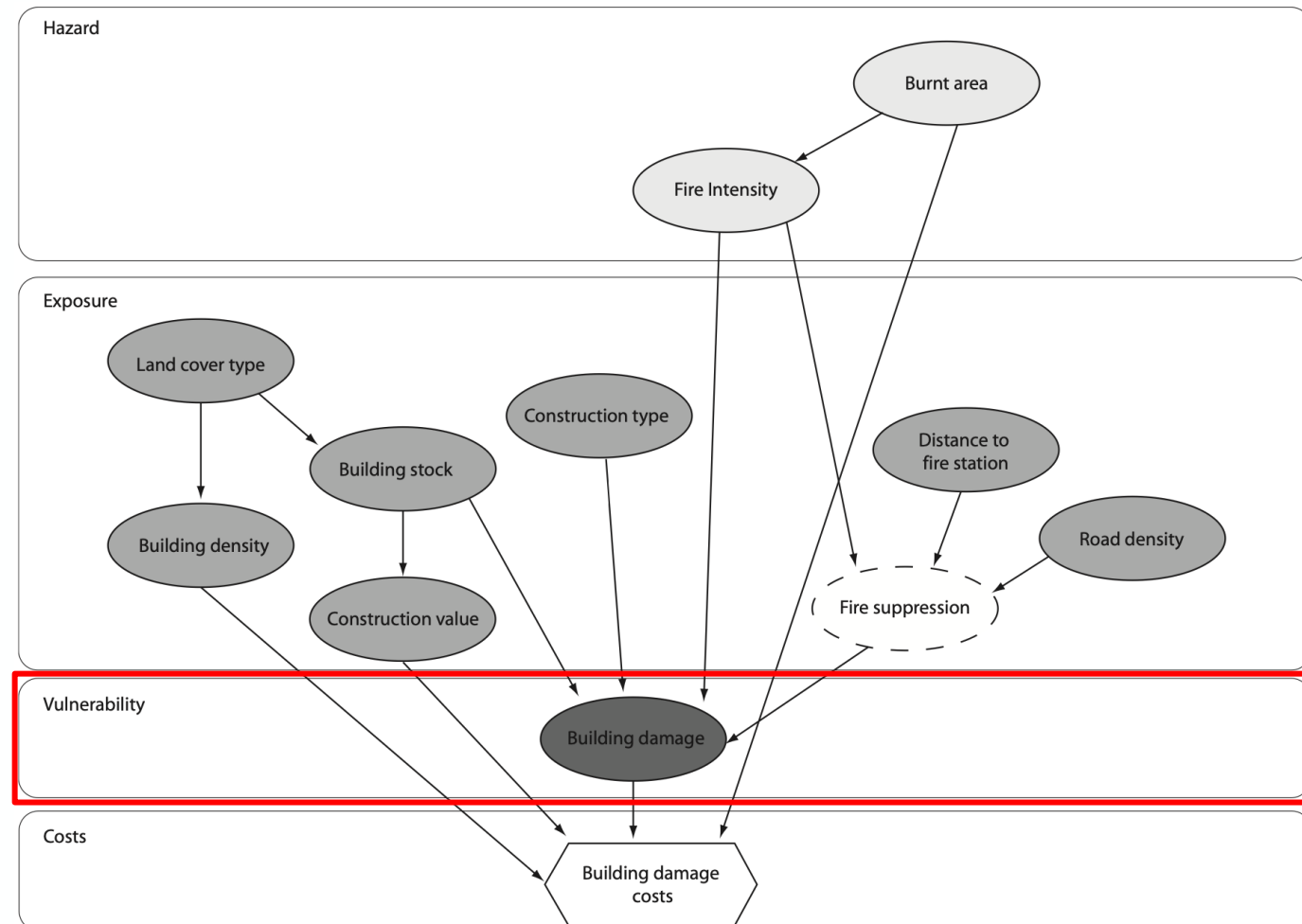


BN FOR BUILDING DAMAGE CONSEQUENCES DUE TO WILDFIRES



BN FOR BUILDING DAMAGE CONSEQUENCES DUE TO WILDFIRES

- degree of damage
- vulnerability of the building portfolio
- % of damage of the building construction

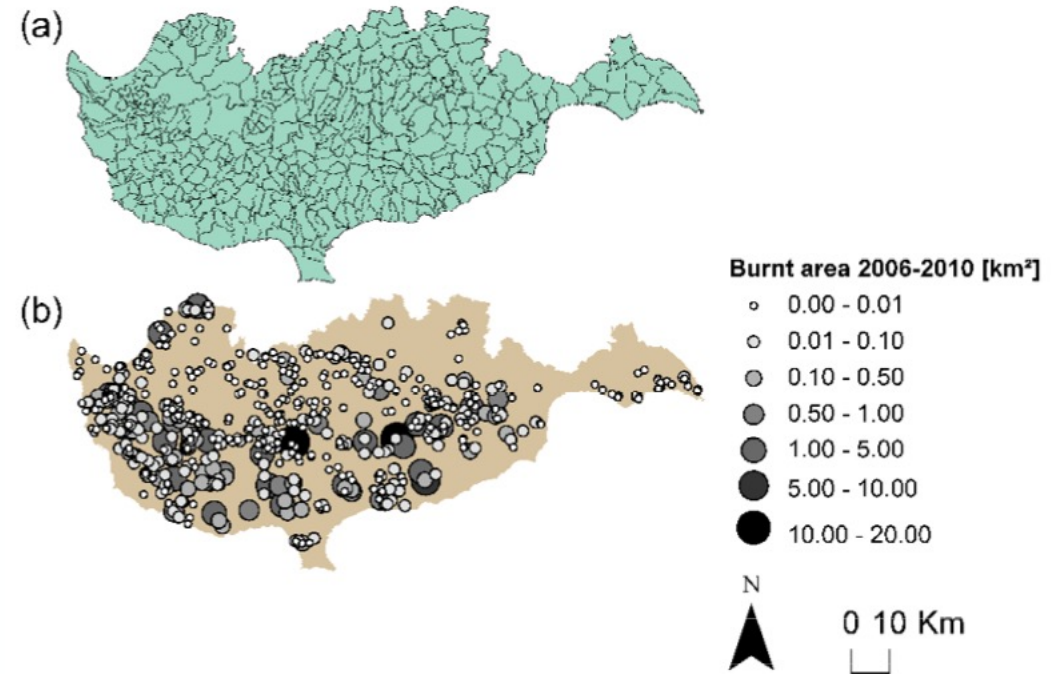
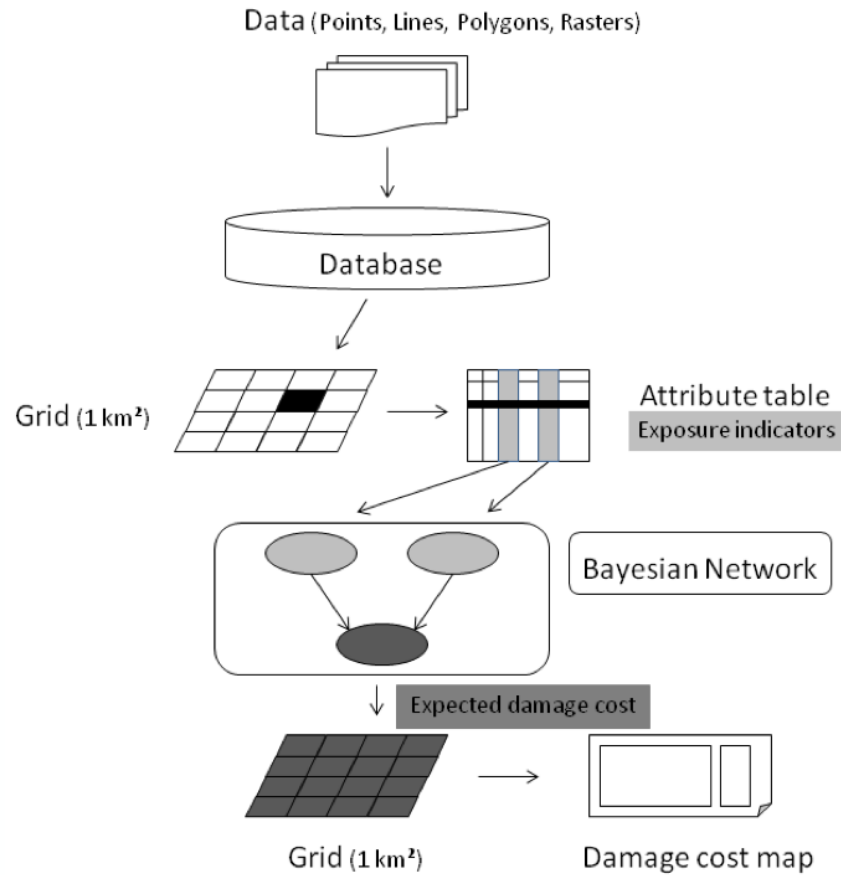


BN FOR BUILDING DAMAGE CONSEQUENCES DUE TO WILDFIRES

- building damage cost = building damage * construction value * building density * burnt area

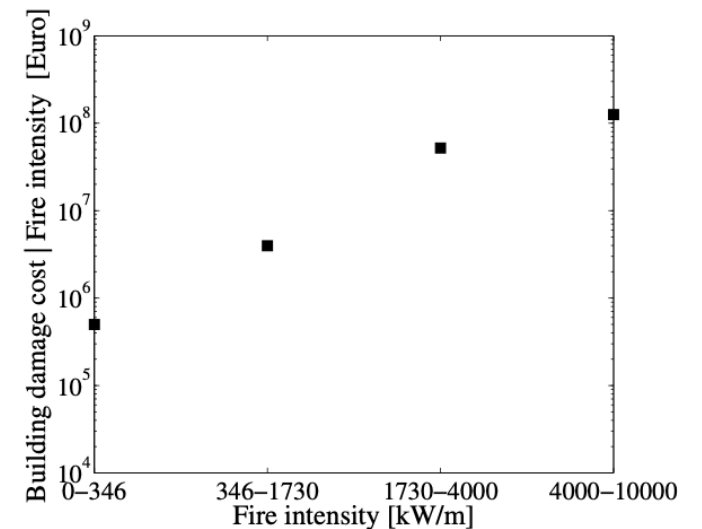
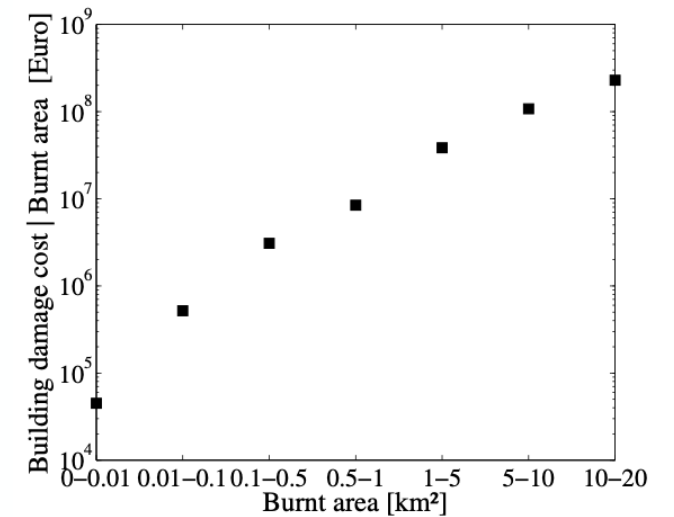


USING THE MODEL WITH GIS DATABASE

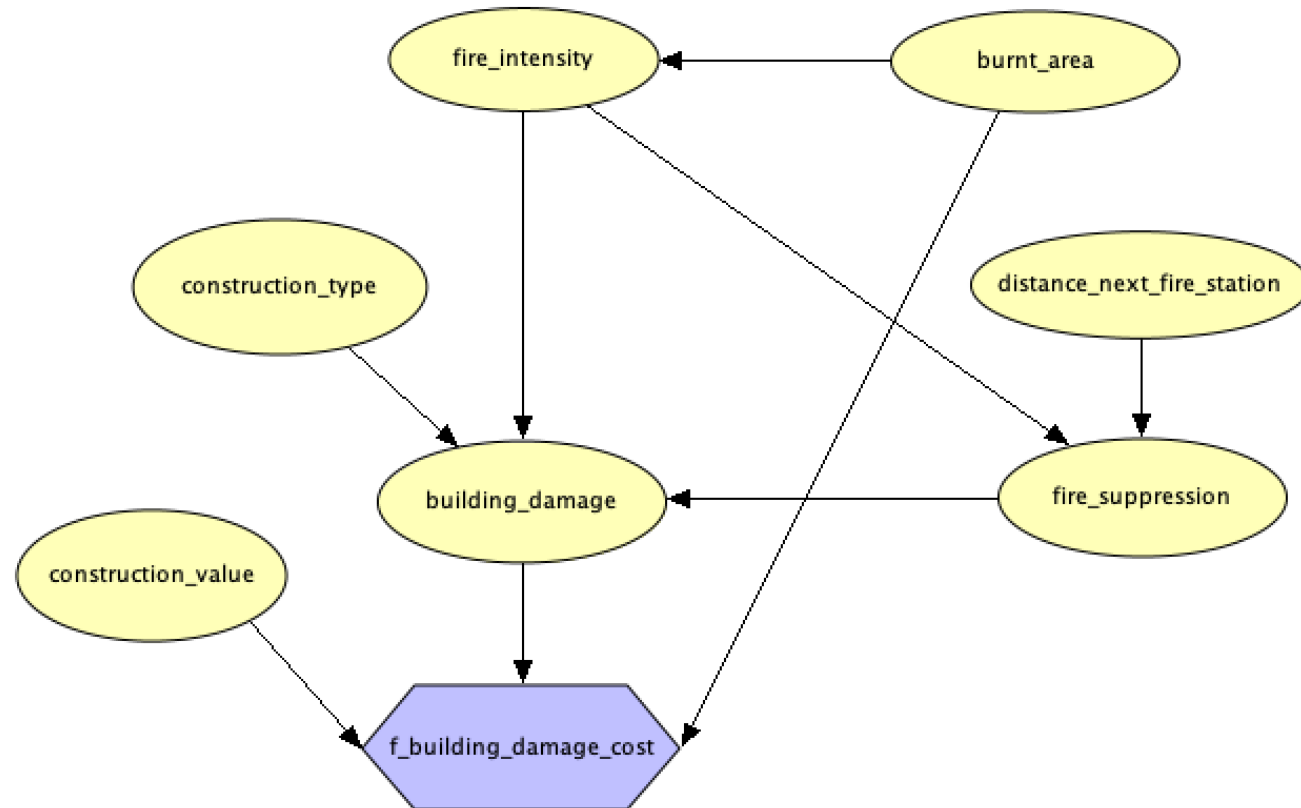


USING THE MODEL WITH GIS DATABASE

- Building damage cost increases with burnt area
- fire intensities higher than 1730 kW/m are associated with crown fires
- → expected to result in higher costs



BUILDING DAMAGE COST: SIMPLIFIED MODEL



LIMITED INFLUENCE DIAGRAMS




INTRODUCTION / DIFFERENCE TO BAYESIAN NETWORKS

- short: LIMIDs
- model decision alternatives in uncertain environments and the utilities associated with these
- BN does not explicitly cover concepts of utility and decisions
- LIMID = BN with *utility nodes* and *decision nodes*
- normal nodes are called *chance nodes*

CHANCE NODE

- uncertain events or factors that influence the outcomes
- at least 2 states



Weather			
	20.00	Rainy	
	30.00	Cloudy	
	50.00	Sunny	

DECISION NODE

- represents a point of decision or choice in the model
- actions or decisions that can be taken
- at least 2 states
- decision maker has control over selecting an action / decision



Invest		<input checked="" type="checkbox"/>
	0.00	Invest
	0.00	Not invest

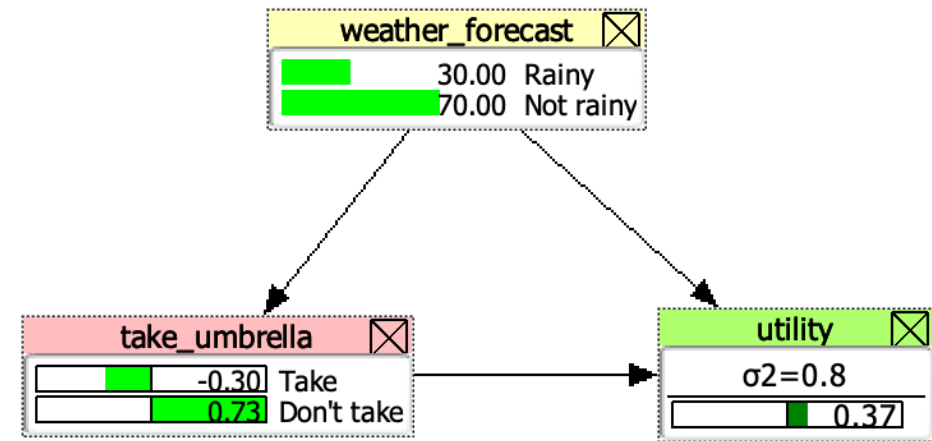
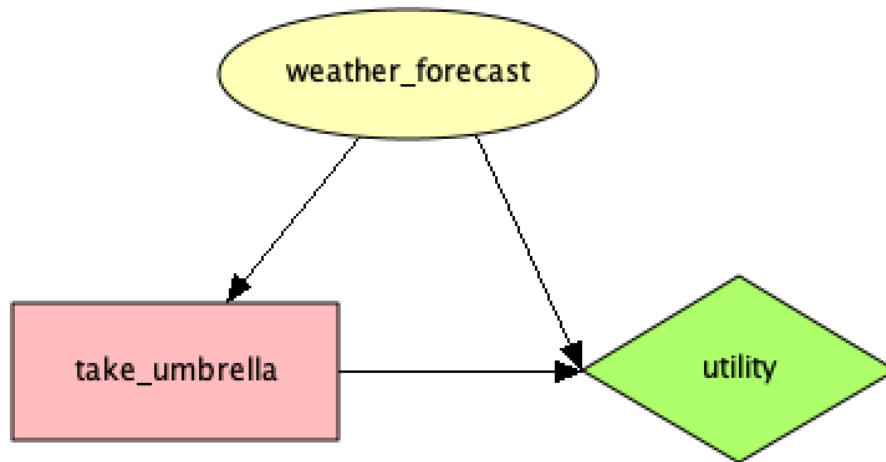
UTILITY NODE

- represents utility / value of the outcome
- allows for incorporating preferences / evaluations into the model
- $\text{Utility} = \text{Utility of each Decision} * \text{Chance of the Decision being made}$
- $\text{Global Utility} = \text{Sum of all utility nodes in model}$



Profit	
$\sigma^2=0$	
	0.00

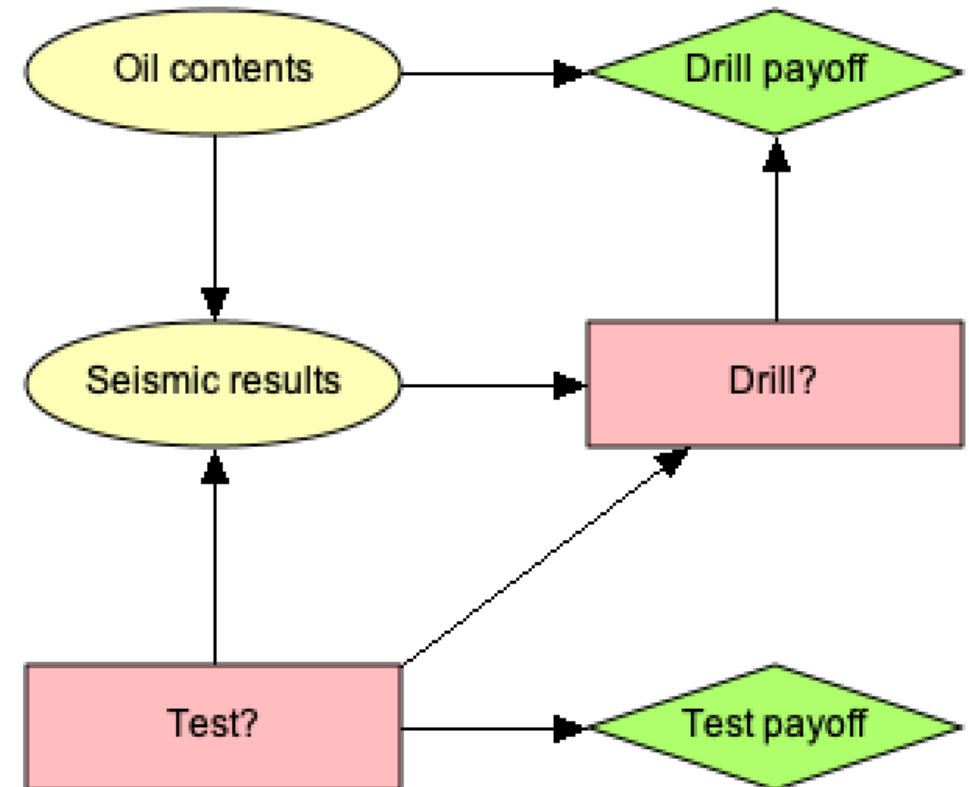
SIMPLE EXAMPLE: UMBRELLA



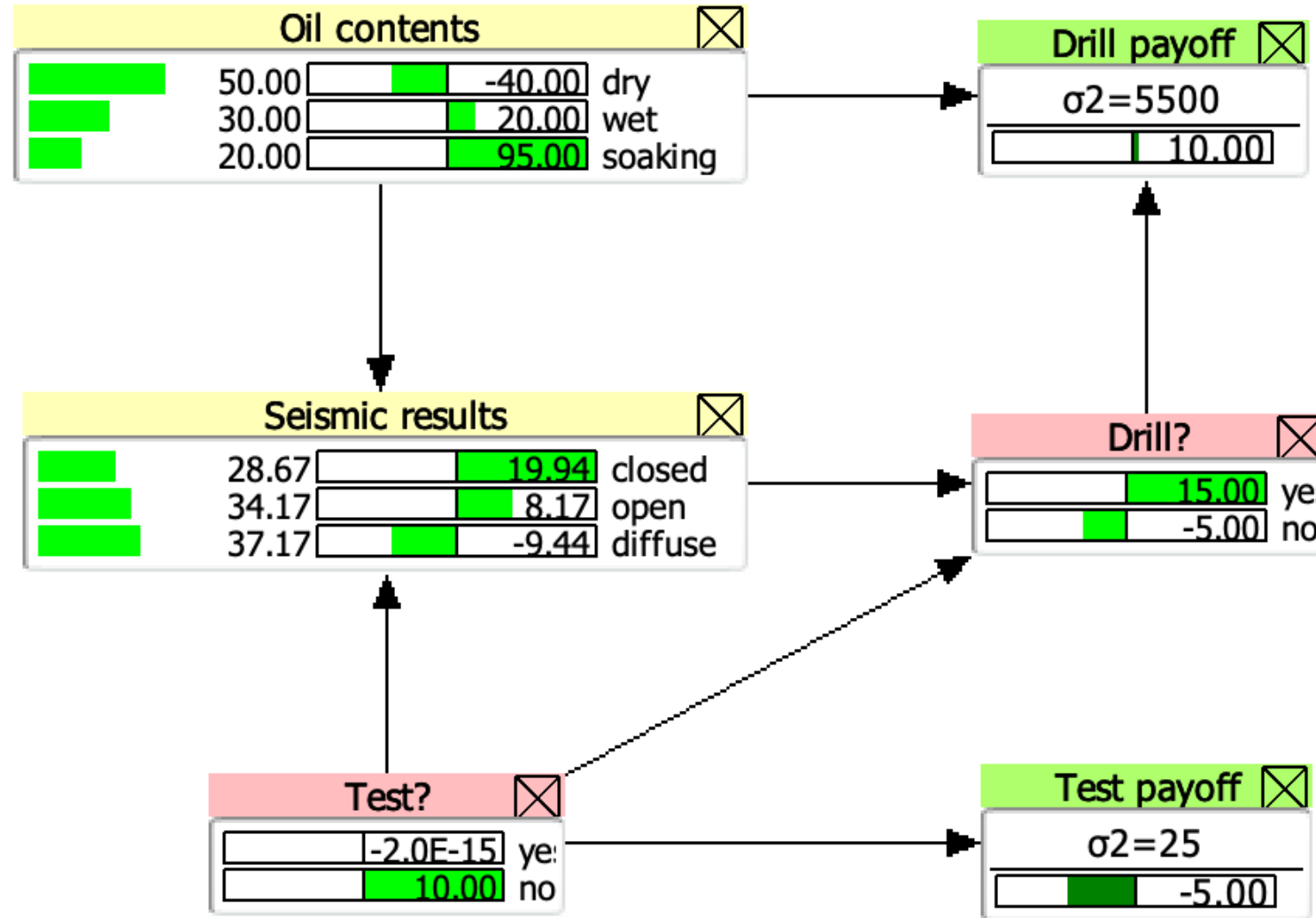
utility				
weather_forecast	Rainy		Not rainy	
take_umbrella	Take	Don't take	Take	Don't take
Utility	0	-2	-1	1

THE OIL WILDCATTER

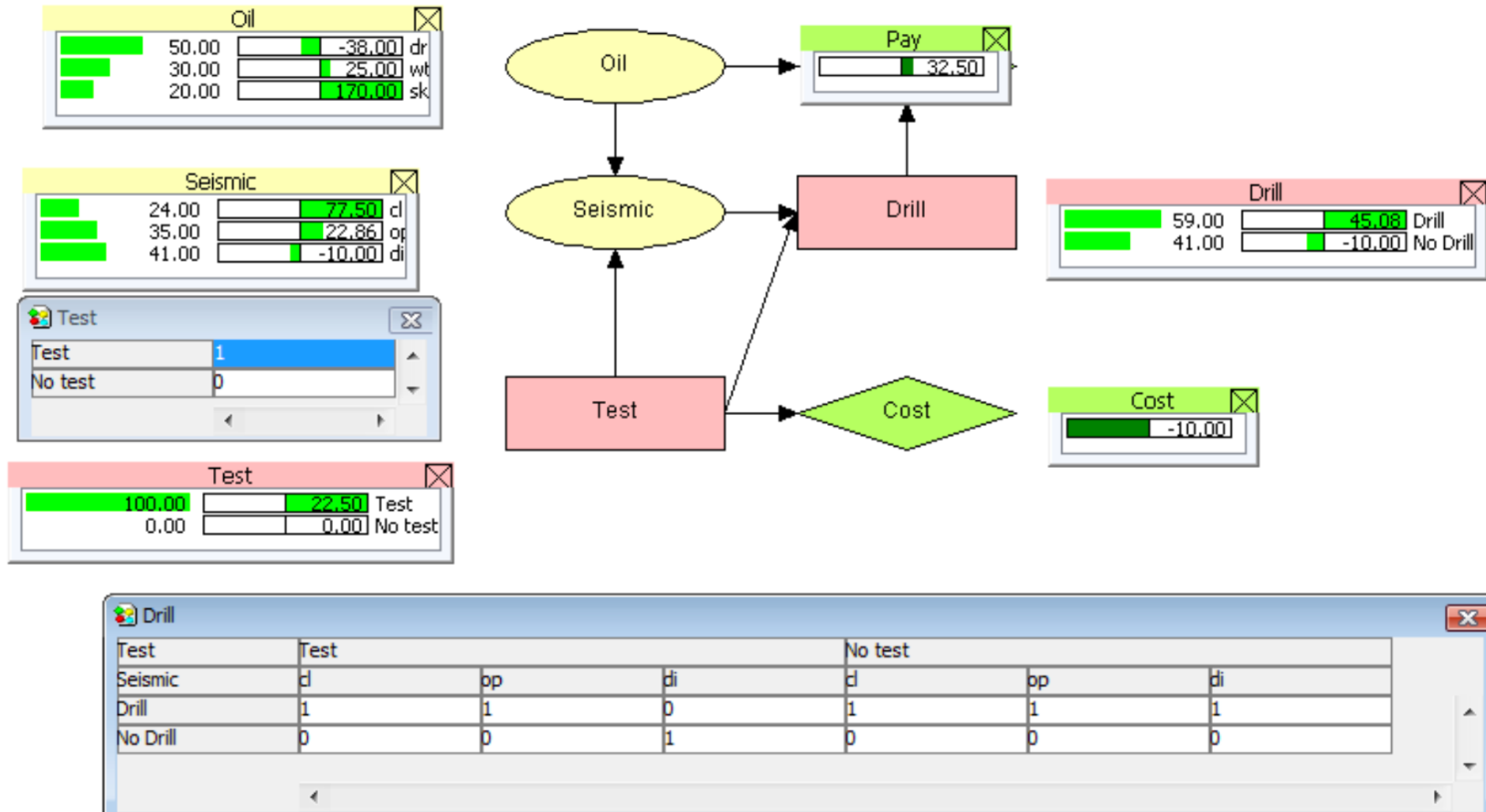
- HUGIN sample
- perform an expensive drilling?
- perform expensive seismic test?
- uncertainty about the presence of oil



THE OIL WILDCATTER



THE OIL WILDCATTER



SOURCES

- <https://mediatum.ub.tum.de/doc/1145639/1145639.pdf>
- <https://media.cnn.com/api/v1/images/stellar/prod/220730210827-01-mckinney-fire-0730.jpg?c=original>
- <https://download.hugin.com/webdocs/manuals/9.4/htmlhelp/index.html>
- Own models created with HUGIN Expert