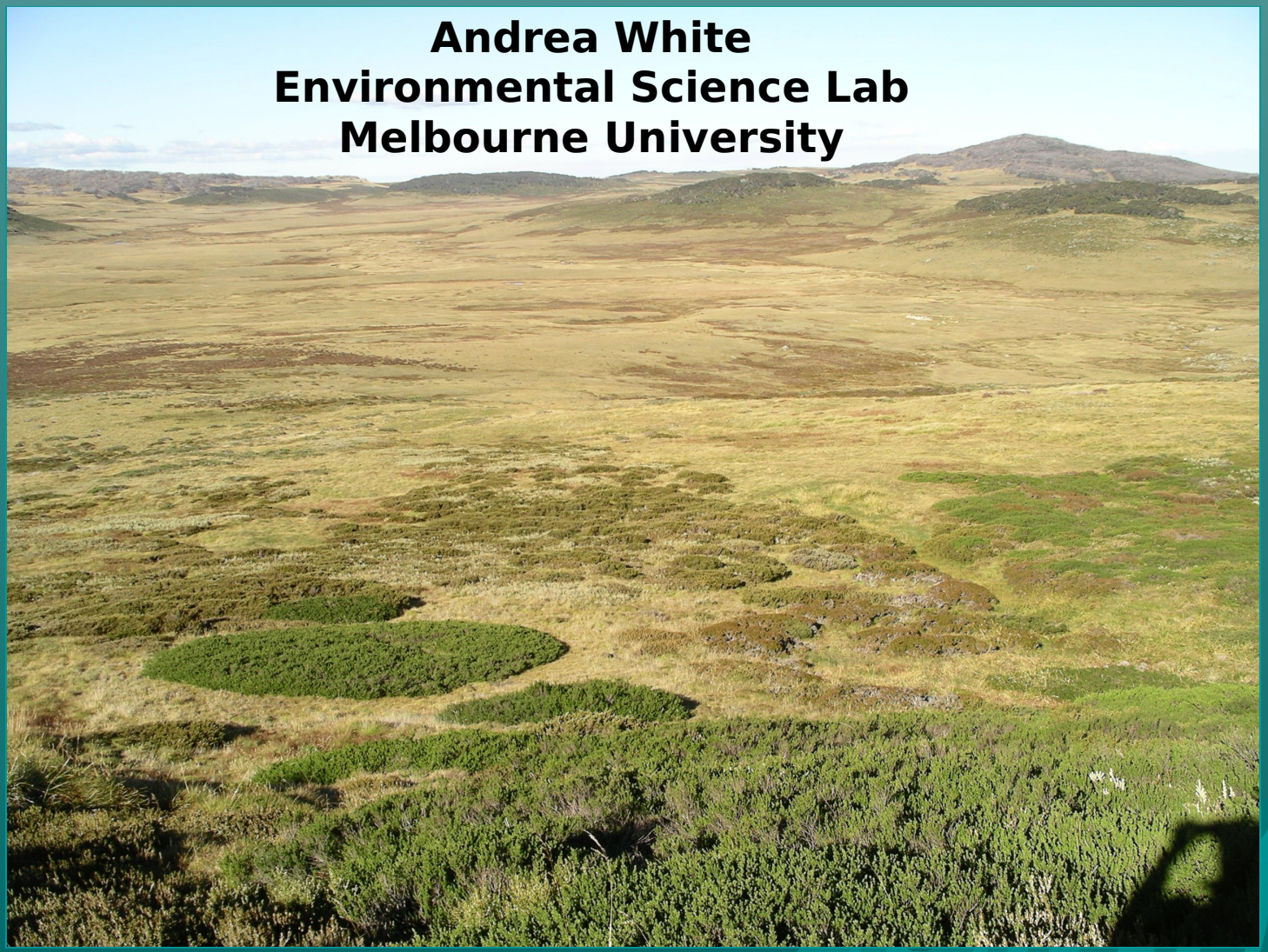
A Bayesian Network for alpine & subalpine peatland risk assessment & management



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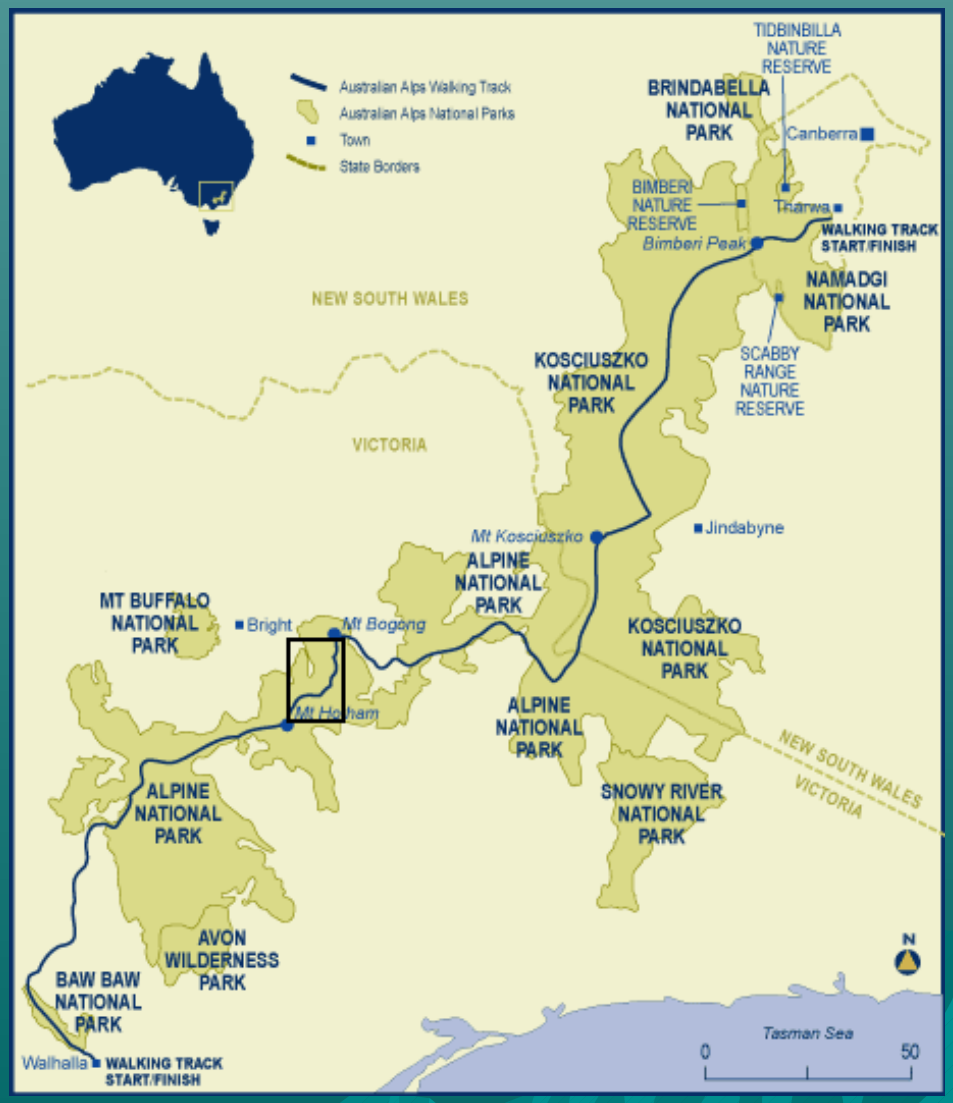
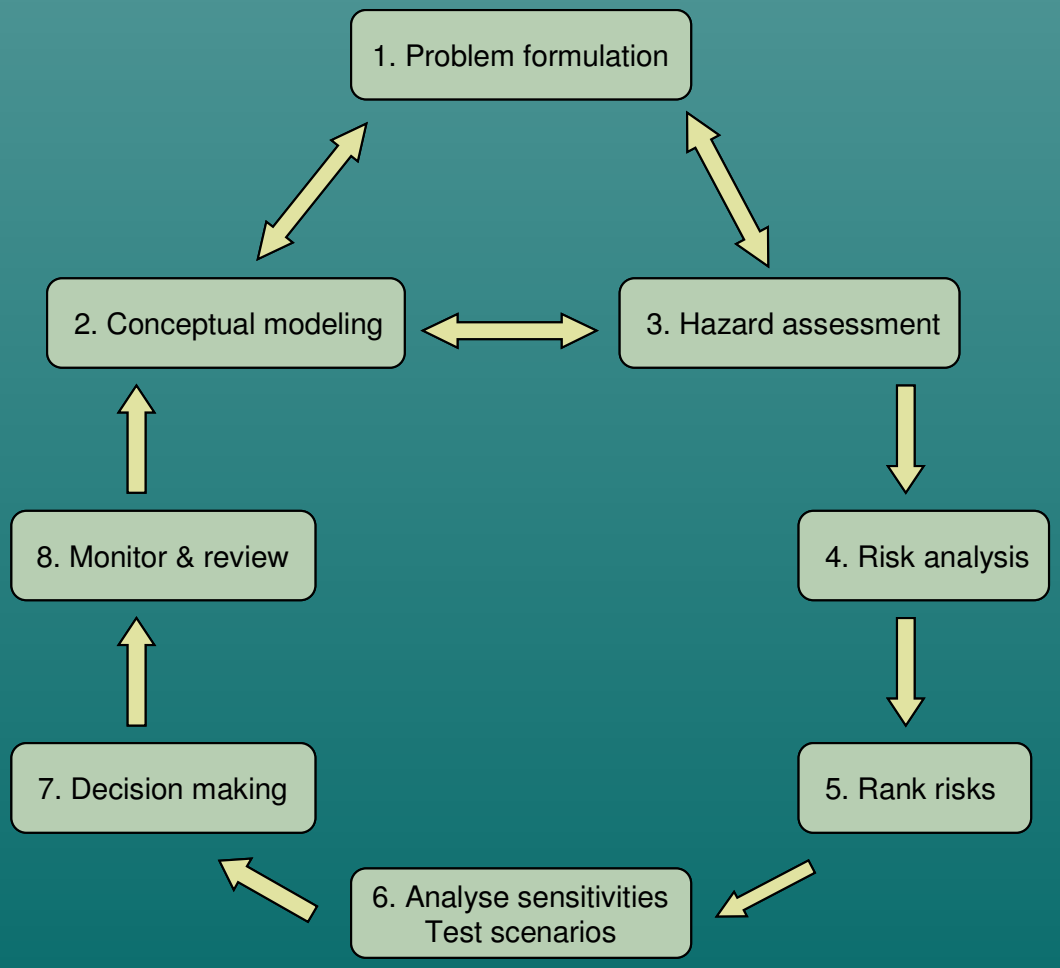


Peatlands

- Peat substrate - organic matter, has extremely high water holding capacity
- *Sphagnum* moss, shrubs, sedges, rushes and herbs
- Vulnerable to physical disturbance
- Peatlands are extremely limited in extent
- In areas of impeded drainage (drainage lines, depressions, seepages)
- Ecosystem functions:
  - Water filtration, removes particulate matter
  - Sink for nitrate & sulfate, exporter of Ca & Mg
  - Transmit water, protect underlying soil
  - Habitat for rare and endangered flora & fauna

Ecological Risk Assessment (ERA)



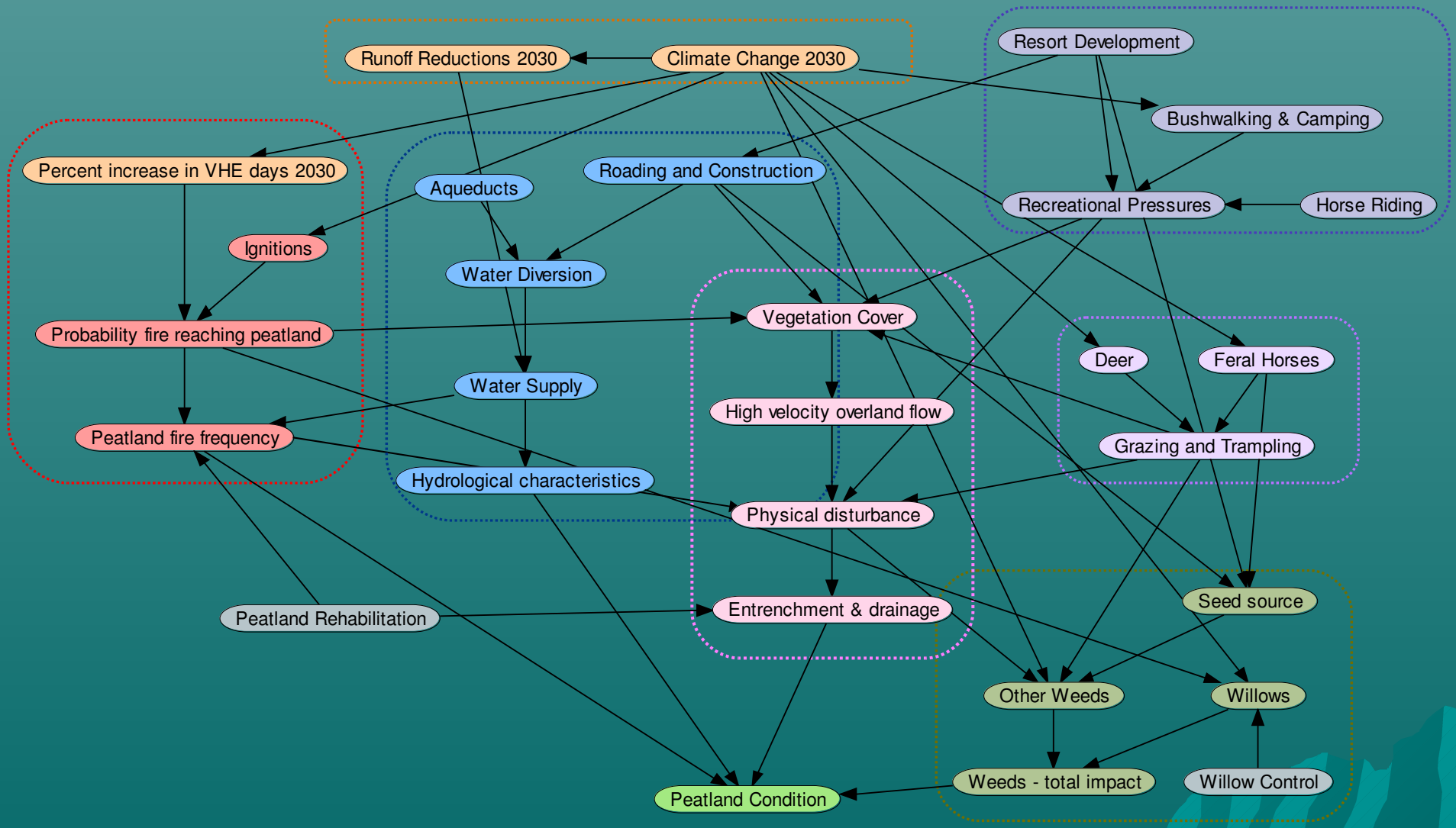
A. Expert group & literature:
   problem formulation
   conceptual modelling
   & hazard assessment

B. Regression models for peatland distribution:
   risk analysis

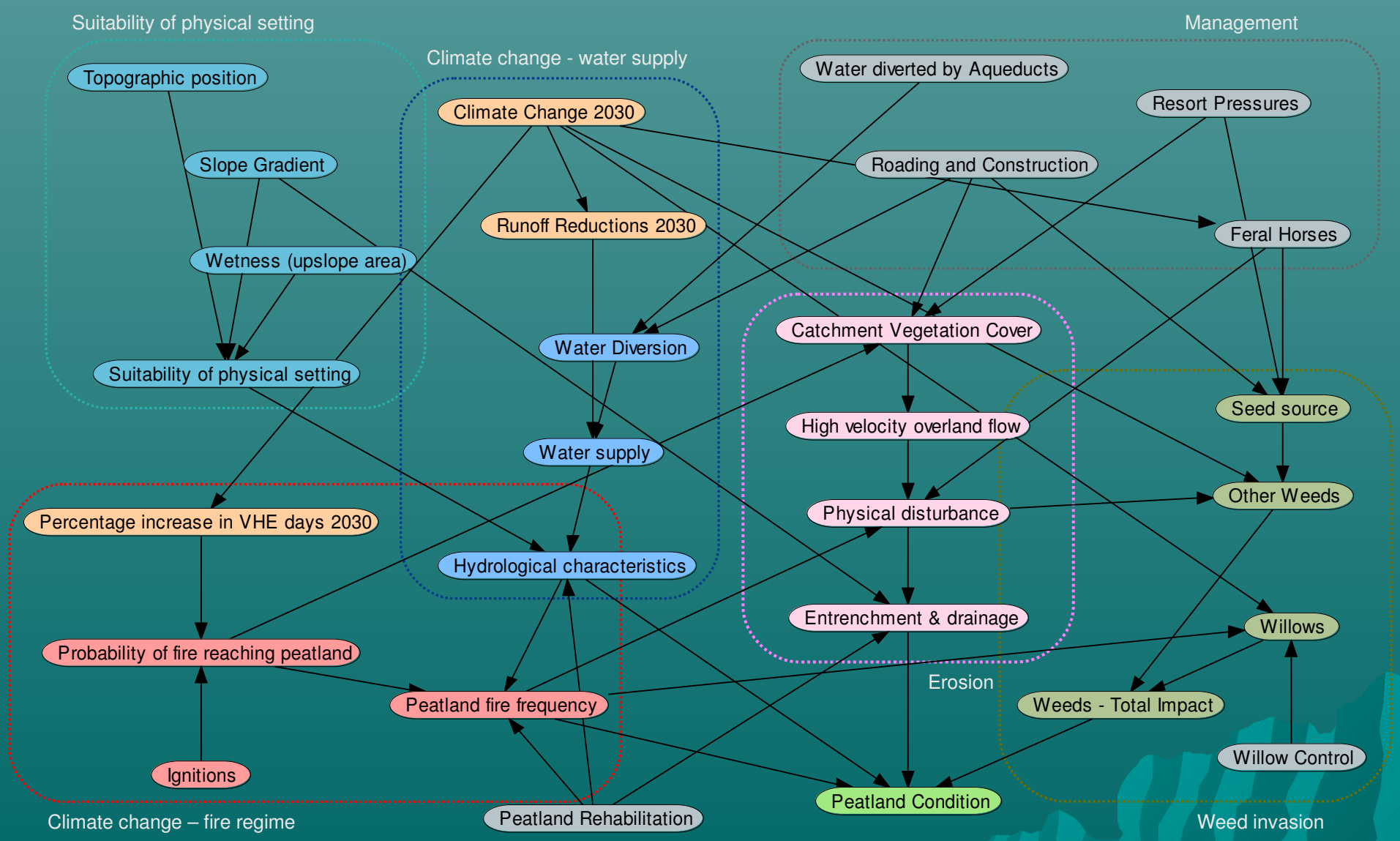
C. Bayesian Network for peatland condition:
   risk analysis & ranking
   sensitivity analysis
   scenario testing
   & decision support

D. Impact assessment and adaptation strategies:
   managing & monitoring peatlands under climate change

Influence Diagram – All Hazards

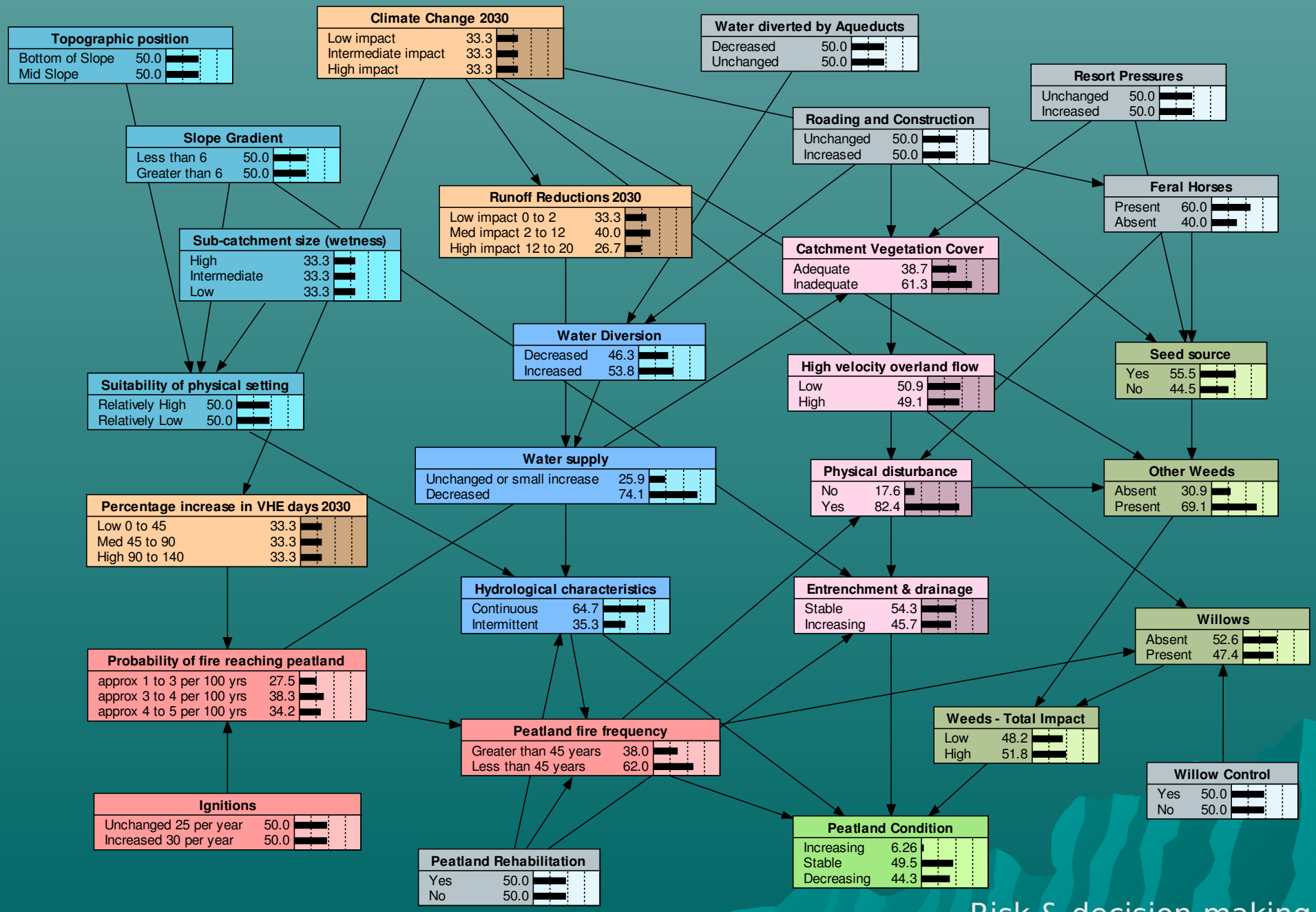


Influence Diagram – Hazards after consultation



Hazard assessment

Bayesian Network for peatland condition



Conditional Probability Table

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Node hydrological_characteri

Apply Okay

Chance Percentages

Reset Close

Water supply	Suitability of physical setting	Peatland Rehabilitati...	Continuous	Intermittent
Unchanged or small increase	Relatively High	Yes	100.00	0.000
Unchanged or small increase	Relatively High	No	100.00	0.000
Unchanged or small increase	Relatively Low	Yes	90.000	10.000
Unchanged or small increase	Relatively Low	No	80.000	20.000
Decreased	Relatively High	Yes	80.000	20.000
Decreased	Relatively High	No	70.000	30.000
Decreased	Relatively Low	Yes	50.000	50.000
Decreased	Relatively Low	No	20.000	80.000

CPTs express the probability of that variable being in a particular state given the state of its parents

Sensitivity analysis

Node	Entropy reduction (mutual information)
Peatland Condition	1.27311
1. Peatland fire frequency (2)	0.22046
2. Hydrological Characteristics (1)	0.09231
Physical disturbance	0.05285
Prob. of fire reaching a peatland	0.05199
Entrenchment and Drainage	0.04931
Bog Rehabilitation	
Weeds integrator	
VHE	
Climate Change	
3. Willows (4)	
4. Other Weeds (6)	
Runoff reductions	
Water Supply	
Site suitability	
Vegetation Cover	
Water Velocity	
Water Diversion	
5. Feral Horses (3)	
Topographic Position	
Slope	
6. Roading and Construction	
Willow Control	
7. Aqueducts (7)	
Seed source	0.00052
Ignitions	0.00036
Catchment size	0.00031
8. Resort pressures (8)	0

Threats we need to pay most attention to

Experts	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Median
Climate change: reduced water supply	1	1	1	2.5	1.5	1	1.5	1	1.5	1	3	11	1.5	1.5	2	1.5
Climate change: increased fire freq.	2	2	3	2.5	1.5	2	1.5	2	1.5	2	3	10	1.5	1.5	1	2
Feral horses	4	4	2	2.5	6	8.5	5	1	4	7	7.5	7	9.5	3.5	4.5	4.5
Willows	3	3	11	2.5	6	6	3.5	9	9.5	8	3	5	5	6.5	4.5	5
Water diversion: roading	9	6	5	7.5	4	3.5	7	5	7	5	11	2	5	8	8	6
Other weeds	6	7	10	7.5	11	7	3.5	8	9.5	3	3	7	5	6.5	4.5	7
Water diversion: aqueducts	10	8	6	7.5	3	3.5	7	10	7	4	11	3	5		8	7
Deer	5	10	7	7.5	6	11	10	11	4	10	7.5	9	9.5	5	4.5	7.5
Resort development	11	5	9	7.5	8	5	7	4	8	12	11	4	5	10	8	8
Horse riding	7	9	4	7.5	9	8.5	10	3	4	11	11.5	7	9.5	11	10.5	9
Bushwalking and camping	8	11	8	11	10	10	10	7	11	9	11.5	12	9.5	9	10.5	10

Experts listed most serious to least serious threat

Ranking of threats

1. Peatland fire frequency (increase with climate change)
2. Reduced water supply (decrease with climate change)
3. Weeds and feral horses
4. Water diversion due to roading
5. Water diversion due to aqueducts
6. Resort development

Decision support

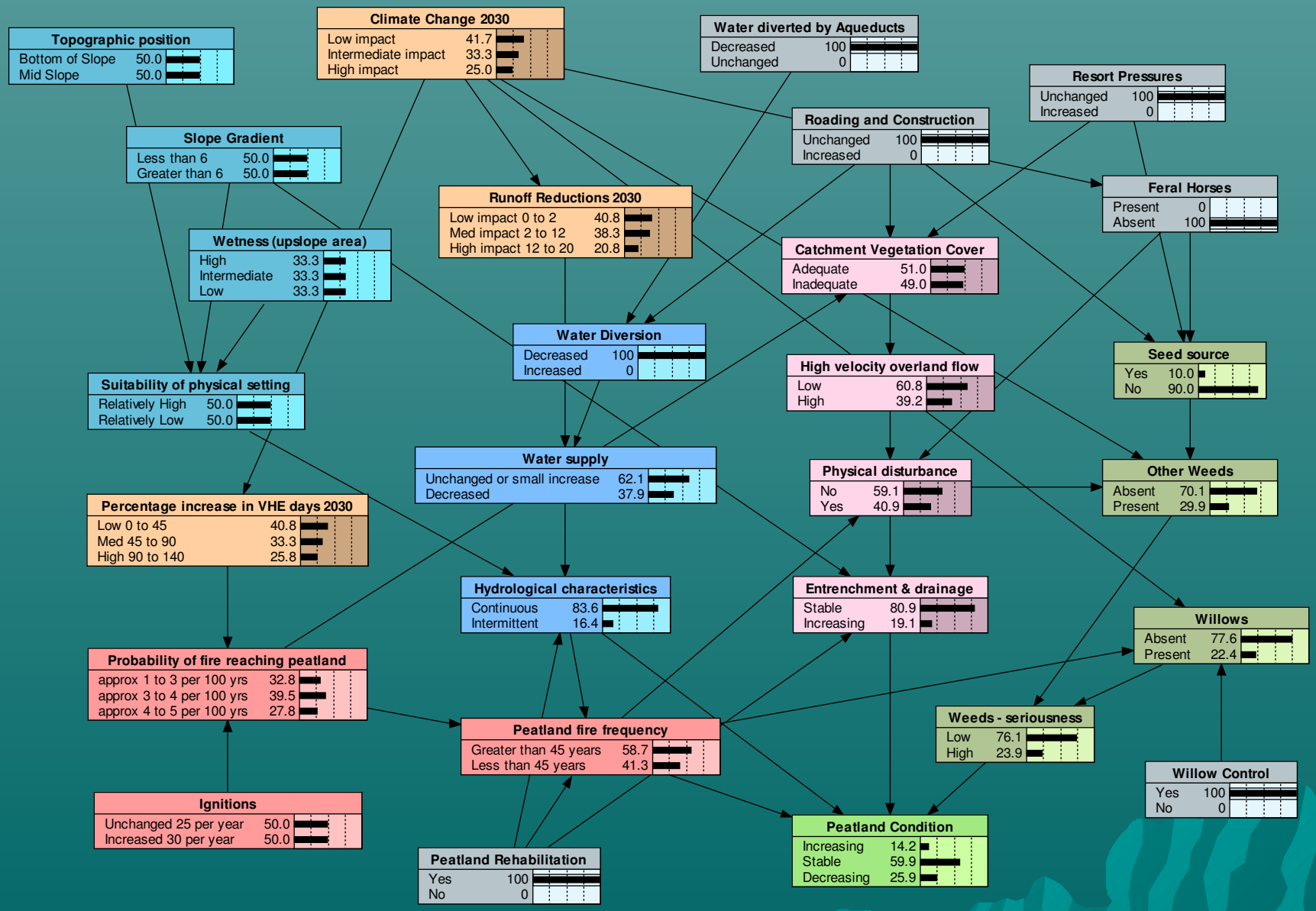
Positive management interventions

- active rehabilitation and willow control
- water diversion from aqueducts decreased
- roading and construction & resort pressures unchanged
- feral horses absent

Negative management interventions

- no rehabilitation or willow control
- water diversion from aqueducts unchanged
- roading and construction & resort pressures increased
- feral horses present

Scenario testing



Decision support

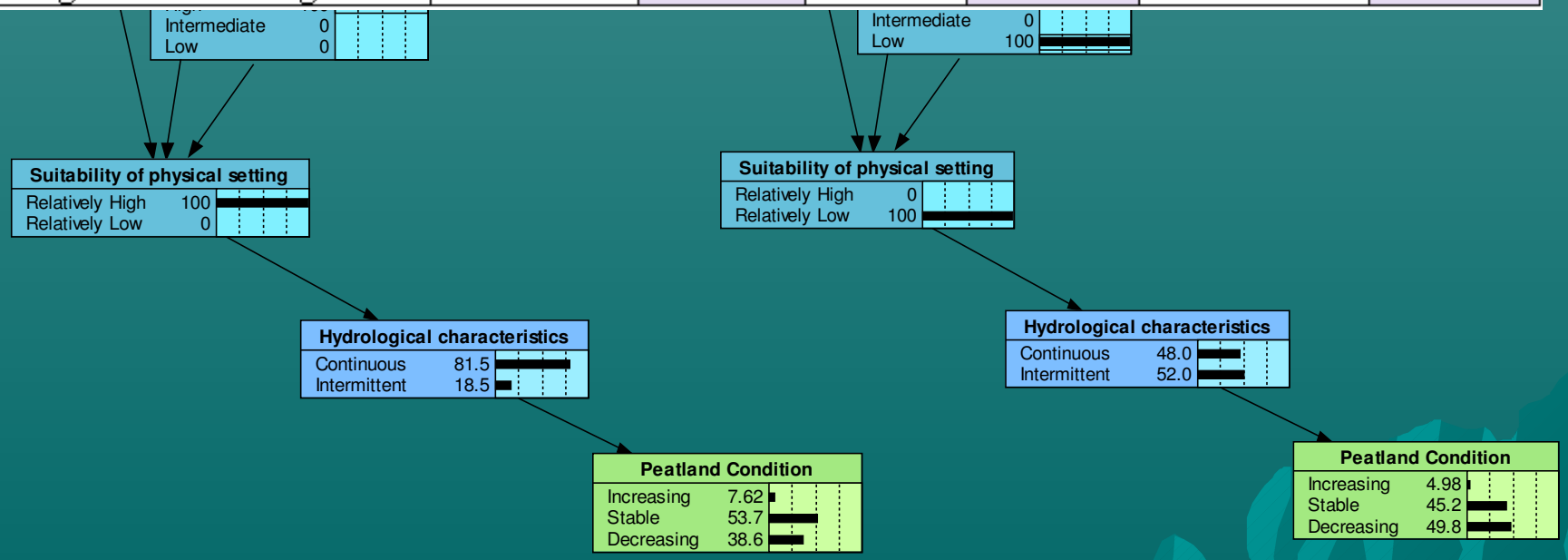
Climate change and management

Peatland Condition	Increasing	Stable	Decreasing
No active management	6	50	44
Climate change findings:			
low impact	10 (4)	58 (8)	32 (-12)
intermediate impact	6 (0)	48 (-2)	46 (2)
high impact	3 (-3)	42 (-8)	55 (11)

Peatland Condition	Increasing	Stable	Decreasing
All interventions positive	14	60	26
Climate change findings:			
low impact	20 (14)	66 (16)	14 (-30)
intermediate impact	12 (6)	58 (8)	30 (-14)
high impact	7 (1)	52 (2)	41 (-3)
All interventions negative	1	38	61
Climate change findings:			
low impact	3 (-3)	45 (-5)	52 (8)
intermediate impact	1 (-5)	37 (-13)	62 (18)
high impact	0 (-6)	33 (-17)	67 (23)

Case studies: physical setting

Peatland Condition	Increasing	Change	Stable	Change	Decreasing	Change
Langford Gap	8		54		38	
All management nodes positive	16	8	62	8	22	-16
All management nodes negative	2	-6	44	-10	54	16
Mt Nelse North	5		45		50	
All management nodes positive	13	7	58	13	30	-20
All management nodes negative	0.5	-4.5	31	-14	68.5	18.5



Individual interventions

Management Interventions	Peatland Condition		
	Increasing	Stable	Decreasing
Peatland rehabilitation – present	10 (4)	56 (6)	34 (-10)
Peatland rehabilitation – absent	2 (-2)	43 (-7)	55 (9)
Feral horses – absent	7 (1)	51 (1)	42 (-2)
Feral horses – present	5 (-2)	49 (0)	46 (2)
Willow control – yes	7 (1)	50 (0)	43 (-1)
Willow control – no	6 (0)	48 (-2)	46 (2)
Roading & construction – unchanged	7 (1)	51 (1)	42 (-2)
Roading & construction – increased	6 (0)	48 (-2)	46 (2)
Aqueducts – diversion decreased	7 (1)	50 (0)	43 (-1)
Aqueducts – diversion unchanged	6 (0)	48 (-2)	46 (2)
Resort pressures – unchanged	6 (0)	50 (0)	44 (0)
Resort pressures – increased	6 (0)	50 (0)	44 (0)

Exposure
(will the climate change where this habitat occurs?

SE Australia: increased temp & ET, decreased runoff

Sensitivity
(will changing climate impact on this habitat?)

Distribution models: 2030
decrease 20% runoff
up to 30% decrease in extent

Potential impact

Adaptive capacity
(does the system have the capacity to adapt via autonomous adaptation or human intervention?)

We are uncertain of the autonomous adaptive capacity of Aust. Alpine plants

Vulnerability

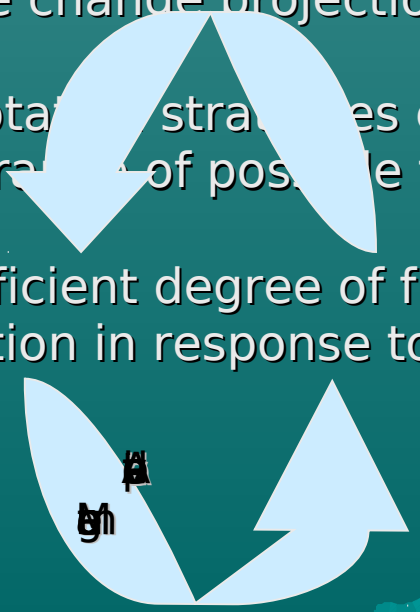
CSIRO (2007), *Climate change in Australia*.

Giorgi, F., Hurrell, J. W., Marinucci, M. R. and Beniston, M. (1997).Elevation dependency of the surface climate change signal: A model study. *Journal of Climate* 10: 288-296.

Byars, S. G., Papst, W. and Hoffmann, A. A. (2007). Local adaptation and cogradient selection in the alpine plant, *Poa hiemata*, along a narrow altitudinal gradient. *Evolution* 61: 2925-2941.

What are the implications?

- Warming will continue long past 2100
- Identification of adaptation strategies are therefore very important
- There are many uncertainties associated with the outcomes of peatland intervention and with climate change projections
- Robust adaptation strategies effective under a broad range of possible futures are required
- Retain a sufficient degree of freedom for course correction in response to monitoring



Uncertainties (knowledge gaps)

- Response to rehabilitation
  - which methods
  - to what degree can condition be increased
  - reduce likelihood of burning, increase resilience to reduced water supply
- Feral horse numbers
  - effect of climate change
  - effectiveness of management
- Willows
  - impact on function and condition
  - effectiveness of management
- Other weeds
  - what we be the future weed threats
- Environmental flows
  - acceptability to stakeholders

Thank you

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