Integrating experts' knowledge into Bayesian Networks – The case of ecosystem services of urban and peri-urban vegetation in Xinjiang, NW China

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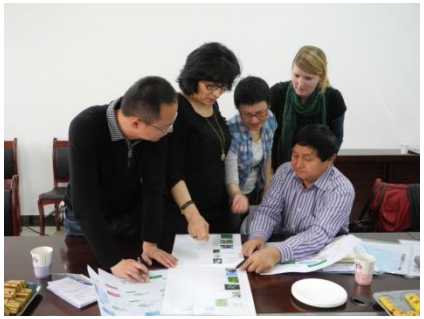
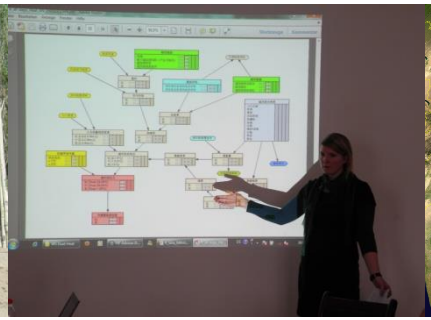
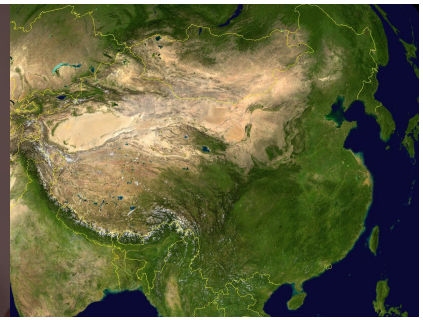
*** KU Eichstätt-Ingolstadt, ****Xinjiang Normal University

5th Annual Conference of the Australasian Bayesian Network Modelling Society,
Hobart, 27-28 November 2013



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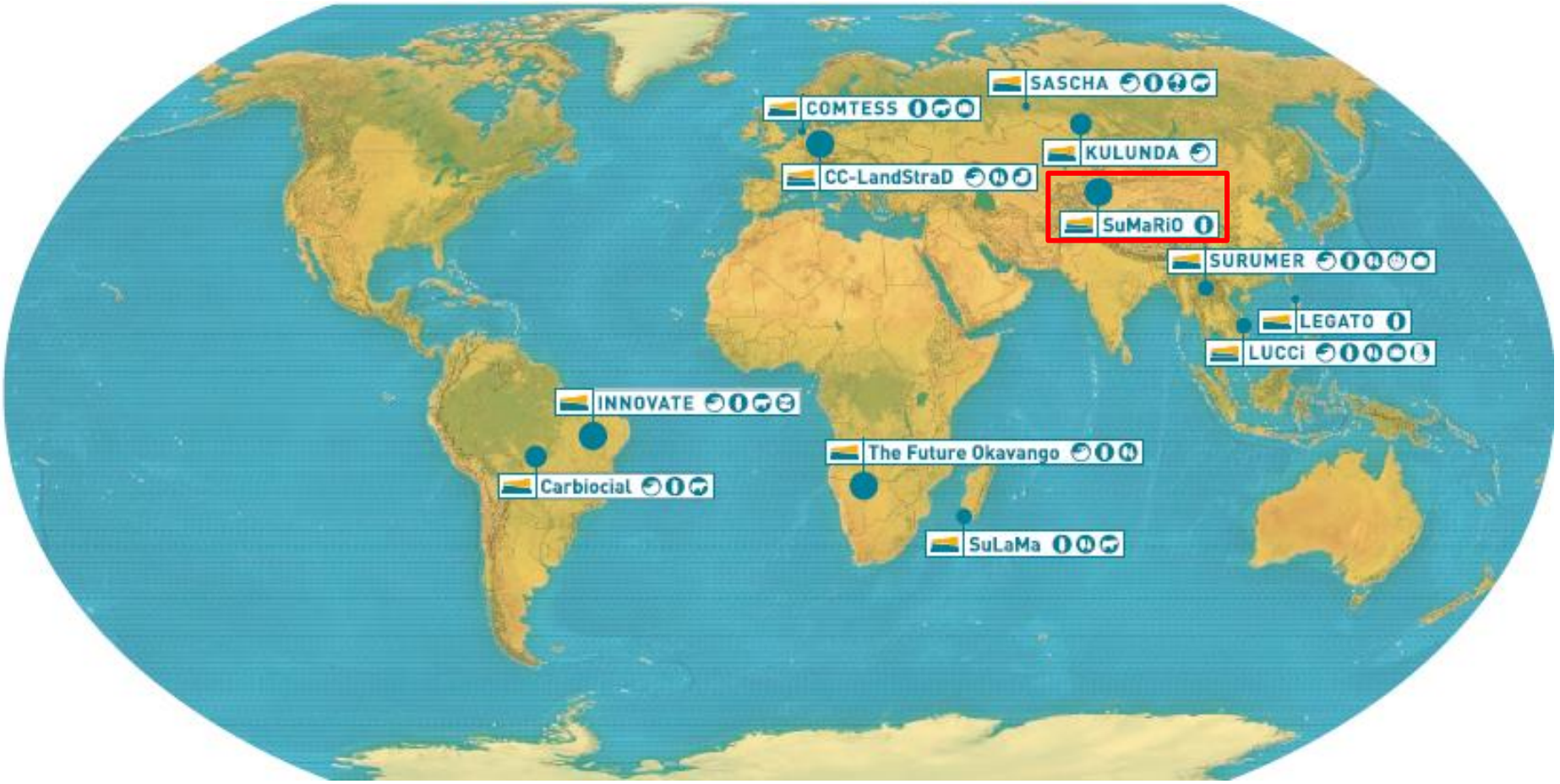

A

»INTERACTIONS BETWEEN LAND MANAGEMENT, CLIMATE CHANGE AND ECOSYSTEM SERVICES«

MODULE

Federal Ministry of Education and Research

Sustainable Management of River Oases along the Tarim River (SuMaRiO)

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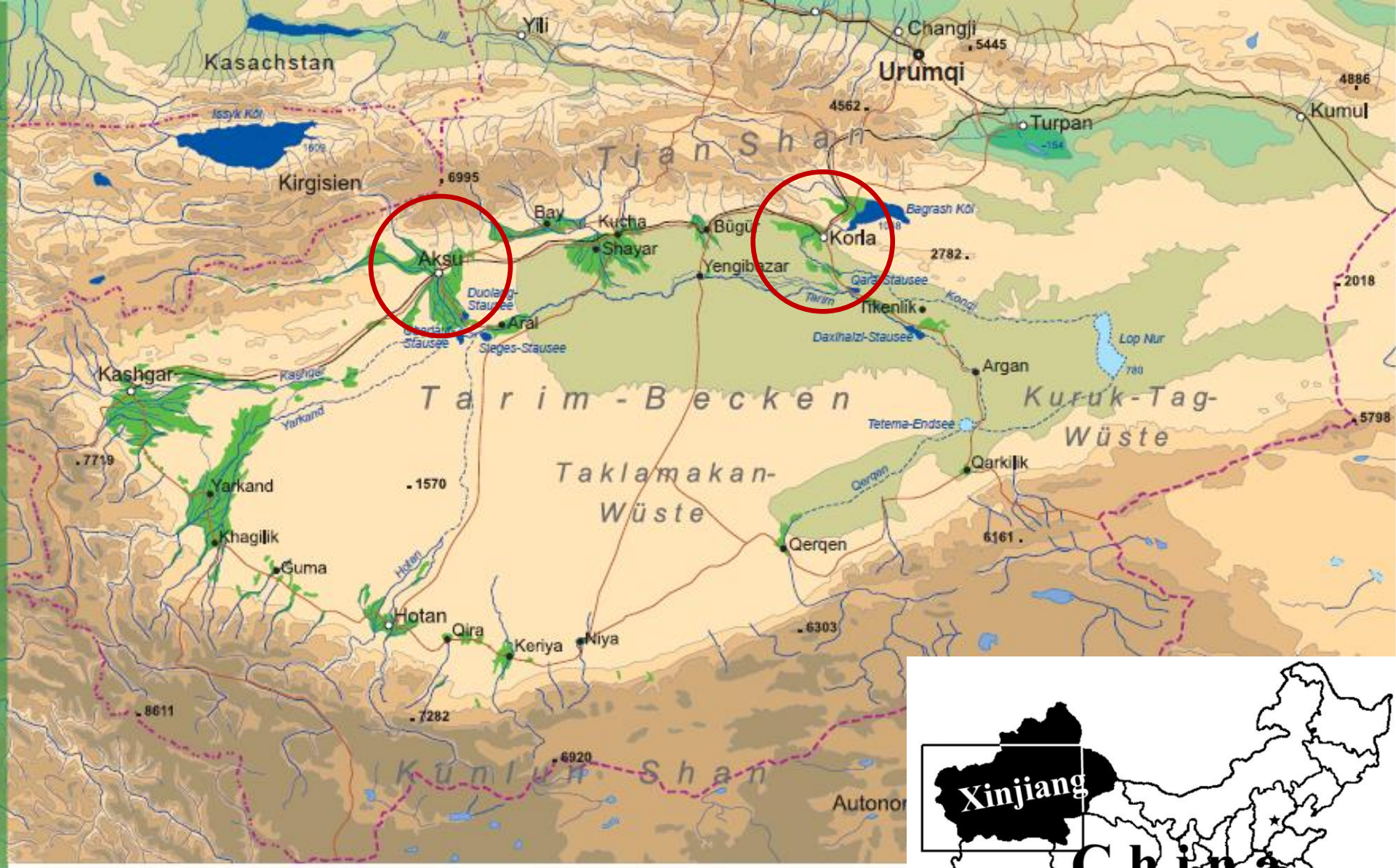

Staatsgrenze VR China
Provinzgrenze Xinjiang
Fernstraße mit Ortschaft
Eisenbahn

Oasen / Bewässerung
Süßwasser- /Stauseen
Salzwasserseen
Ausgetrocknete Seen
Fluss

> 5000
4000 - 5000
3000 - 4000
2000 - 3000
1000 - 2000
500 - 1000
0 - 500
< 0 m NN

Environmental problems in oasis towns: Dust weather & urban heat stress

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Aims

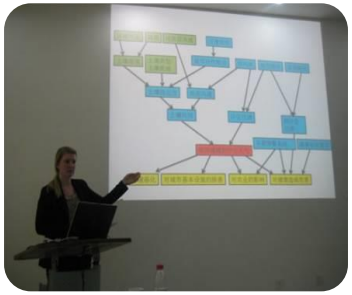
1. To inform local planners, managers, decision-makers
2. To apply, adapt & evaluate Bayesian Networks for transdisciplinary knowledge integration

Model purpose

- To identify plant/tree species that are most effective to mitigate dust weather and urban heat stress while requiring the least irrigation

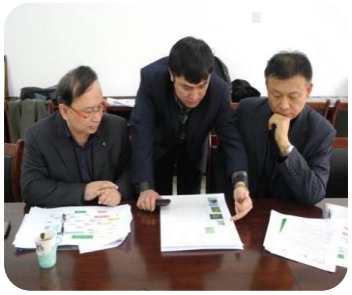
- Management options (root nodes): Increase/decrease extent of vegetation; 17 plant species in urban/peri-urban areas

Research plan



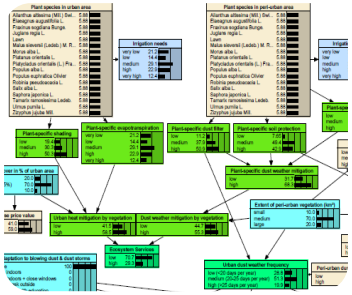
2011: Expert interviews in Aksu, Korla & Beijing

2012: Expert interviews in Germany & Aksu, First Workshop in Urumqi



2013: Expert interviews in Germany

Second Workshop in Korla



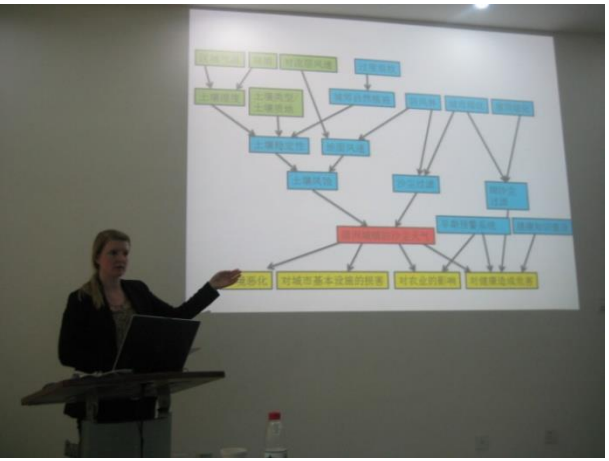
2014: Third Workshop in Korla

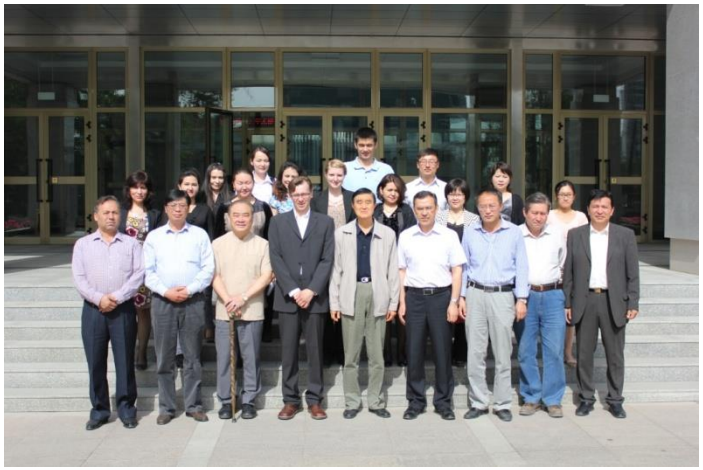
Interviews and Workshop 2011/2012

Interview partners in 2011/2012	Workshop participants, Urumqi 2012
• Aksu Environment Protection Bureau • Aksu Urban Greening Committee • Aksu Forestry Bureau • Aksu Agriculture Bureau • Aksu Urban Construction Bureau (Urban Vegetation dept.) • Korla Urban Greening Bureau • China Center for Sustainable Development Research , Beijing • College of Architecture and Landscape Architecture, Beijing University • School of Public Health, Department of Toxicology, Beijing University	• Urumqi Urban Greening Committee • Aksu Institute of Forestry Research • Xinjiang Forestry Academy • Xinjiang Bureau of Meteorology • Xinjiang Agricultural University • Xinjiang Academy of Social Sciences • Xinjiang Normal University • Xinjiang University

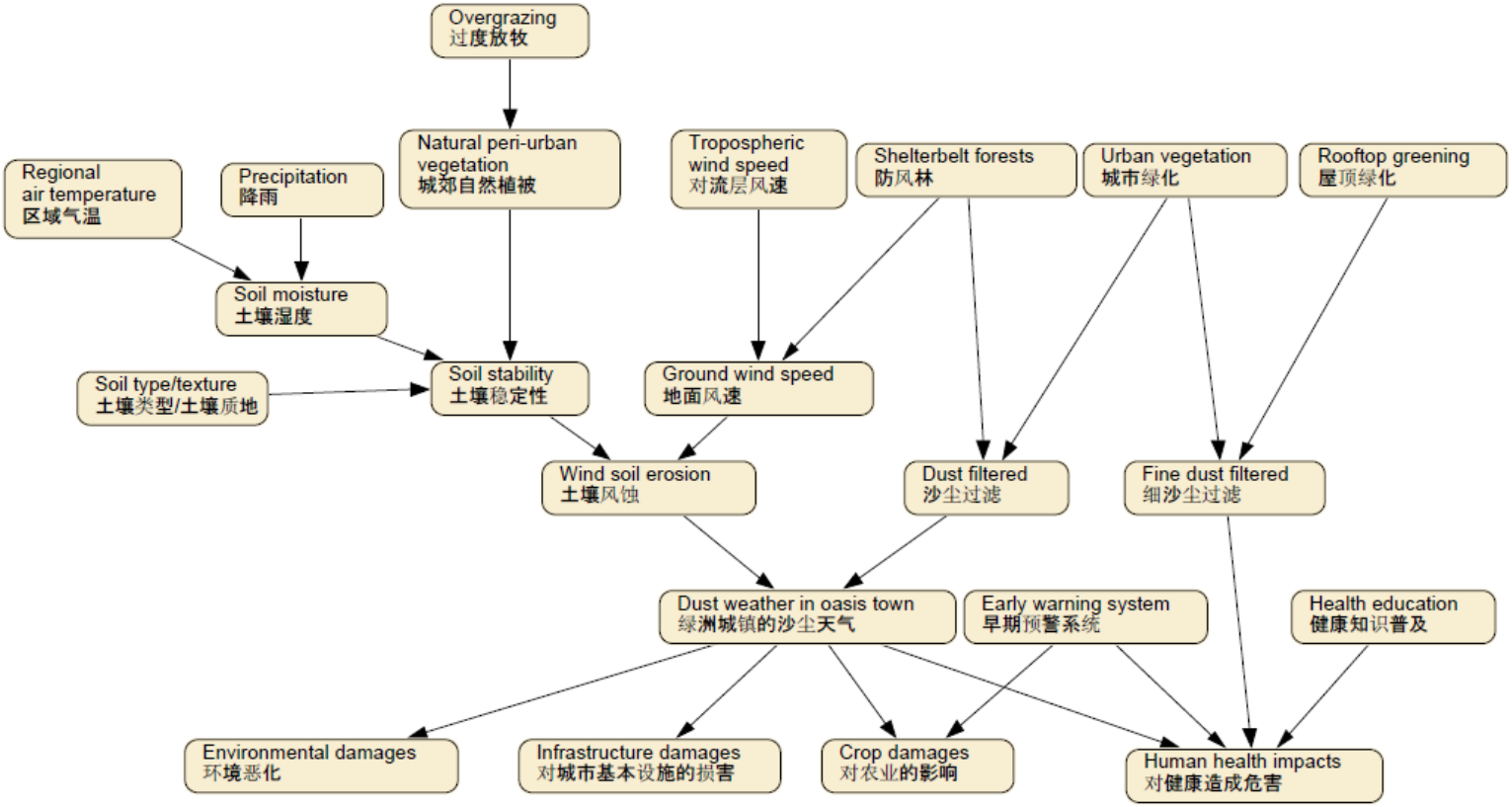
First Workshop in Xinjiang (May 2012)

- Chinese scientists and institutional stakeholders discussed and improved causal network structure (plus questionnaire & workshop evaluation)
- BNs are very visual & easily facilitate discussions (19 new nodes added to preliminary BN during a 1hr discussion)

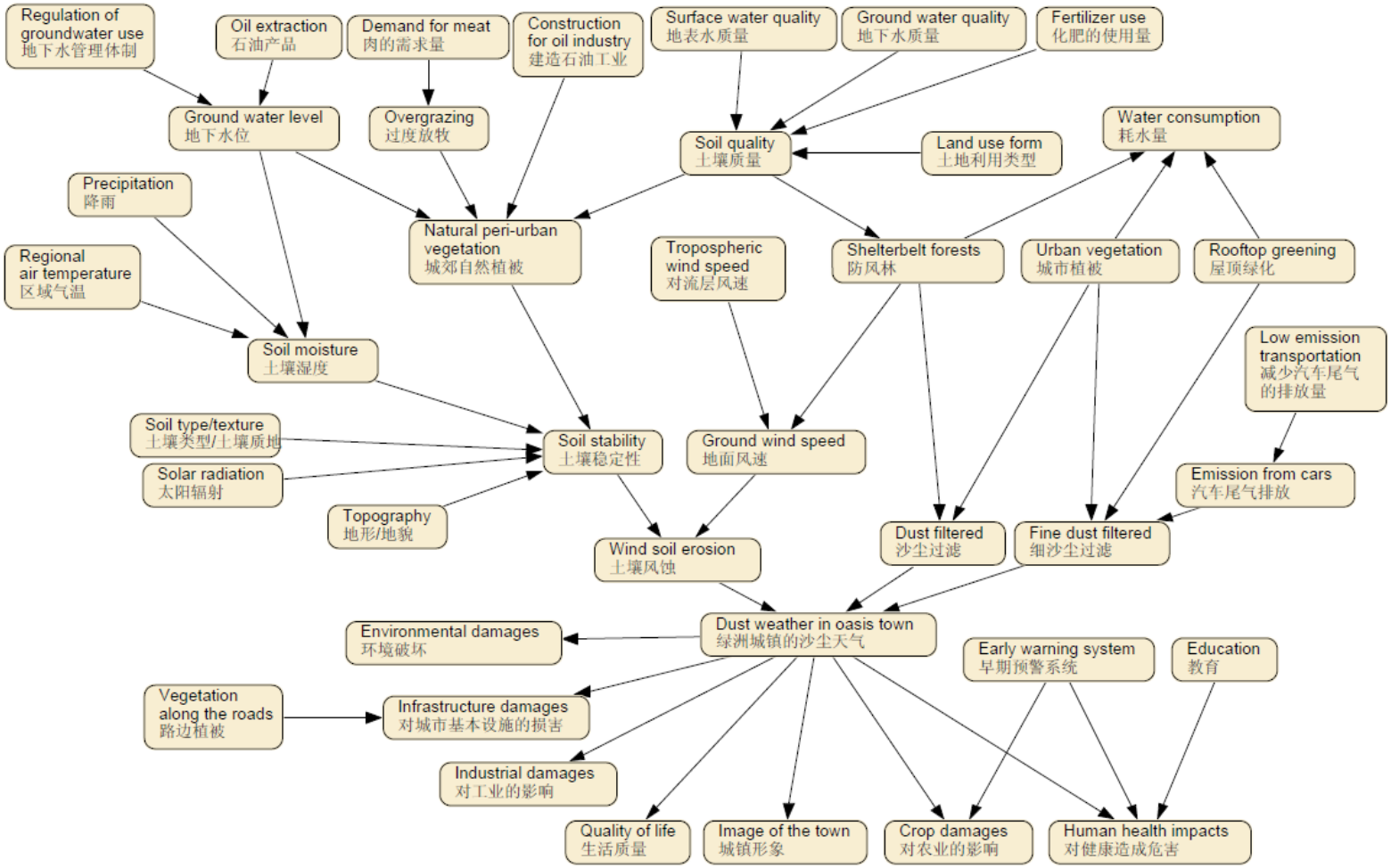


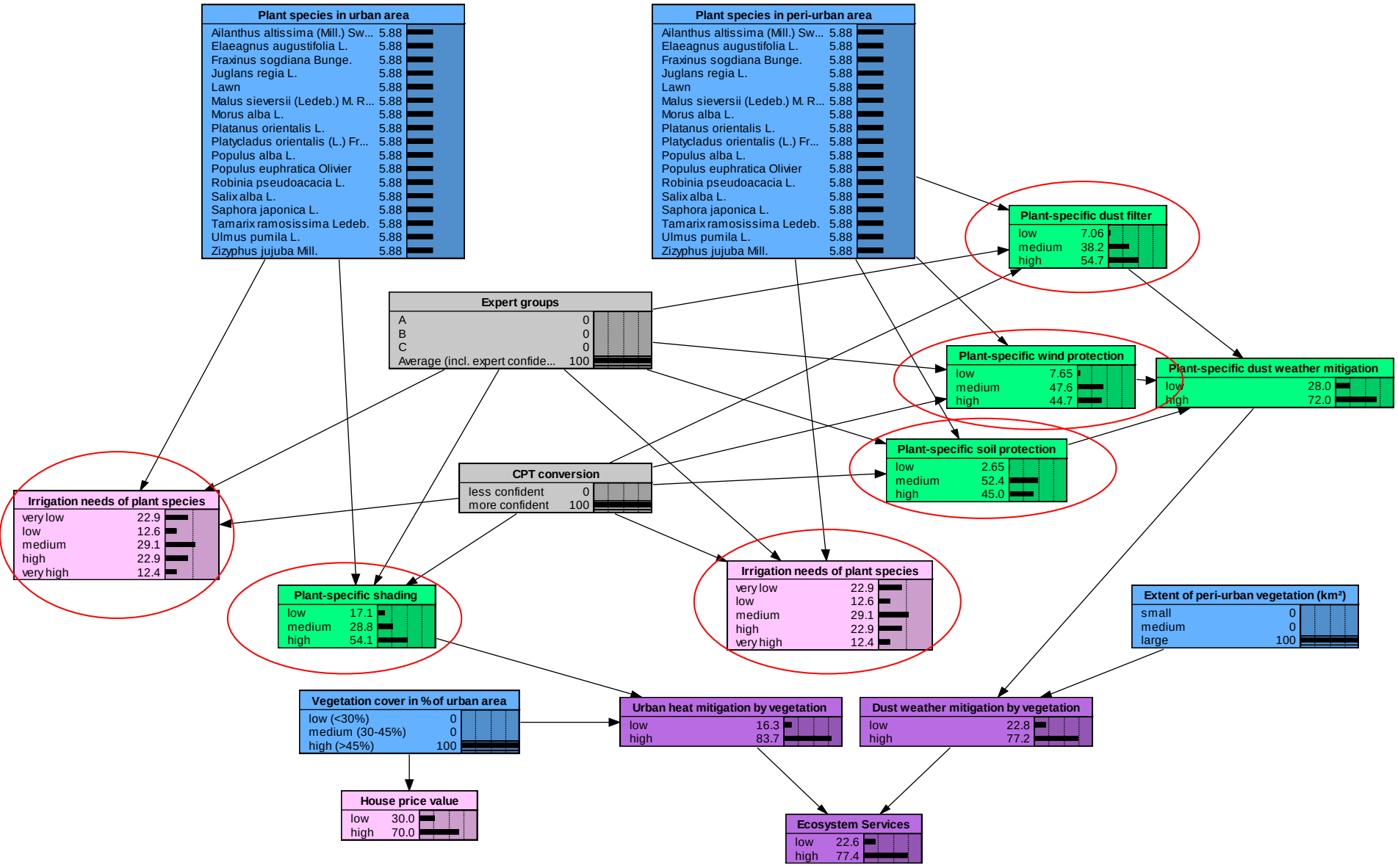


Causal network before Workshop 1



Causal network after Workshop 1




Plant species in urban area
Ailanthus altissima (Mill.) Sw... 5.88
Elaeagnus augustifolia L. 5.88
Fraxinus sogdiana Bunge. 5.88
Juglans regia L. 5.88
Lawn 5.88
Malus sieversii (Ledeb.) M. R... 5.88
Morus alba L. 5.88
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Platycladus orientalis (L.) Fr... 5.88
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Plant species in peri-urban area
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Plant-specific dust filter
low 7.06
medium 38.2
high 54.7
Expert groups
A 0
B 0
C 0
Average (incl. expert confide... 100
Plant-specific wind protection
low 7.65
medium 47.6
high 44.7
Plant-specific dust weather mitigation
low 28.0
high 72.0
Plant-specific soil protection
low 2.65
medium 52.4
high 45.0
CPT conversion
less confident 0
more confident 100
Irrigation needs of plant species
very low 22.9
low 12.6
medium 29.1
high 22.9
very high 12.4
Plant-specific shading
low 17.1
medium 28.8
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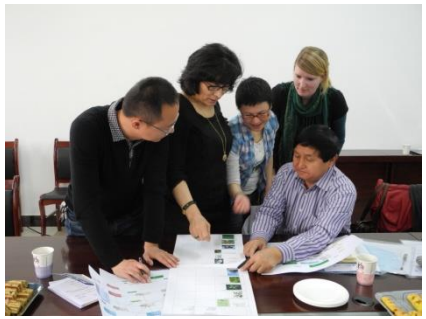
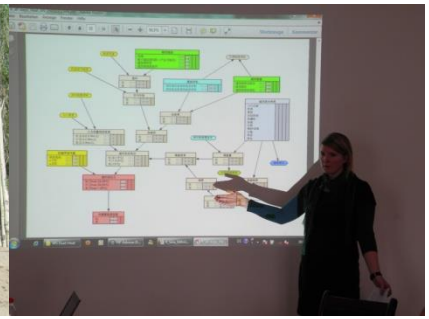
Extent of peri-urban vegetation (km²)
small 0
medium 0
large 100
Vegetation cover in % of urban area
low (<30%) 0
medium (30-45%) 0
high (>45%) 100
Urban heat mitigation by vegetation
low 16.3
high 83.7
Dust weather mitigation by vegetation
low 22.8
high 77.2
House price value
low 30.0
high 70.0
Ecosystem Services
low 22.6
high 77.4

Second Workshop in Xinjiang (March 2013)

Second Workshop

- Bayesian networks require conditional probability tables – however it was easier for workshop participants to express their knowledge in other units (0-1, - to +++)
- Experts‘ knowledge on urban and peri-urban vegetation elicited (combination of CPTs and other tables) – always including confidence





		Irrigation needs (between 0 - 1) 1 highest need 0 lowest need	Soil stability Very high +++ high ++ rather high + low –	Wind protection Very high +++ high ++ rather high + low –	Dust filter Very high +++ high ++ rather high + low –
1	臭椿 Ailanthus altissima (M.) Swing. (Götterbaum)				
2	沙枣 Elae (Schmalblätt				
3	核桃 Jugla				

		Irrigation needs (between 0 - 1) 1 highest need 0 lowest need	Shading by canopy Very high +++ high ++ rather high + low –
1	小叶白蜡 Fraxinus sogdi Bunge. (Fluß-Esche)		
2	核桃 Juglans		
3	桑树 Morus c		

	Potential to improve shading very high +++ high ++ rather high + low –
Arcades	
Narrow roads	

How confident are yo
□ very confident
□ rather confident

Soil moisture	Extent of the peri-urban vegetation	Soil stability	
		low	high
low	small		
high	small		
low	medium		
high	medium		
low	large		
high	large		

How confident are you with your estimates?

□ very confident □ rather unconfident

□ rather confident □ very unconfident

Workshop 2: Selection of tables used to elicit experts' knowledge

Conversion of expert knowledge into conditional probability tables (CPTs)

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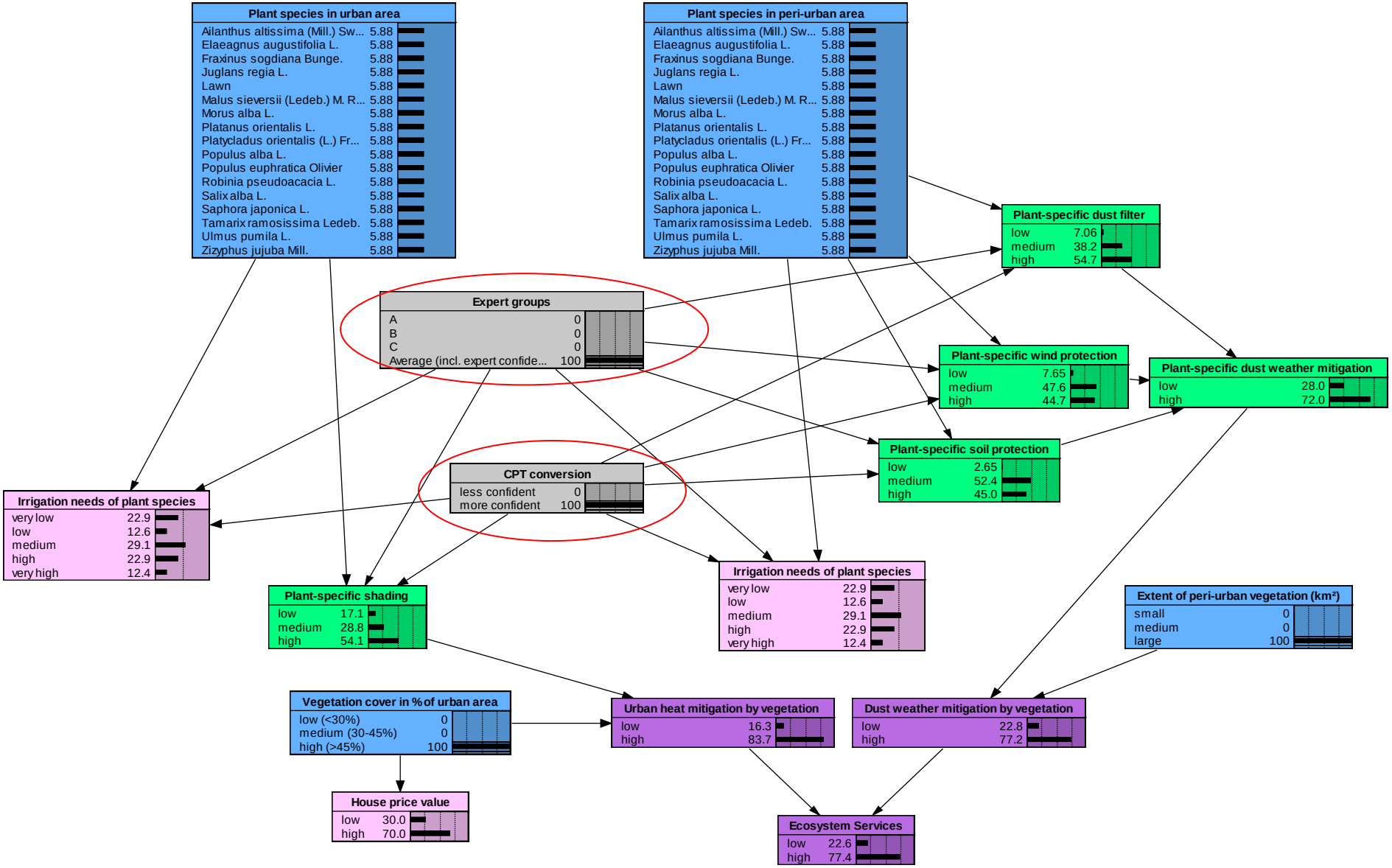
1. Calculation of weighted average (incl. confidence) for 3 expert groups
2. Conversion into conditional probability tables
   - Values 0-1
   - Values 0-3 (– to +++)
   - Hierarchical ranking (bringing combinations of states into a hierarchy from most favorable to least favourable according to literature & expert opinion)

沙尘天气管理的贝叶斯网络:加权平均数

		Irrigation needs (between 0 - 1) 1 highest need 0 lowest need	Soil stability Very high +++ (3) high ++ (2) rather high + (1) low – (0)	Wind protection Very high +++ (3) high ++ (2) rather high + (1) low – (0)	Dust filter Very high +++ (3) high ++ (2) rather high + (1) low – (0)
1	臭椿 Ailanthus altissima (M.) Swing. 	0.23	1.43	1.38	1.75
2	沙枣 Elaeagnus augustifolia L. 	0.13	2.43	2.63	2.38
3	核桃 Juglans regia L. 	0.57	1.71	2	2.13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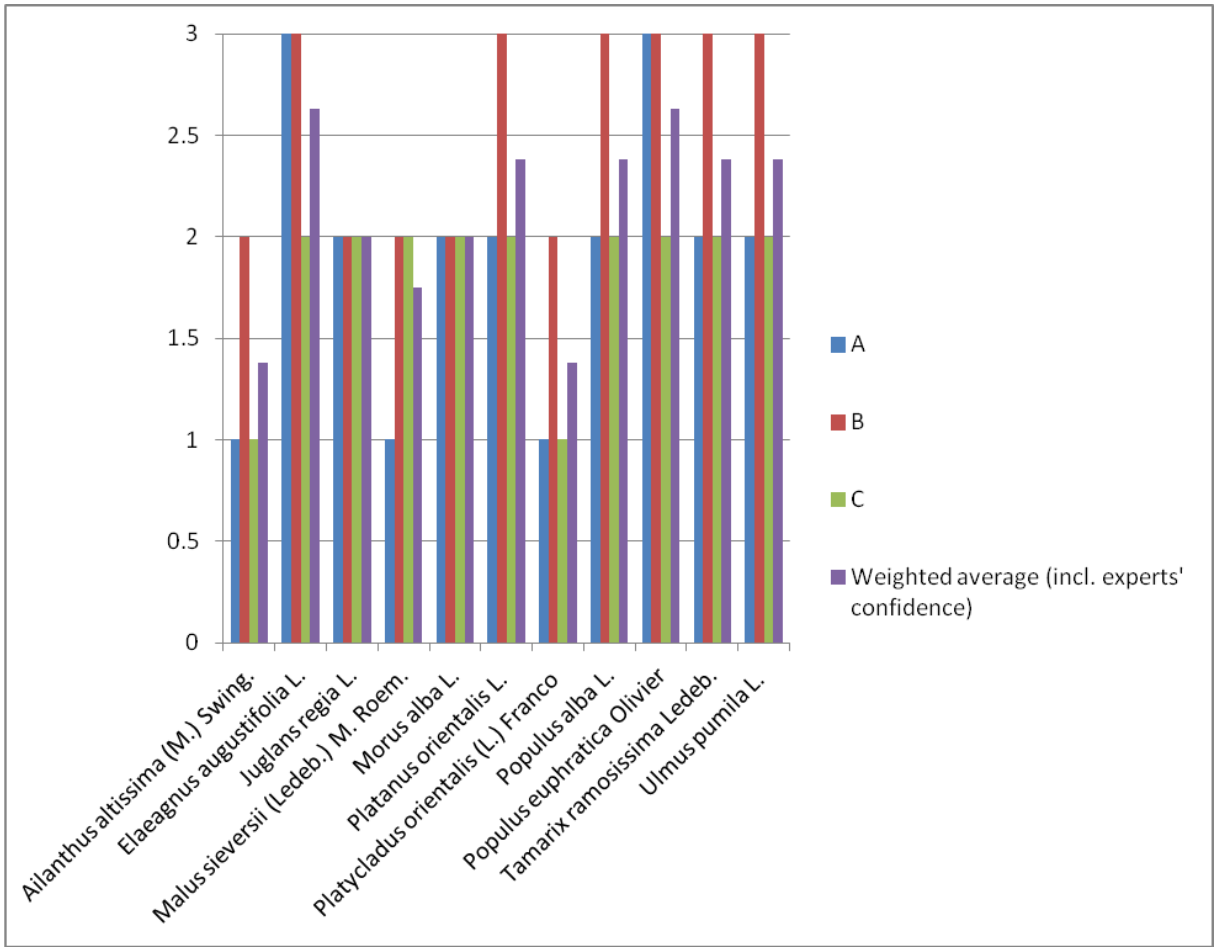


Estimates on plant-specific wind protection in – to +++ (0-3)

of three expert groups (A, B, C)

CPT conversion for values 0-1 and 0-3 (for nodes with 3 and 5 states), less and more confidence in experts' estimates

	less confident				
	very low (0-0.20)	low (0.21-0.40)	medium (0.41-0.60)	high (0.61-0.80)	very high (0.81-1)
0-0.05	90	10	0	0	0
0.06-0.15	80	15	5	0	0
0.16-0.20	70	20	10	0	0
0.21-0.25	20	70	10	0	0
0.26-0.35	10	80	10	0	0
0.36-0.40	10	70	20	0	0
0.41-0.45	0	20	70	10	0
0.46-0.55	0	10	80	10	0
0.56-0.60	0	10	70	20	0
0.61-0.65	0	0	20	70	10
0.66-0.75	0	0	10	80	10
0.76-0.80	0	0	10	70	20
0.81-0.85	0	0	10	20	70
0.86-0.95	0	0	5	15	80
0.96-1	0	0	0	10	90

	more confident				
	very low (0-0.20)	low (0.21-0.40)	medium (0.41-0.60)	high (0.61-0.80)	very high (0.81-1)
0-0.05	100	0	0	0	0
0.06-0.15	90	10	0	0	0
0.16-0.20	80	15	5	0	0
0.21-0.25	15	80	5	0	0
0.26-0.35	5	90	5	0	0
0.36-0.40	5	80	15	0	0
0.41-0.45	0	15	80	5	0
0.46-0.55	0	5	90	5	0
0.56-0.60	0	5	80	15	0
0.61-0.65	0	0	15	80	5
0.66-0.75	0	0	5	90	5
0.76-0.80	0	0	5	80	15
0.81-0.85	0	0	5	15	80
0.86-0.95	0	0	0	10	90
0.96-1	0	0	0	0	100

CPT conversion for values 0-3 (for nodes with 3 states), less and more confidence in experts' estimates

less confident

	low (0-1.0)	medium (1.1-2.0)	high (2.1-3)
0-1.0	80	15	5
1.1-2.0	10	80	10
2.1-3	5	15	80

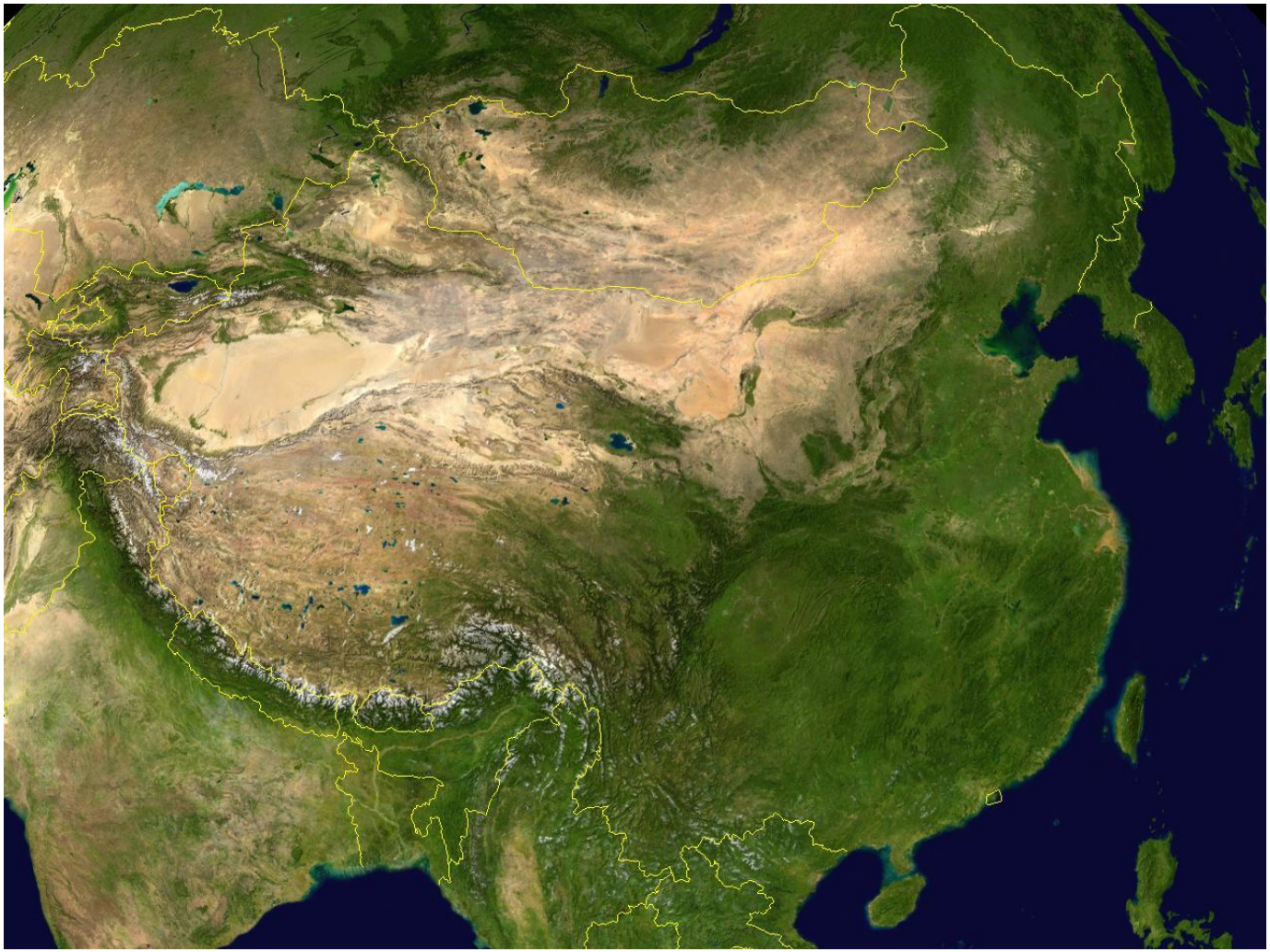
more confident

	low (0-1.0)	medium (1.1-2.0)	high (2.1-3)
0-1.0	90	10	0
1.1-2.0	5	90	5
2.1-3	0	10	90

To do

- Bayesian Networks/Bayesian Decision Networks need to be tested and evaluated
  - Formal model evaluation by experts (December 2013)
  - Add provisioning services to the BN
- Preparations for third workshop (March 2014)

Thank you!



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