Ranking relative importance of marine monitoring related parameters with Bayesian networks

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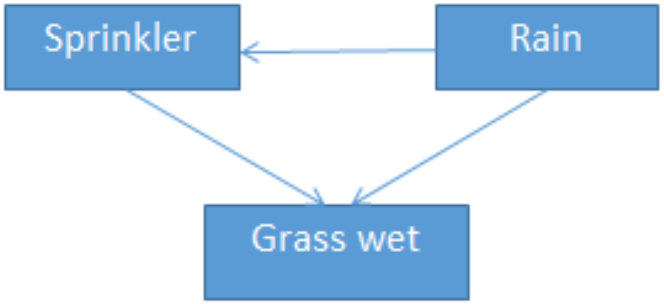
Hierarchical Bayesian networks

- Directed acyclic graph that represents a set of random variables and their conditional dependencies
- Nodes represent variables and edges represent dependencies between them
- $p(\theta|x) \propto p(x|\theta)p(\theta)$
- $p(\theta, \varphi|x) \propto p(x|\theta)p(\theta|\varphi)p(\varphi)$



Data description

- A questionnare/survey for the researchers of marine monitoring in Finland, N=10

- Three stages
  - Descriptors (11)
  - Indicators (115)
  - Variables (42)

- Importance, expertise, cost


$\alpha_{D1.exp}$
D1.exp$_i$
$\alpha_{D1.imp}$
D1.imp$_i$
$\alpha_{I111.exp}$
I111.exp$_i$
$\alpha_{I173.exp}$
I173.exp$_i$
$\alpha_{I111.imp}$
I111.imp$_i$
$\alpha_{I173.imp}$
I173.imp$_i$
Value.I111$_i$
Value.I173$_i$
$\alpha_{Var1.I111.imp}$
Var1.I111$_i$
$\alpha_{D11.exp}$
D11.exp$_i$
$\alpha_{D11.imp}$
D11.imp$_i$
$\alpha_{I1122.exp}$
I1122.exp$_i$
$\alpha_{I1122.imp}$
I1122.imp$_i$
Value.I1122$_i$
$\alpha_{Var1.I1122.in}$
Var1.I1122$_i$
Value.Var1$_i$

Results - Descriptors

	Descriptor	Mean	Sd
D5	Eutrophication	**52,87**	1,42
D1	Biodiversity	**49,28**	2,03
D4	Food webs	**48,24**	2,00
D8	Contaminants	**48,10**	2,01
D9	Contaminants in seafood	46,54	1,33
D3	Commercial fish and shellfish	46,03	1,95
D2	Non-indigenous species	40,28	1,34
D6	Sea-floor integrity	32,98	1,59
D10	Marine litter	31,96	1,24
D7	Hydrographical conditions	30,90	1,28
D11	Energy incl. underwater noise	29,84	1,18

Results - Indicators

D5, eutrophication	Mean	Sd
Concentration of chlorophyll a	**50,72**	1,39
Water transparency	**49,69**	1,37
…		
Concentrations of toxic substances by dinoflagellates (PST and DST) in plankton	30,72	1,69
Length of Cladophora length	30,26	1,74

D1, Biodiversity	Mean	Sd
Abundance of breeding seabirds (fish and benthic feeders)	**44,44**	2,08
Number of threathened marine species	**41,04**	1,86
…		
Bycatch of grey seal and ringed seal	29,50	1,94
The proportion of trapnets that are non-mortal to seals	28,29	2,04

D4, food webs	Mean	Sd
White-tailed sea eagle reproductive capacity	**45,99**	2,11
Abundance of cyprinids in coastal waters	**41,43**	2,08
…		
Amount of hunted seals	29,72	2,33
Cathces of cyprinids in removal fisheries	27,95	1,91

D11, energy incl. underwater noise	Mean	Sd
Amount of days when anthropogenic impulsive noise causes impacts on marine biota	**35,98**	1,97
Temporal change in noise in the enviroment	31,26	1,24
Change in temperature regime: impacts of introduced heat	24,64	0,98
Change in temperature regime: amount of introduced heat	19,34	1,16

Results – Indicators (the big picture)

Desc.	Indicator	Mean	Sd
D5	Concentration of chlorophyll a	**245,40**	7,81
D5	Water transparency	**240,30**	7,70
D5	Concentrations of phosphate, nitrogen and silicate	**235,00**	7,77
D5	Annual inputs of waterborne nutrients	**226,00**	6,65
D5	Oxygen concentration in near-bottom water and the distribution and area of anoxic areas	**214,80**	9,56
D4	White-tailed sea eagle reproductive capacity	**206,50**	10,90
D5	Atmospheric deposition of nutrients	**205,10**	6,33
D1	Abundance of breeding seabirds (fish and benthic feeders)	**204,10**	10,66
D5	The condition of the Fucus vesiculosus belt (ratio of Fucus and filamentous algae)	**200,50**	9,33
D5	Lower depth limits of bladderwrack and red algae	**198,50**	9,68
	…		
D10	Amount of macroscopic sea-floor litter	87,99	4,22
D6	Recovery of dumping areas to natural state	84,93	6,92
D11	Change in temperature regime: impacts of introduced heat	66,56	3,92
D10	Amount of collected litter	52,43	4,60
D11	Change in temperature regime: amount of introduced heat	52,36	4,63

Results - Variables

Considering only indicators

Variable	Mean	Sd
Fish	**770,20**	15,76
Synthetic compounds	**497,50**	15,51
Salinity	**468,50**	15,58
Temperature	**450,70**	15,60
Chlorophyll	**436,70**	22,21
P inputs	**407,20**	15,59
Benthic fauna	**405,40**	15,63
N inputs	**404,00**	15,59
DIP	**386,00**	15,60
DP	**385,40**	15,47
…		
Erosion	214,10	15,44
Noise	210,70	15,43
pCO2	209,30	15,52
Radionuclids	200,90	15,38
Micro pathogens	177,00	15,37

Considering the big picture

Variable	Mean	Sd
Fish	**12130,00**	234,40
Synthetic compounds	**7388,00**	229,70
P inputs	**7114,00**	237,10
N inputs	**7082,00**	237,30
Chlorophyll	**6992,00**	376,50
Salinity	**6904,00**	239,90
DIP	**6508,00**	232,90
DP	**6505,00**	231,50
Benthic fauna	**6494,00**	233,80
TN	**6484,00**	231,60
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Erosion	3138,00	229,20
Littering	3101,00	228,40
Radionuclids	3003,00	228,00
Noise	2925,00	229,00
Micro pathogens	2642,00	228,50

Conclusions

- Bayes networks can be used to rank monitoring parameters
- The results could be used to allocate resources more effectively
- The results of this model are no absolute truths but are based on expert opinions