



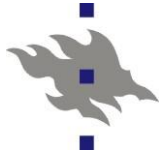
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Ecological and social goals in forest planning - MCDM solutions

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Integrated planning approach

- All goals are included in one optimization problem
 - in principle the optimal way
- MOLP as an example

$$\max \left\{ \begin{array}{l} \sum_{j=1}^n c_j x_j \\ \dots \\ \sum_{j=1}^n d_j x_j \end{array} \right.$$

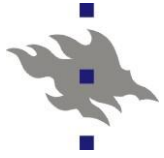
$$\sum_{j=1}^n a_{ij} x_j \leq b_i, \quad i = 1, \dots, m \text{ (input)}$$

$$x_j \geq 0, \quad j = 1, \dots, n \text{ (decision variables)}$$



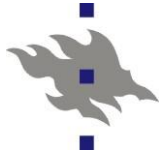
Potential problems in MOLP (1)

- n All goals cannot be expressed in linear form
- n Spatial problems especially are non-linear
 - n connectivity problems
 - increasing core area of old forest
 - clustering harvests
 - n dispersing problems
 - avoiding large clear-cut areas
 - maximizing the edge between adjacent stands
- n Can be solved using metaheuristics
 - n simulated annealing,
 - n tabu search,
 - n ...



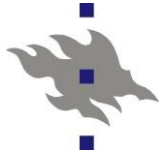
Potential problems in MOLP (2)

- n The relative value of goals need to be assessed
 - n value of ecological goals and (especially) social goals are subjective
 - n how much recreation areas is enough?
 - public opinion
 - changing values of society
- n No objective weights can be given to these goals!
- n No objective target values can be given to these goals!
- n MCDM methods can be used for eliciting the public values
 - n AHP
 - n SMART



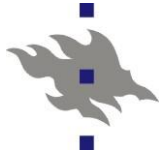
Potential problems in MOLP (3)

- n All goals cannot be expressed in mathematical form
- n No empirical production models for many goods
 - n e.g. biodiversity
 - n recreational values
- n In some cases qualitative information can be transformed to mathematical form
 - n modelling expert opinion
 - n e.g. biodiversity indices based on criteria & indicators
- n In some cases the values are too complicated for that also
 - n e.g. recreational values of hiking routes in a forest

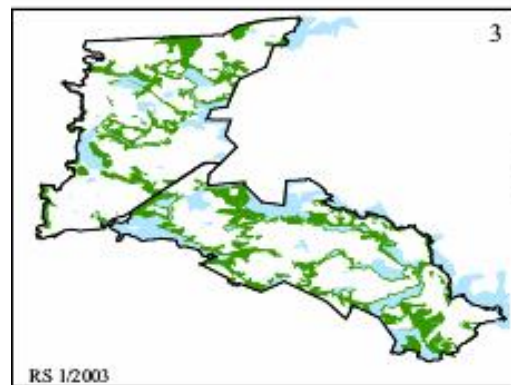
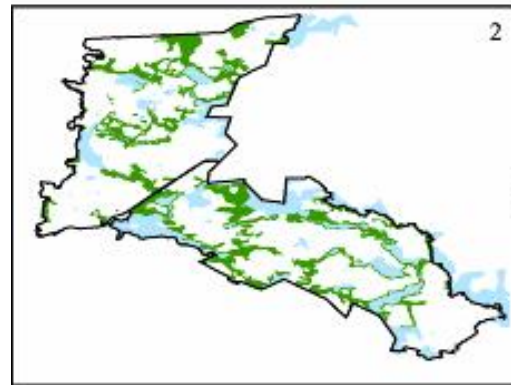
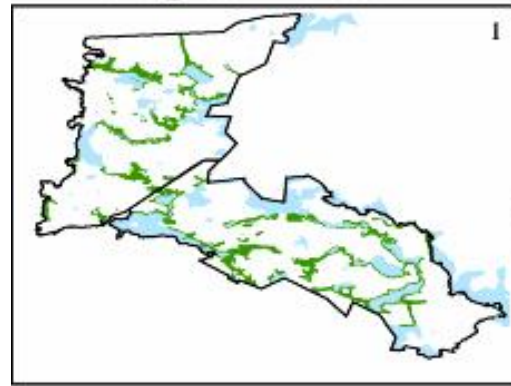


Non-integrated planning approach

- Economic (and any other that have a mathematical form) values are included in an optimization problem
 - the optimization problem (max incomes) is solved several times with different restrictions concerning the other values
- The restrictions come from ecological and sociocultural networks
 - restrictions on treatments suggested to stands belonging to the network
 - and the area of network included

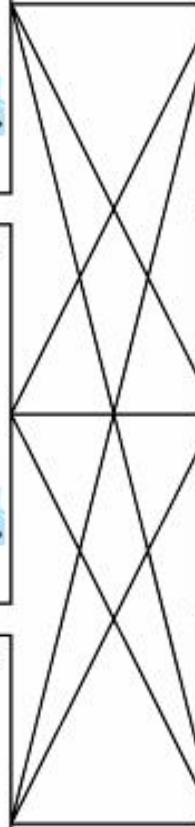
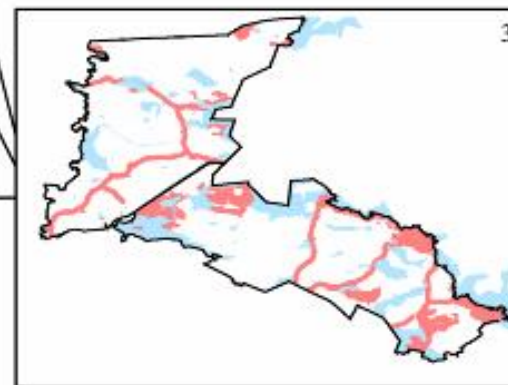
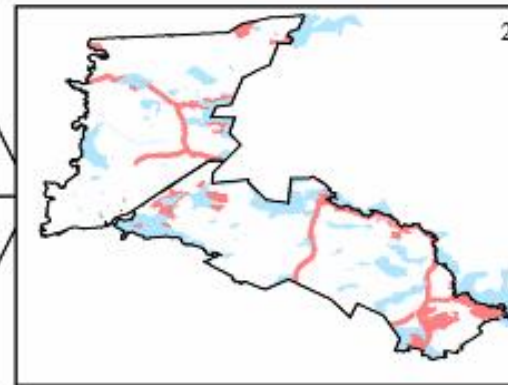
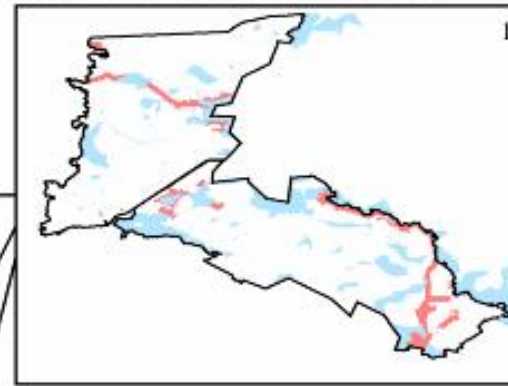


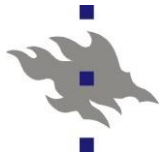
Ekological network



RS 1/2003

Sociocultural network





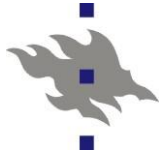
Non-integrated planning approach

- n Thus, several alternative networks with varying ecological and social value are first formed
- n Their economic consequences are evaluated with optimization
 - n possible with the normal planning tools available (e.g. MELO)
 - n does not provide "optimal" socioecological network as such network may not be among the options evaluated
 - n but provides the tradeoffs of the values that are not normally dealt with in optimization approaches
 - n the question is which method does provide solution nearer to the true optimum?



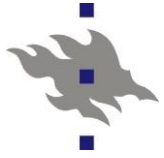
Non-integrated planning approach

- n Tradeoffs between economic, ecological and social values are elicited with MCDM
 - n with AHP (Analytic Hierarchy Process):
 - the alternatives and criteria are compared pairwise
 - from a pair of alternatives, which alternative is better with respect to each criterion and how much?
 - from a pair of criteria, which criterion is more important and by how much?
 - AHP calculates the overall priority of alternatives



Non-integrated planning approach

- n Tradeoffs between economic, ecological and social values are elicited with MCDM
 - n with SMAA-O (Stochastic Multicriteria Acceptability Analysis with Ordinal criteria):
 - what is the performance order of the alternatives with respect to each criterion?
 - what is the importance order of the criteria?
 - SMAA-O calculates the probability of each alternative achieving any specified rank



Example

Criteria	Ranking
Timber Production	$P_{11} > P_{12} > P_{21} > P_{31} ? P_{22} > P_{13} > P_{32} > P_{23} > P_{33}$
Recreation	$P_{33} ? P_{23} > P_{13} > P_{22} ? P_{32} > P_{12} > P_{31} > P_{21} > P_{11}$
Ecology	$P_{32} > P_{33} > P_{23} ? P_{31} > P_{22} ? P_{21} > P_{13} ? P_{12} ? P_{11}$



Example continues

Plan	R1	R2	R3	R4	R5	R6	R7	R8	R9	HAI	CF
P11	12.3	7.2	4.1	3.6	4.3	3.9	8.7	12.4	43.6	24.2	61.0
P12	9.6	13.1	6.1	5.4	7.5	20.7	19.0	17.7	0.9	32.9	47.0
P21	2.0	3.6	10.8	7.7	9.2	18.2	12.9	27.9	7.7	22.1	16.2
P13	0.7	1.4	8.5	8.5	16.3	15.3	15.7	10.1	23.3	18.9	7.6
P31	2.2	4.4	6.2	18.5	22.5	16.3	20.0	6.4	3.5	26.8	18.5
P22	9.0	8.4	14.1	36.5	23.9	5.5	1.6	0.9	0.0	41.6	44.1
P32	24.2	9.6	21.1	5.5	4.1	5.0	8.2	13.2	2.7	49.7	76.3
P23	16.0	24.2	21.1	5.5	4.1	5.0	8.2	13.2	2.7	47.7	50.0
P33	23.9	28.1	7.7	4.5	3.8	3.7	5.4	7.7	15.2	50.4	67.4