



EUROPEAN FOREST INSTITUTE  
ATLANTIC EUROPEAN REGIONAL OFFICE – EFIATLANTIC



# Multi-criteria risk analysis: comparing different types of forest management in terms of related multiple risks on key-species of the SUDOE area

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Partners : EFI, ISA, CETEMAS, NEIKER, HAZI, INRA, CRPF, CNPF/IDF, FCBA, TRAGSA





Existing and increasing risks in forests

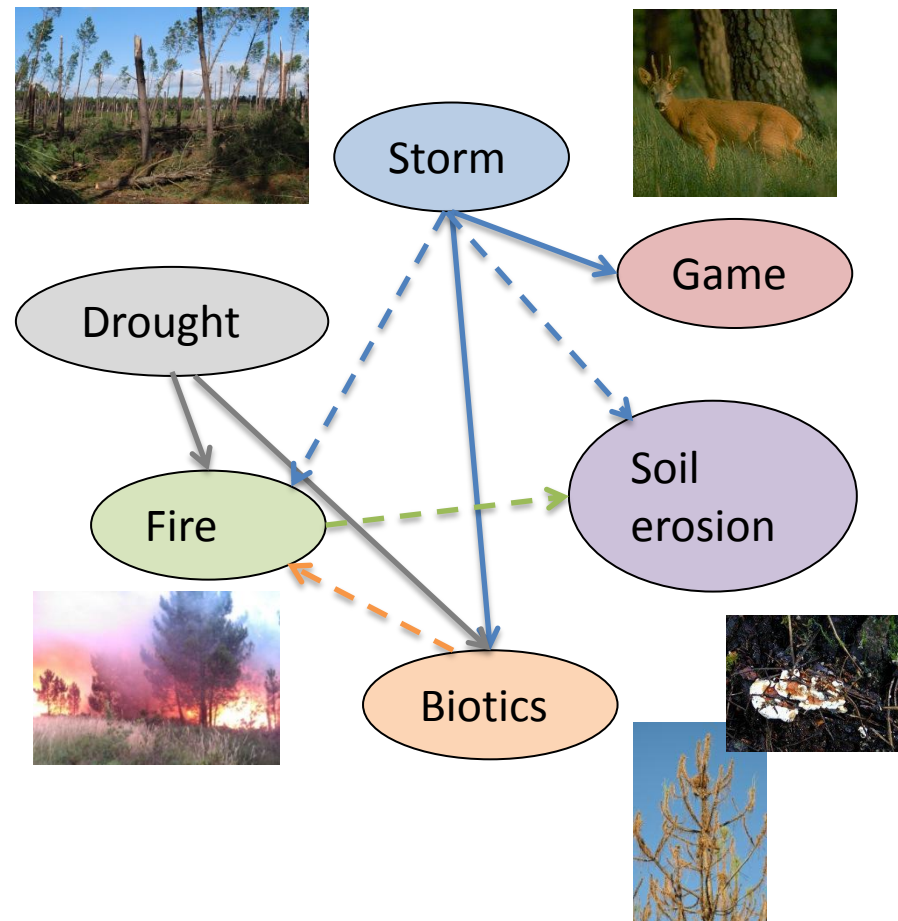
Strong links between risks

Need for multiple risks integration in forest management

Multiple risks assessment not well-developed

Need for the development of a specific tool for multiple risks analysis in forest

MCRA





→ Full risk analysis

Hazard x Vulnerability x Impact





→ Full risk analysis

→ On main productive species of the regions

Hazard x Vulnerability x Impact

Contrasted forest management scenarios

- To compare several regions

	Portugal	Basque-Country	Galicia	Asturias	Aquitaine	Midi-Pyrénées
Radiata pine		X	X	X		
Eucalypts	X	X	X	X	X	
Maritime pine	X		X	X	X	
Douglas		X				X
Laricio pine		X				
Poplar						X



→ Full risk analysis

→ On main productive species of the regions

Hazard x Vulnerability x Impact

Contrasted forest management scenarios

- To compare several regions
- To go further than what is usually done

Radiata pine	R1-Classic	R2-Short term	R3-Mid term	R4-High quality	R5-Sophisticated	R6-Biomass		
Eucalypts	E1-Standard	E2- Low investment	E3- Intensive	E4-Short rotation	E5-High quality	E6-Nitens plantation	E7-Lack of active management	E8-France Standard
Maritime pine	M1-High quality	M2-Standard classic	M3-Low investem ent	M4-Short-term with subsidies	M5-Low density without thinning	M6-Half-dedicated to biomass	M7- Biomass	M8- No management
Douglas	D1- Intensive big wood	D2-Standard	D3- Uneven-aged	D4- Intensive thinnings	D5- Mixed	D6-France standard	D7-France short	
Laricio pine	L1- Intensive big wood	L2-Standard	L3- Uneven-aged	L4- Mixed				
Poplar	P1-Standard	P2-Low investment	P3- Intensive	P4-Short rotation		P5- Very short rotation		



→ Full risk analysis

→ On main productive species of the regions

**Detailed description of the scenarios**

Hazard x Vulnerability x Impact

Contrasted forest management scenarios

- To compare several regions
- To go further than what is usually done

Scenario name	Type of management option	Description of management option
R1-Classic	<b>Site preparation</b>	Mechanized forestry harvesting with skidders, elimination of residues from the stand with a bulldozer and ripping; plantation is done by hand;
	<b>Fertilization</b>	Fertilization without technical prescription
	<b>Stand composition</b>	Single Species
	<b>Stand structure</b>	Even aged
	<b>Genetic material</b>	Commercial seedlings
	<b>Regeneration type</b>	1500-1600 stems/ha
	<b>Cleaning</b>	1-2 cleaning for weed control
	<b>Clearing</b>	1 clearing at 4-6 years.
	<b>Thinnings</b>	3 thinnings at: 8-10 years, 13-15 years, 18-23 years
	<b>Pruning</b>	2 prunings at: 8-10 years and 13-15 years
	<b>Harvest and objective</b>	LOG HARVESTING for industrial wood 35-40 years (SQ=I, 450-500m3/ha), (SQ=II, 400-450m3/ha)



→ Full risk analysis

→ On main productive species of the regions

### Common points between the scenarios

Hazard x Vulnerability x Impact

Contrasted forest management scenarios

- To compare several regions
- To go further than what is usually done

Radiata pine	R1-Classic	R2-Short term	R3-Mid term	R4-High quality	R5-Sophisticated	R6-Biomass		
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→ Full risk analysis

→ On main productive species of the regions

→ For main hazards in each region

Hazard x Vulnerability x Impact

Contrasted forest management scenarios

- To compare several regions
- To go further than what is usually done

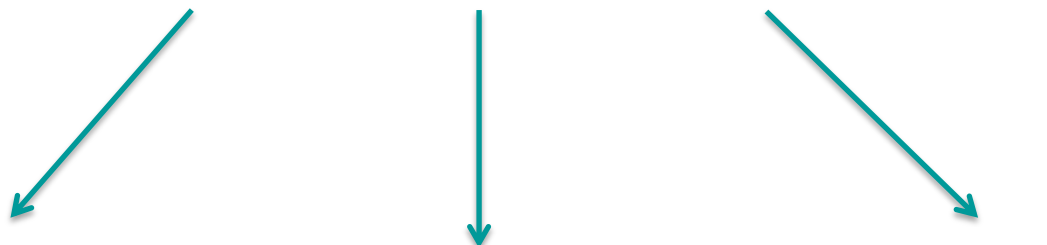
	Portugal	Basque-Country	Galicia	Asturias	Aquitaine	Midi-Pyrénées
Radiata pine		Wind, fire, PPM, <i>Diplodia</i> , <i>Dothistroma</i> , <i>Fusarium</i>	Fire, wind, game, <i>Fusarium</i> , nematode	Fire, wind, game, biotics		
Eucalypts	<i>Gonipterus</i> , <i>Phoracantha</i> , <i>Mycosphaerella</i> , fire, heavy rain, drought, frost and storm	Wind, fire, <i>Gonipterus</i> , <i>Mycosphaerella</i>	Wind, fire, game, <i>Gonipterus</i> , <i>Mycosphaerella</i>	Fire, wind, game, <i>Gonipterus</i> , <i>Mycosphaerella</i>	Wind, fire, Game, Drought, Frost, <i>Phytophthora</i>	
Maritime pine	Fire, heavy rain, PPM, bark beetles, <i>Fusarium</i> , frost, storm		Fire, wind, game, <i>Fusarium</i> , nematode	Fire, wind, game, biotics	Wind, fire, Game, Drought, PPM, bark beetle, <i>Heterobasidion</i>	
Douglas		Wind, fire, <i>Hylobius</i> , <i>Dothistroma</i>				Wind, game, drought, heavy snow, <i>Hylobius</i> , <i>Heterobasidion</i>
Laricio pine		Wind, fire, PPM, <i>Dothistroma</i> ,				
Poplar						Wind, game, drought, frost, <i>Phloeomyzus</i> , Rust, weakness pathogens, flood





Main problem : to cope with the lack of data aggregation or data itself

Hazard x Vulnerability x Impact



**Results integration in Visual Prométhée:** software able to integrating all these values (quantitative or comparative)  
⇒ classification of each silvicultural scenario regarding risks  
⇒ For each region or all regions together

**Hazards characteristics :**

**Experts' meeting**

**Value at stakes**

- impacted surface each year
- type of damage





### Hazards characteristics :

- impacted surface each year
- type of damage

Année	Lieux	Importance
1976	Landes	1,5 M m3
1996	Aquitaine	1,5 Mm3
1999	LdG	24 M m3
2009	LdG	42 millions de m3 (source IFN)

Maritime pine	Impacted volume or surface each year	Mark 1	Type of damage	Percentage of economic loss in case of occurrence	Mark 2	Mark3= Mark1*Mark2
Wind	Data compilation from CNPF/IDF and NFI	1.5%	Mortality	Huge loss on wood prices (data from last storm)	86.5%	1.30%
Fire	GIP ATGeRI	0.2%	Mortality	Huge loss on wood prices (similar to loss when storm)	86.5%	0.17%
Game	Article from IRSTEA Nogent	1%	Browsing	Article from IRSTEA Nogent	2%	0.02%
Insect : Thaumetopoea pityocampa	Calculation on Forest Health Data monitoring	16%	Growth loss	financial analysis ( Gatto et al., 2009): difference in revenues =17.3%	17.3%	4.00%
Scolyte	Book from Forest Health Department	0.4%	Mortality	Data from last storm	94%	2.77%
Sécheresse	Data from INRA, study following Aquitaine reforestation	20%	Growth loss	Data from INRA, study following Aquitaine reforestation	20%	0.38%
Pathogen: Heterobasidion annosum	Experts' knowledge	3%	Mortality	Data from experts' knowledge	94%	2.82%



### Experts' meeting

#### → Panels of experts in all regions

- on different hazards
- on different species

→ Debates and discussion to give **comparative marks** to silvicultural practices in scenarios regarding each risk





## Experts' meeting

Scenario name	Type of management option	Name of management option	Heteroba						
			Wind	Fire	Game	Drought	Moth	Bark beetle	sidion
M1	Site preparation	Full Ploughing. Broadleaf trees preservation	0.25	0.5	0.75	0.25	0	0	0.75
M2	Site preparation	Strip ploughing	0.25	0.5	0.5	0	0.25	0.25	0.75
M3	Site preparation	Smashing roll	0.5	0.75	0	0.75	0.25	0.25	0.25
M4	Site preparation	Full ploughing	0.25	0.25	0.75	0.5	0.25	0.25	0.75
M5	Site preparation	Full ploughing	0.25	0.25	0.75	0.5	0.25	0.25	0.75
M6	Site preparation	Full ploughing-Stump removal	0	0	0.75	0.5	0.25	0.25	0
M7	Site preparation	Stump removal, full ploughing	0	0	0.75	0.5	0.25	0.25	0
M8	Site preparation	No	0.5	1	0	0.75	0.25	0.25	0.25
M1	Fertilization	Yes	0.25	0.25	0	0.25	0	0	0
M2	Fertilization	Yes	0.25	0.25	0	0.25	0	0	0
M3	Fertilization	No	0	0	0.75	0	0	0.25	0
M4	Fertilization	Yes	0.25	0.25	0	0.25	0	0	0
M5	Fertilization	Yes	0.25	0.25	0	0.25	0	0	0
M6	Fertilization	Yes	0.25	0.25	0	0.25	0	0	0
M7	Fertilization	No	0	0	0.75	0	0	0.25	0
M8	Fertilization	No	0	0	0.75	0	0	0.25	0



## Experts' meeting

Scenario name	Type of management option	Name of management option	Wind	Fire	Game	Drought	Moth	Bark beetle	Heterobasidion
M2	Site preparation	Strip ploughing	0.25	0.5	0.5	0	0.25	0.25	0.75
M2	Fertilization	Yes	0.25	0.25	0	0.25	0	0	0
M2	Stand composition	Single species forests	0	0.25	0	0.5	0.75	0.5	0.5
M2	Stand structure	Even-aged forests	0	0	0	0.25	0	0.25	0
M2	Genetic material	Genetically improved plants	0	0	0	0.25	0	0	0
M2	Regeneration type	Plantation 1250 stems/ha	0.25	0.25	0.5	0	0.75	0.25	0.25
M2	Cleaning	Full cleaning at 5 years and then each time there is an intervention (4-5 with the thinnings)	0.5	0	0.5	0	0.5	0	0
M2	Clearing	No clearing	0	0.25	0	0	0	0	0
M2	Thinnings	3 thinnings	0.5	0	0	0	0.5	0.5	0.5
M2	Pruning	No	0	0.25	0	0	0	0	0
M2	Harvest and objective	40 years; 300 stems/ha ; Timber 1 to 1,2 m3	0.75	0.25	0.25	0.25	1	1	0.25



### Economic assessment of scenarios

- Value exposed to hazards => not profitability assessment
- Different methods : mainly standing value + different possibilities for costs integration or not (can be compared)
  - Regional models to determine yield for all scenarios
  - Regional wood prices to determine standing values
  - Regional costs for silvicultural practices
  - Average value per year



GesMO



Capsis

Computer-aided projection of strategies in silviculture



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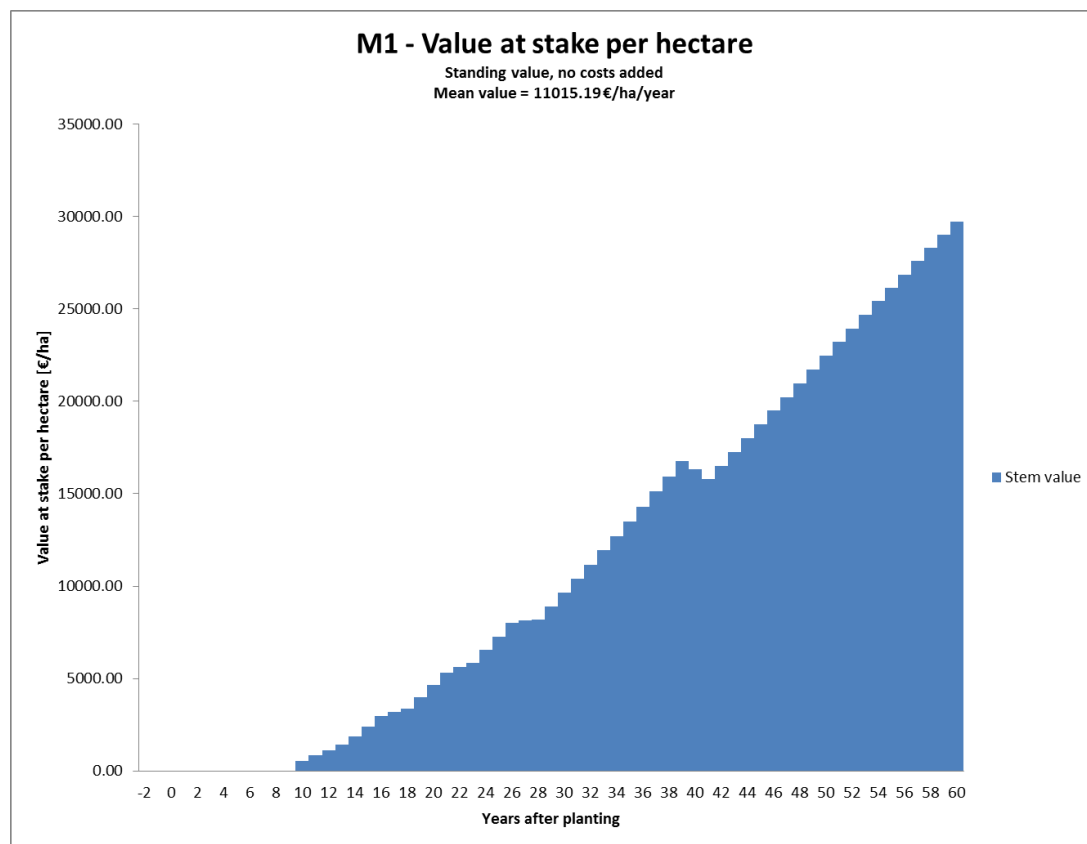




### Economic assessment of scenarios

→ Different methods : mainly standing value + different possibilities for costs integration or not (can be compared)

- **Ideal forest** : one plot of each age=> evaluation of standing value in this forest
- **Standing value only**
- Standing value and re-establishment costs only
- Standing value + costs when appearing
- Standing value+ past actualized costs



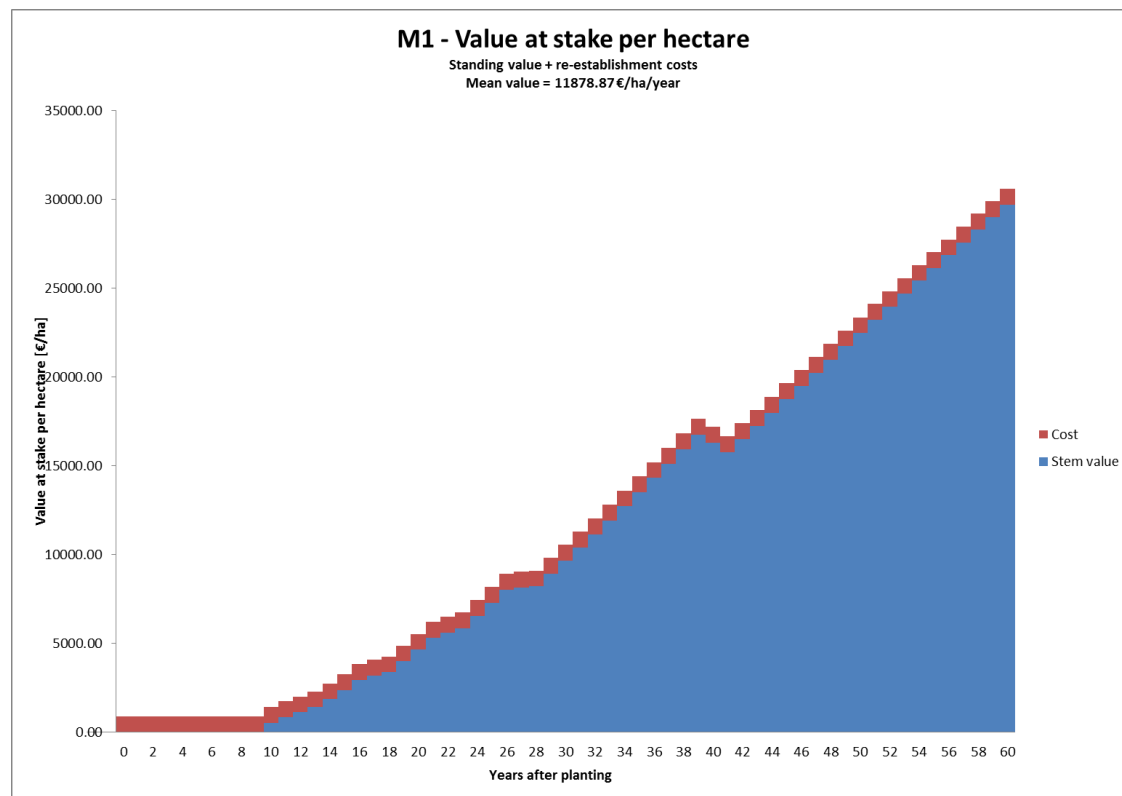




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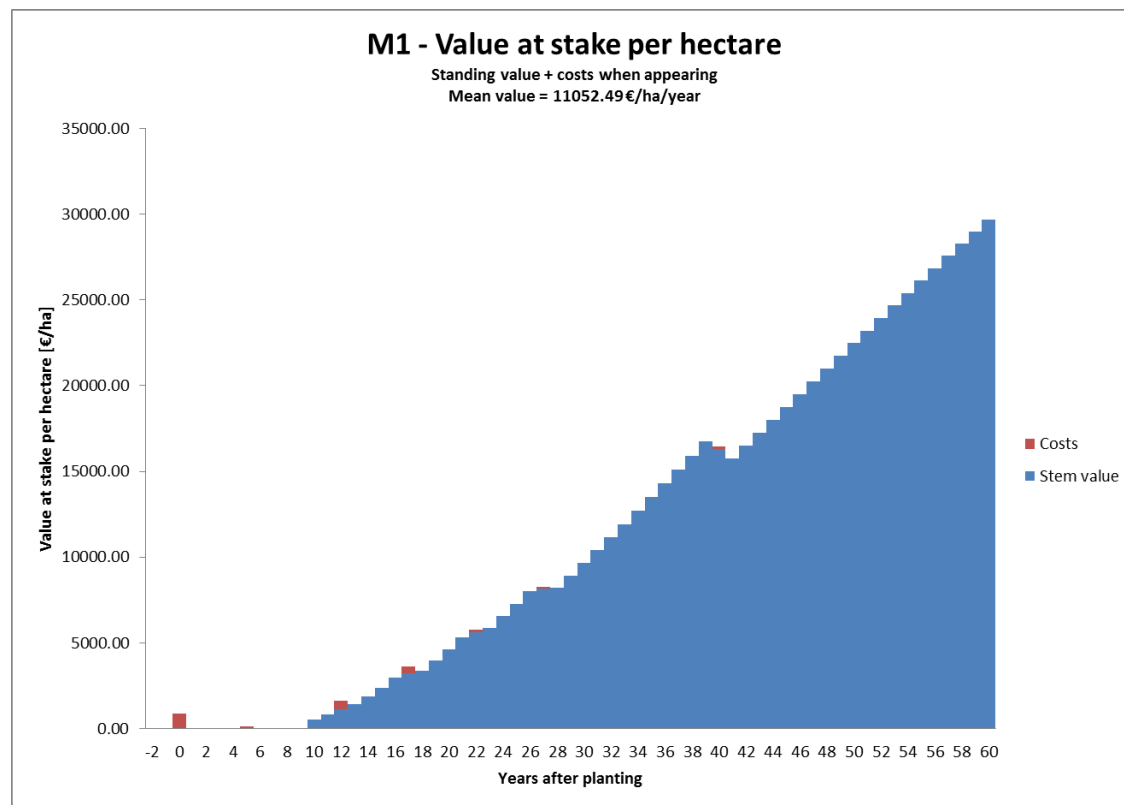




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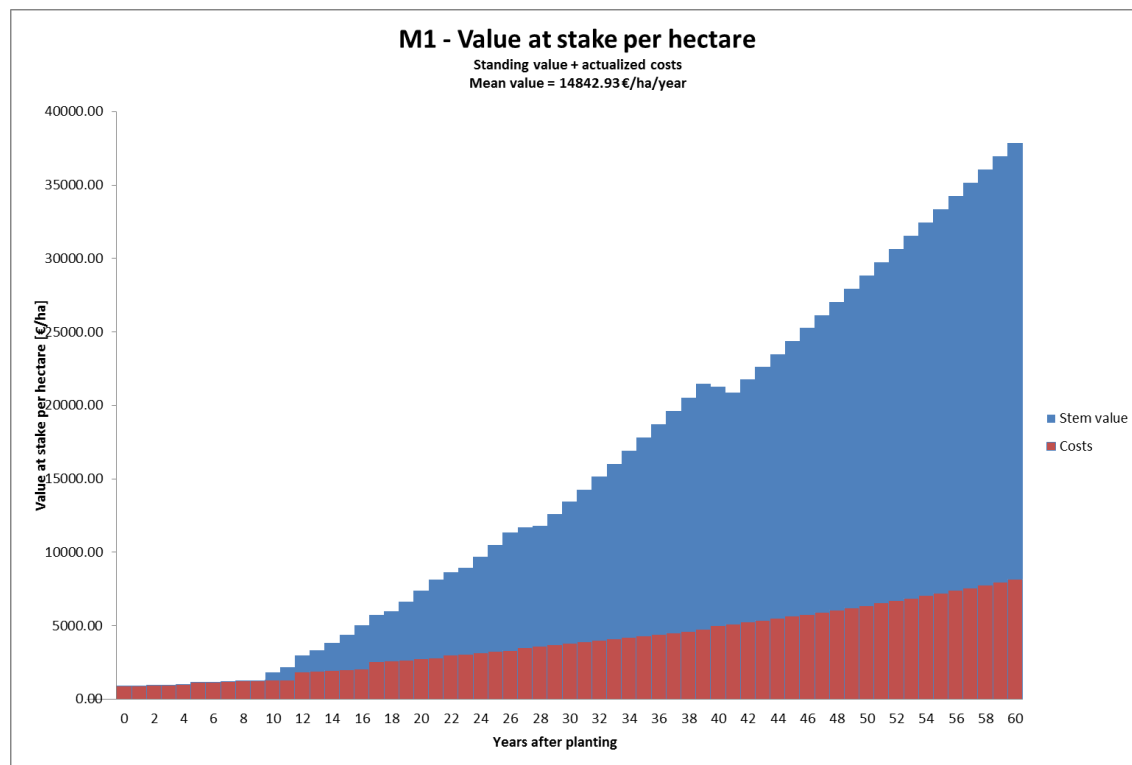




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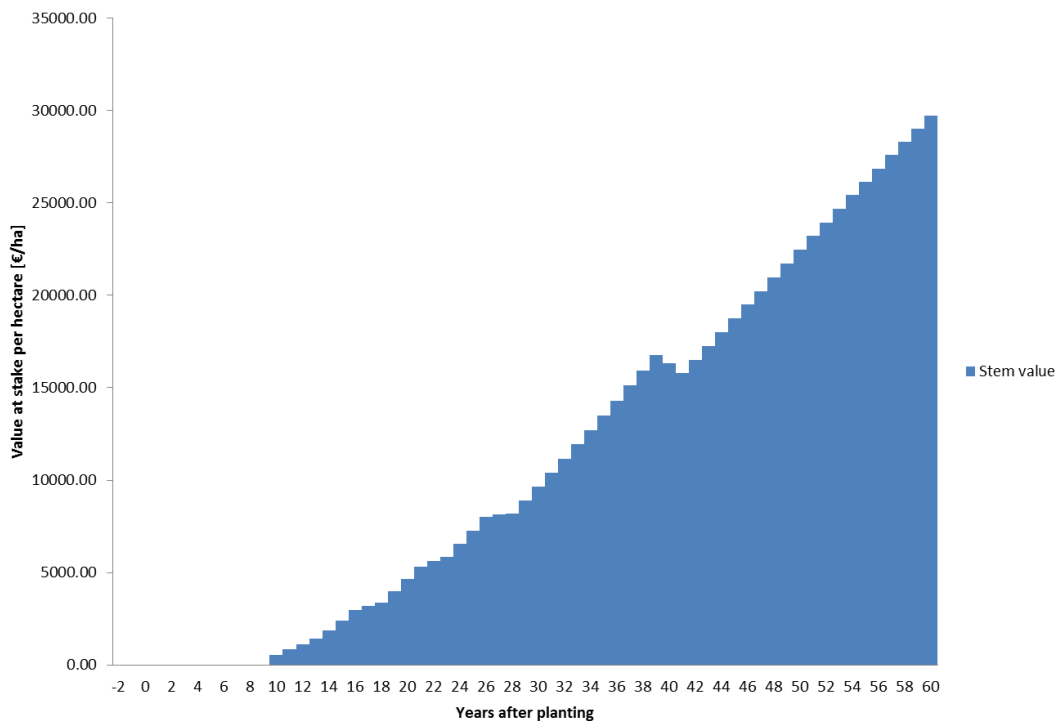
- Standing value and re-establishment costs only

- Standing value + costs when appearing

- Standing value+ past actualized costs

### M1 - Value at stake per hectare

Standing value, no costs added  
Mean value = 11015.19 €/ha/year





### Data integration

Criteria to be minimized or maximised

Combination of vulnerability and standing value

Weights of criteria

Scenario to be compared

Visual PROMETHEE Academic - pin\_maritime\_multiregions\_v1.vpg (saved)

File	Edit	Model	Control	PROMETHEE-GAIA	GDSS	GIS	Custom	Assistants	Snapshots	Options	Help
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<b>Aquitaine</b>	Wind	Fire	Game	Drought	PPM	Barkbeetle	Heterobasidion	Heavy Rain	Fusarium	Frost	Nematode
Unit	unit	unit	unit	unit	unit	unit	unit	unit	unit	unit	unit
Cluster/Group	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
<b>Preferences</b>											
Min/Max	min	min	min	min	min	min	min	min	min	min	max
Weight	11,30	1,50	0,20	34,90	24,20	3,30	24,60	0,00	0,00	0,00	0,00
Preference Fn.	V-shape	V-shape	V-shape	V-shape	V-shape	V-shape	V-shape	Usual	Usual	Usual	Usual
Thresholds	absolute	absolute	absolute	absolute	absolute	absolute	absolute	absolute	absolute	absolute	absolute
- Q: Indifference	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
- P: Preference	2,00	2,00	2,00	2,00	2,00	2,00	2,00	n/a	n/a	n/a	n/a
- S: Gaussian	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
<b>Statistics</b>											
Minimum	30,79	554,30	246,36	153,97	153,97	431,12	153,97	n/a	n/a	n/a	n/a
Maximum	38553,16	61739,04	24784,18	35799,37	35799,37	28297,06	27618,40	n/a	n/a	n/a	n/a
Average	15022,07	17799,94	10214,41	14100,28	14100,28	13356,02	11173,08	n/a	n/a	n/a	n/a
Standard Dev.	13133,25	18200,77	7501,14	11211,32	11211,32	9728,57	9992,05	n/a	n/a	n/a	n/a
<b>Evaluations</b>											
<input checked="" type="checkbox"/> M1-High quality	38553,16	61739,04	24784,18	35799,37	35799,37	16522,78	27537,97	n/a	n/a	n/a	n/a
<input checked="" type="checkbox"/> M2-Standard	13107,64	10486,11	9175,35	19661,46	19661,46	14418,40	11796,87	n/a	n/a	n/a	n/a
<input checked="" type="checkbox"/> M3-Low investm...	25116,90	27618,40	16110,80	25316,90	25316,90	27618,40	27618,40	n/a	n/a	n/a	n/a
<input checked="" type="checkbox"/> M4-Short term ...	2942,46	6473,42	4119,45	5296,43	5296,43	4707,94	4707,94	n/a	n/a	n/a	n/a
<input checked="" type="checkbox"/> M5-Low density ...	301,67	7988,82	6759,77	6145,25	6145,25	5530,72	3072,62	n/a	n/a	n/a	n/a
<input checked="" type="checkbox"/> M6-Half dedicate...	7626,90	11016,63	5084,60	12711,50	12711,50	9321,77	6779,47	n/a	n/a	n/a	n/a
<input checked="" type="checkbox"/> M7-Biomass	30,79	554,30	246,36	153,97	153,97	431,12	153,97	n/a	n/a	n/a	n/a
<input checked="" type="checkbox"/> M8-No managem...	28297,06	61739,04	15434,76	7717,38	7717,38	28297,06	7717,38	n/a	n/a	n/a	n/a



## Maritime pine example

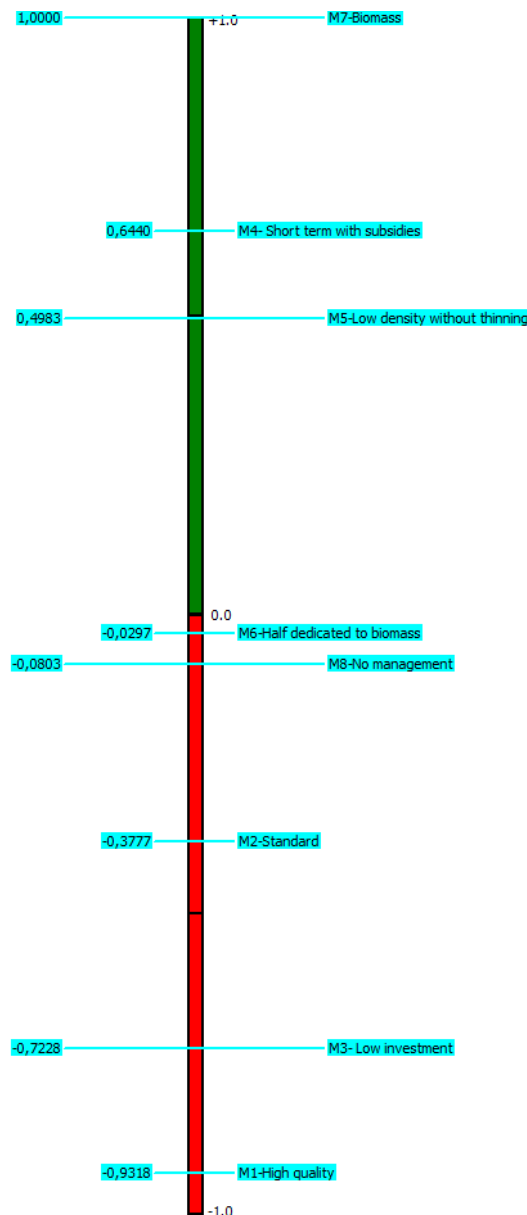
Maritime pine	M1-High quality	M2-Standard classic	M3-Low investment	M4-Short-term with subsidies	M5-Low density without thinning	M6-Half-dedicated to biomass	M7- Biomass	M8- No management
General characteristics	Long-term revolution (60 years) to produce big high quality wood. Plantation 1250 stems/ha and genetically improved plants. 4-5 thinnings	40 years revolution. Plantation 1250 stems/ha and genetically improved plants. 3-4 thinnings	Natural regeneration and as little investment as possible before 1st thinning	25 years revolution. Small timber production. Taking advantage of subsidies for plantation and first operations.	Plantation around 800 stems/ha to harvest 700 stems/ha at 25 years	Plantation 2500 stems/ha. Half of them harvested at year 9 (biomass) and then standard silviculture until 35 years (final harvest)	Plantation 3000 stems/ha. Full harvest around 9-12 years.	Nothing done

	Portugal	Galicia	Aquitaine
Maritime pine	Wind, fire, heavy rain, PPM, bark beetles, <i>Fusarium</i> , frost,	Fire, wind, game, <i>Fusarium</i> , nematode	Wind, fire, Game, Drought, PPM, bark beetle, <i>Heterobasidion</i>





Example of output  
from the software :  
Prométhée II Ranking





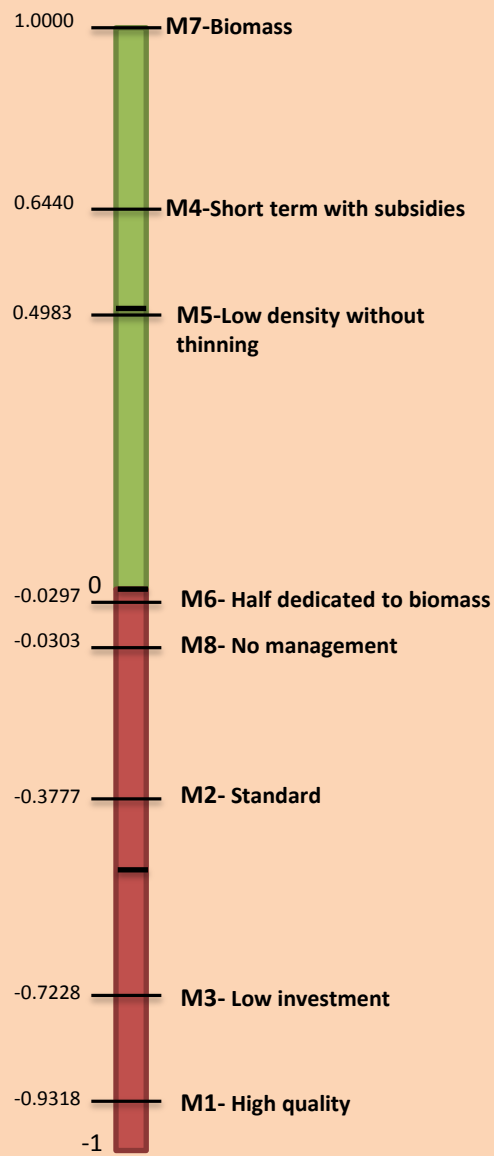


# Multi-criteria risk analysis

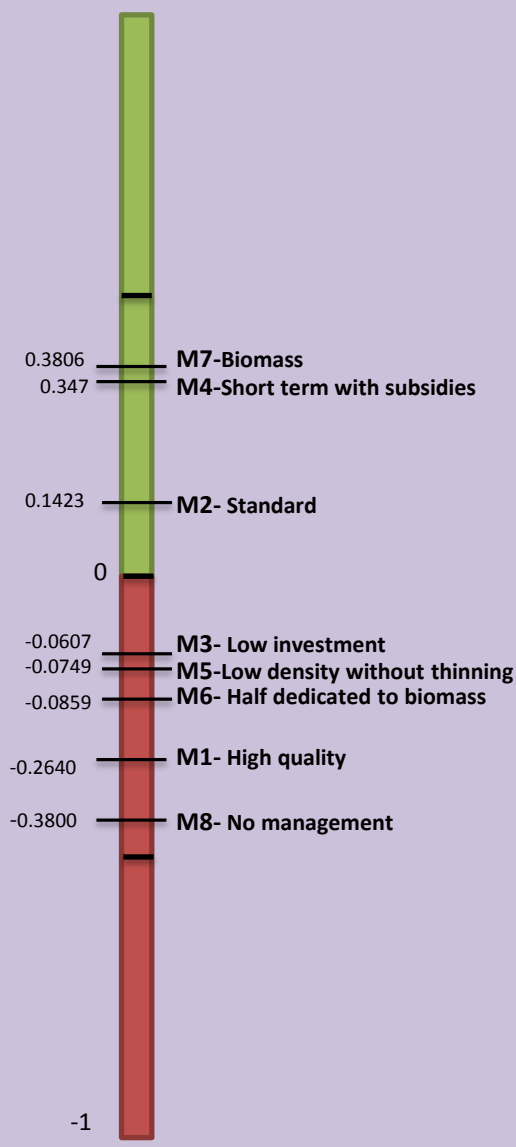
## Some results: regions



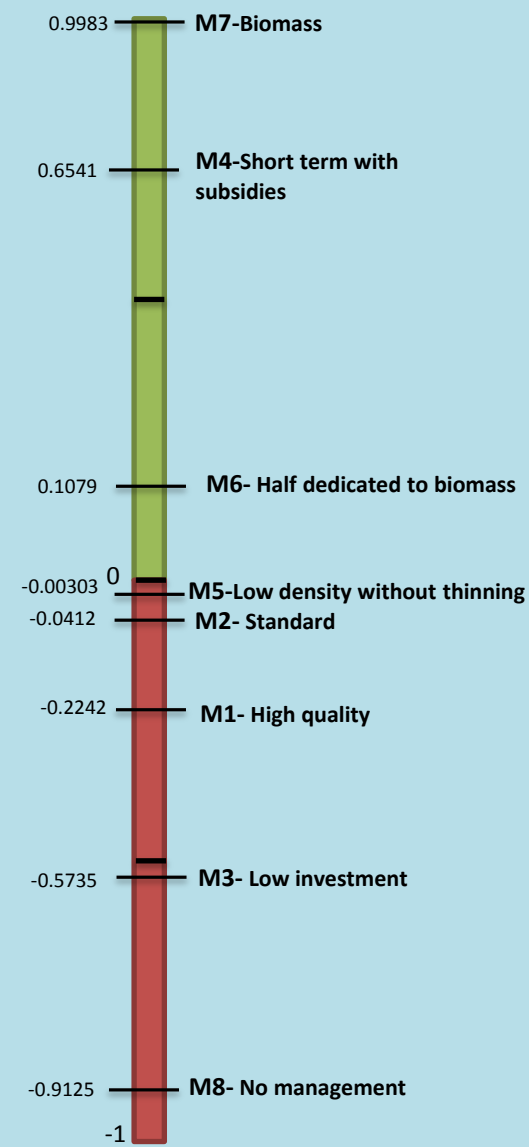
### Aquitaine



### Portugal



### Galicia





# Multi-criteria risk analysis

## Some results: regions

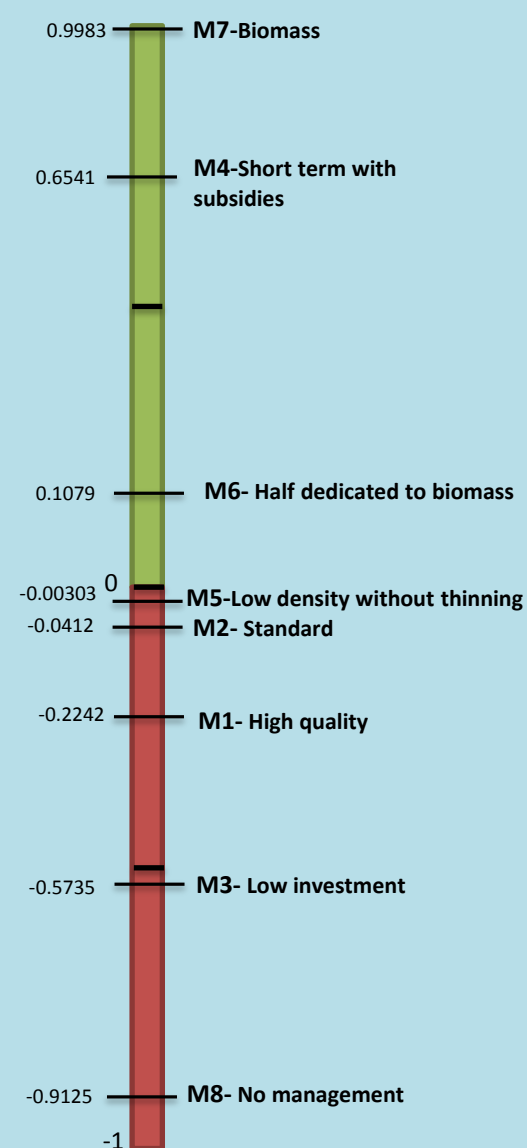
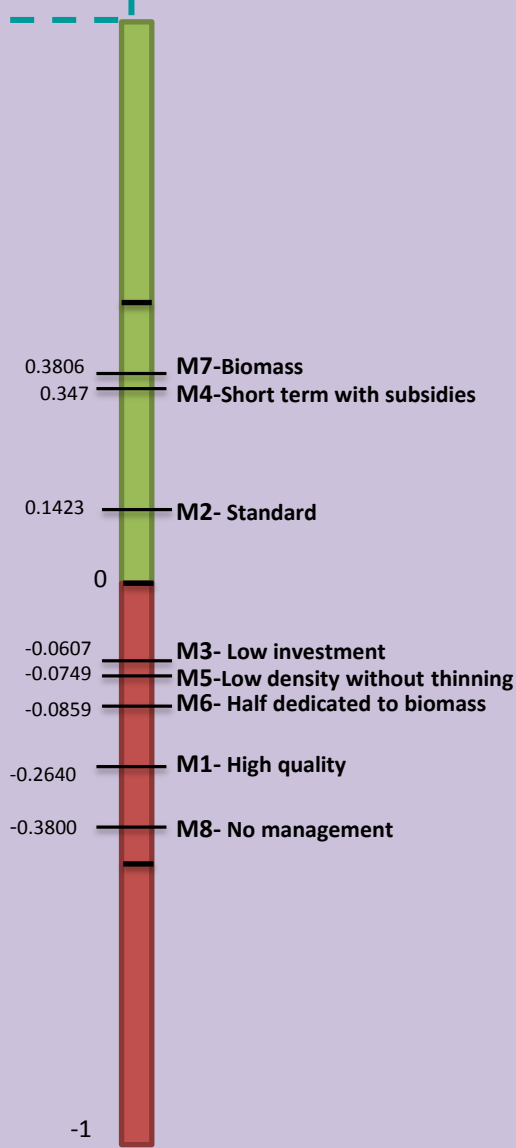
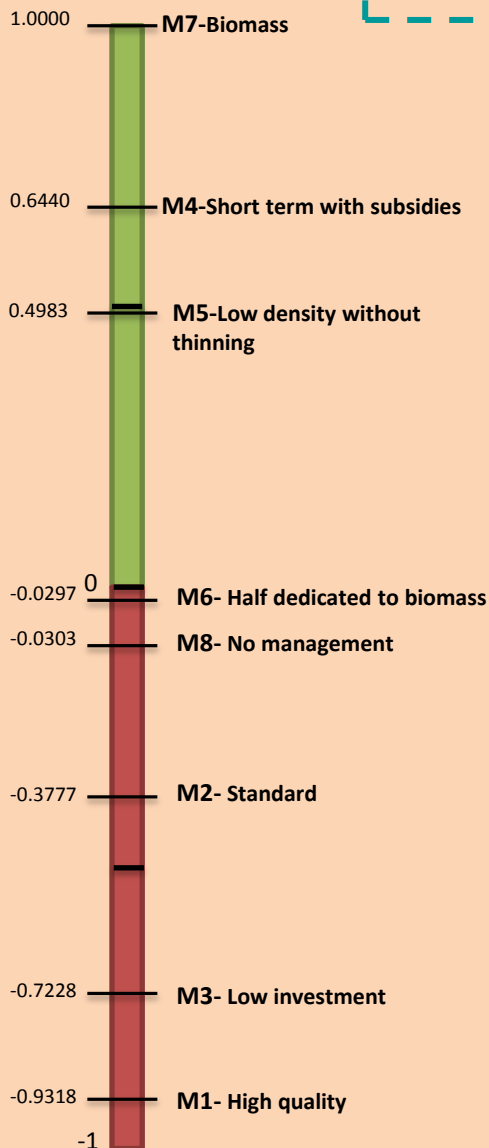


### Aquitaine

### Portugal

### Galicia

Different hazards



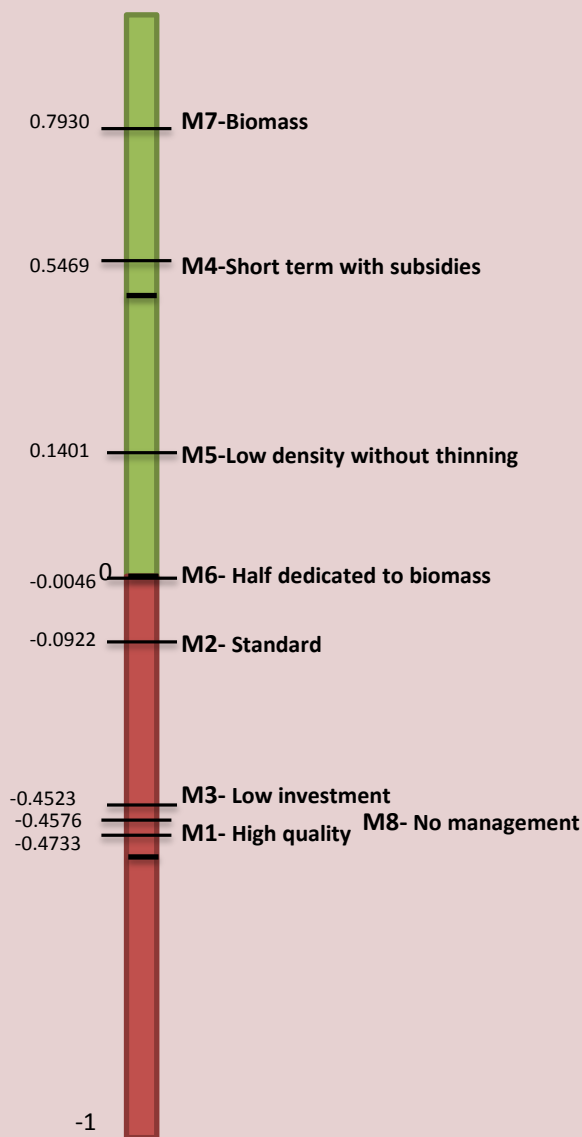


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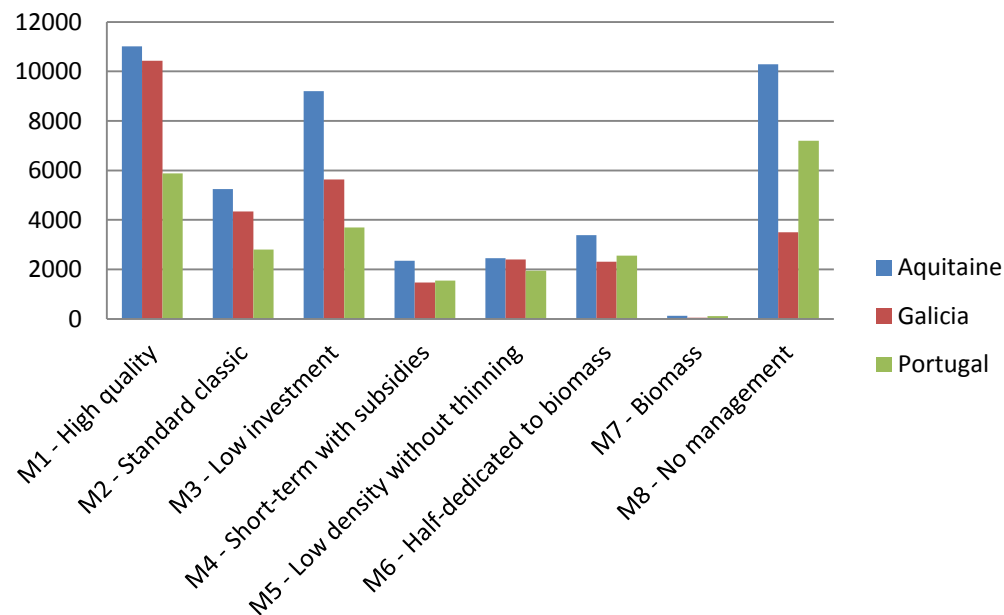
## Some results: regions



### All-regions



### Standing value (€/ha/an)



→ M7- Biomass: standing value very low=> profitability?

→ M1,M3,M8: the longest revolutions

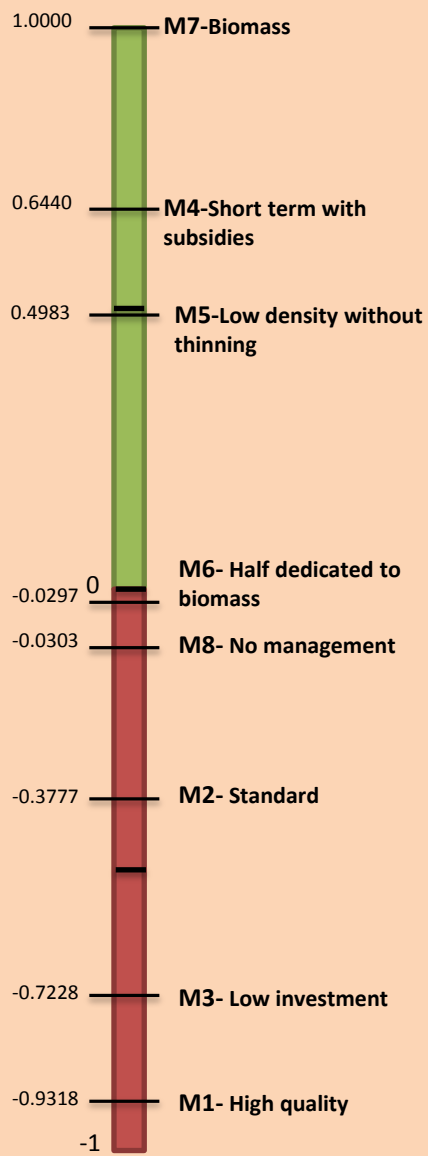


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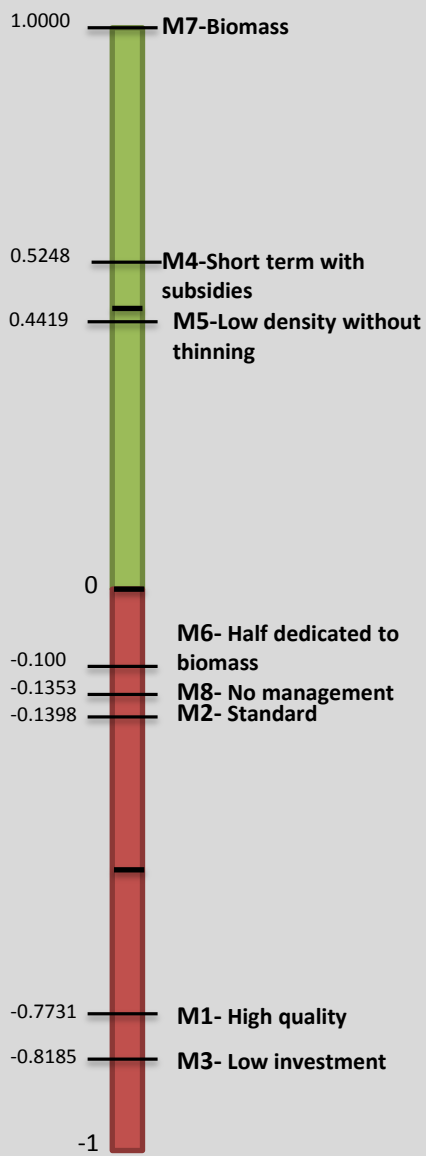
## Some results: values at stake Aquitaine



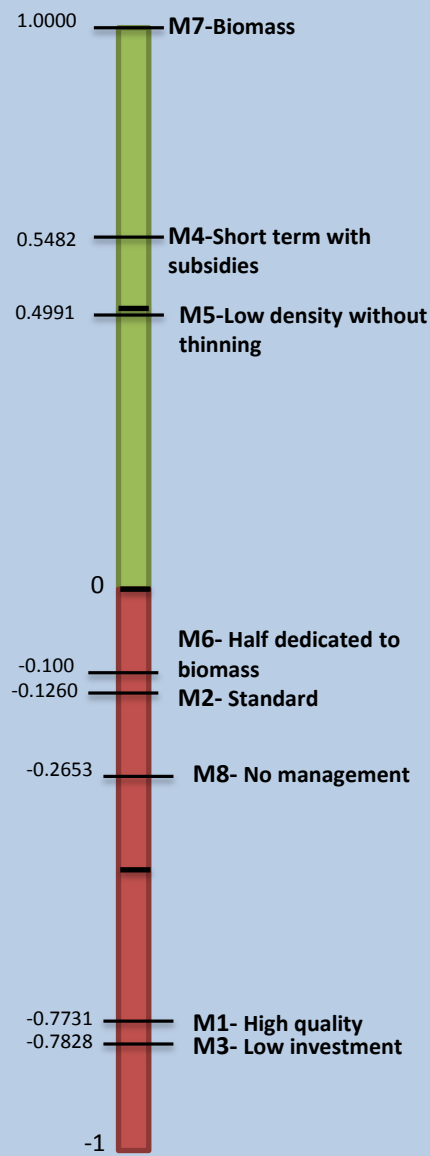
### Standing value



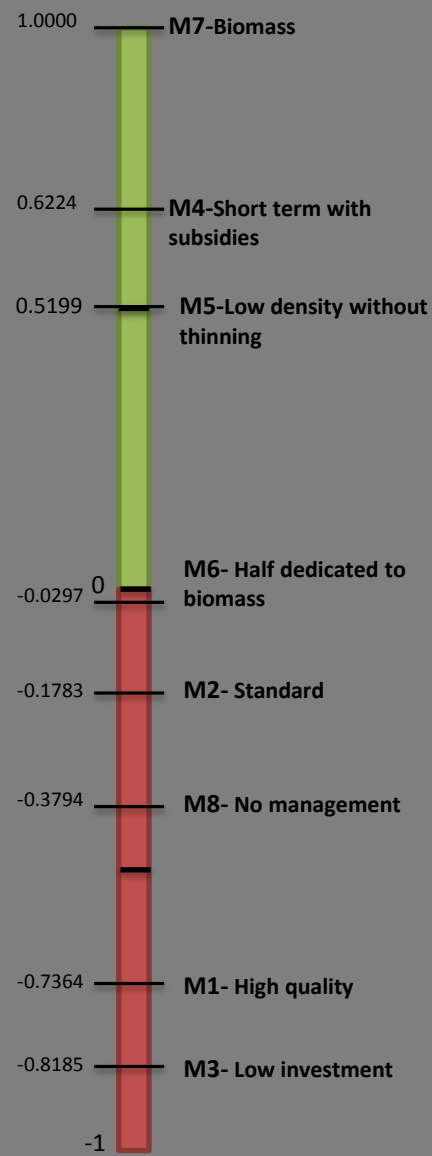
### Actualised



### Re-establishment



### Costs when appear



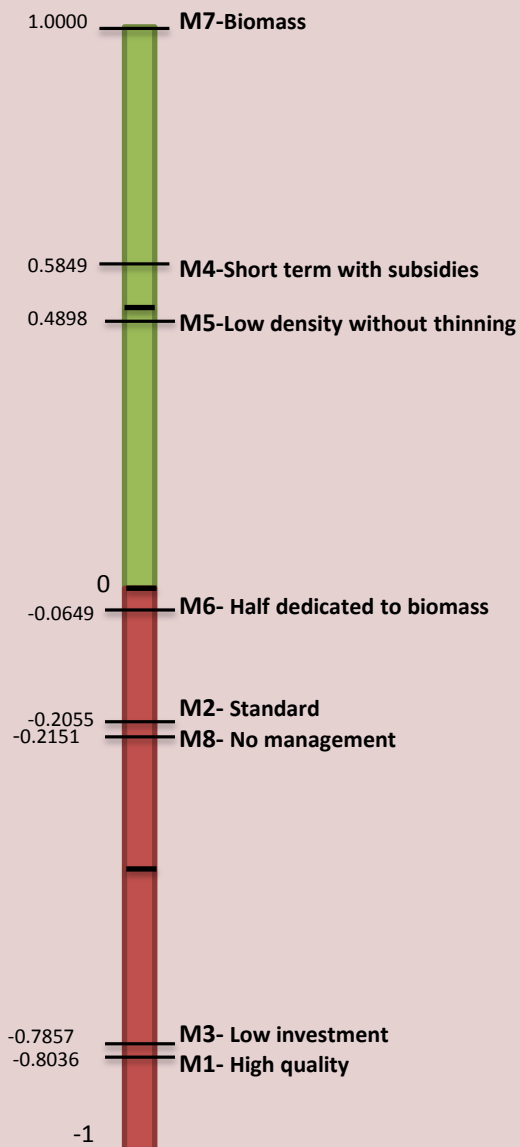


## Multi-criteria risk analysis

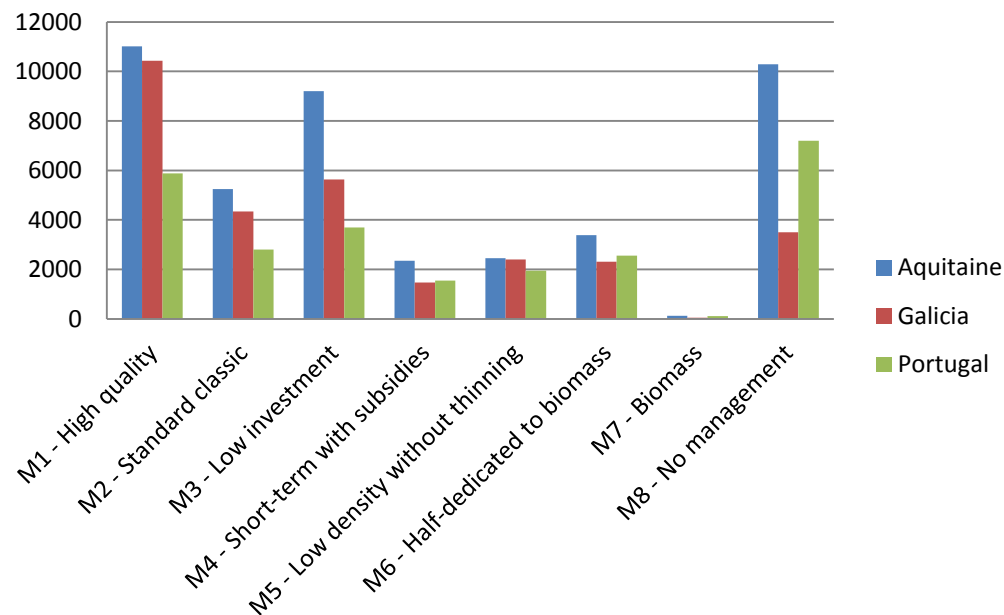
### Some results: values at stake Aquitaine



#### All-Aquitaine



#### Standing value (€/ha/an)



- M7- Biomass: standing value very low=> profitability?
- M1,M3 : the longest revolutions



### What next ?

→ MCRA for all species in the project with

- **Regional analysis** (specific scenarios or species)
- **Global analysis** (comparison between regions)
- Different methods for **value at stakes assessment**
- Comparison of “faced hazards” to “felt hazards”
- Integration of **profitability** of the scenarios
- Dynamic method => **improvements** with new findings

