THE PARADIGM OF RISK AND ITS INSTITUTIONAL FRAMEWORK IN FORESTRY

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A lecture held for the participants of the Socrates Project INNO-FOREST

Technical University of Zvolen, Slovakia

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OBJECTIVE:

To explain the essence of risk concerning forest land management and the new managerial attitudes how to cope the destructive occurrence of natural elements on the example of wind and fire.

CONTENT:

- Introduction
- Definitions of basic concepts
- Paradigm of risk and its shifting
- Description of hazard
- Measurement of risk
- Economic analysis of risk
- Preliminary results
- Conclusions
- Institutional framework for accepting the risk in forestry

INTRODUCTION

Gales and forest fires are the most formidable natural elements that affect the forest management in Slovakia.

A QUESTION:

Can we know the risks we face, now or in the future?

AN ANSWER:

No, we cannot; but we must act as we do.

(Douglas & Wildawsky, 1983)

Definition of hazard:

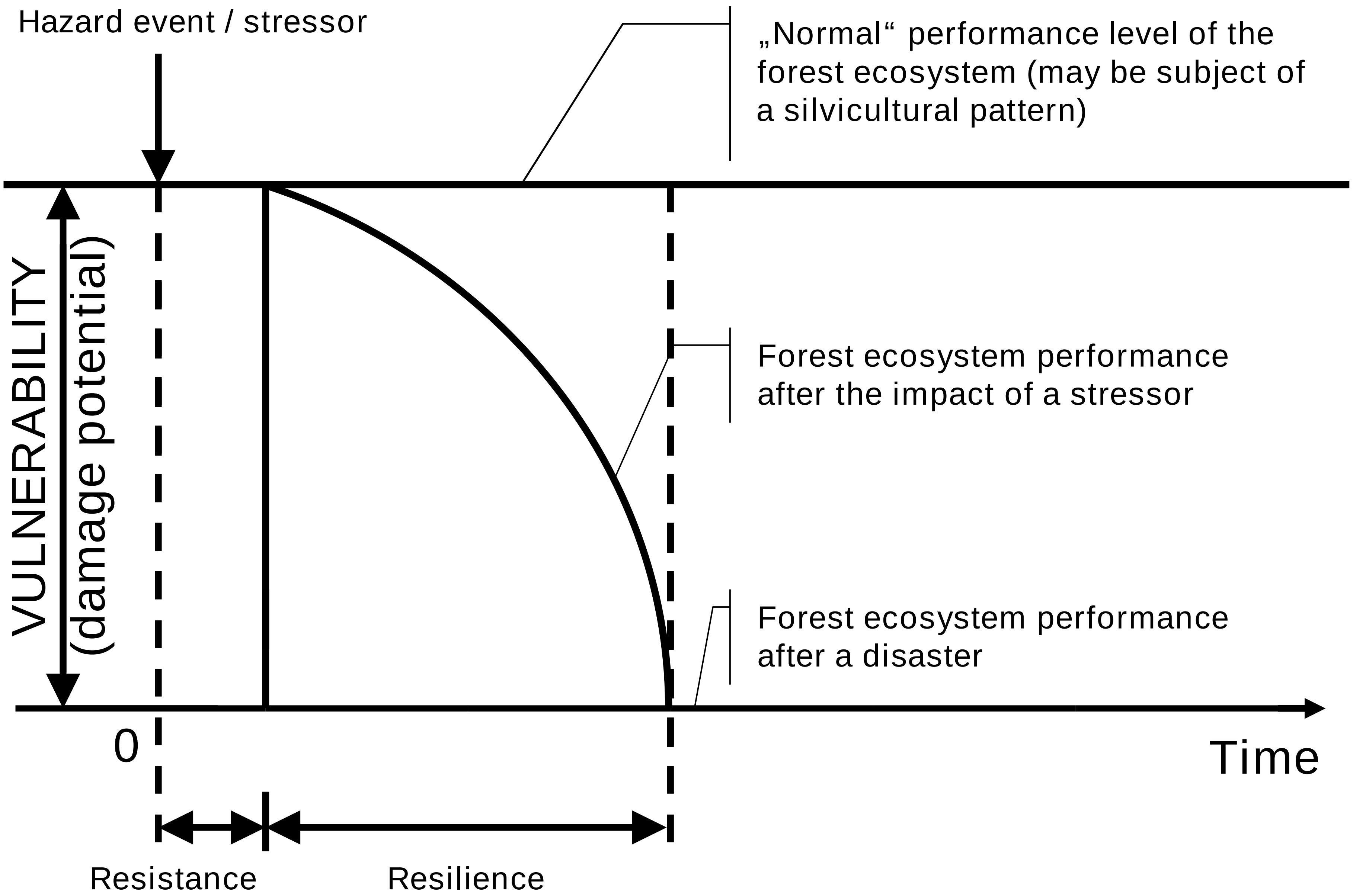
HAZARD is a thread to humans or what they value.

Alternatively:

HAZARD is a situation that in particular circumstances could lead to harm (human being) or damage (loss of inherent quality) suffered by a biological or physical entity.

We distinguish different kinds of hazard (bolt striking, hurricane, fire, diseases, flood, earthquake ...)

Definition of vulnerability:



Visualisation of the concept of vulnerability:

Resistance + Resilience = Coping Capacity

(expressing them as the complementary quantities to the value of vulnerability)

Disaster = when the own coping capacity (without external help) is insufficient to return the ecosystem back to the " normal " state

The concept of the economic vulnerability of forest :

$$VFSV(t) = FSV(t) - SVFS(t)$$

VFSV (t) is the vulnerable forest stand value at age (t) and it refers to the endangered value of a forest stand

FSV (t) - the forest stand value at age (t)

SVFS (t) - the salvage value of a forest stand after its damaging or destruction at age (t)

Definition of risk:

RISK is hazard quantitatively expressed as the probability of particular natural element occurrence multiplied by the endangered value of a forest.

Risk = Probability * Vulnerability

Vulnerability = endangered value of a forest

Economic interpretation of risk concerning management of forest:

Risk = ?á Probability * Vulnerability

kinds of hazard

Vulnerability is referred in terms of money.

A PARADIGM OF RISK AND ITS SHIFTING

Ensuring security forestry requires a paradigm shift in the concept of disaster prevention and preparedness.

Instead of starting with a focus on natural hazards and their quantification, the assessment and ranking the vulnerability of forest should serve as the starting point in defining the priorities and means of remedial interventions.

Old Paradigm		New Paradigm
Focus on natural hazards and their Quantification	⟷	Focus on the assess-ment and ranking of Vulnerability
From the „security forestry“		To the „risk forestry“

DESCRIPTION OF HAZARD

Data: Areas of forest destroyed by natural elements

Source: National Forest Inventory Database
Institute for Forest Management
Planning in Zvolen, Slovakia

Period of observation: 1993 – 2002

Area of observed forest land: 1 217 463 ha

MEASUREMENT OF RISK

Modelling the probabilities of forest stands destruction by the occurrence of natural elements:

Point estimate of the population proportion (p):

$$p = \frac{\sum_{i=1}^{k} n_i}{\sum_{i=1}^{k} N_i} \qquad \sum_{i=1}^{k} n_i = n \quad \text{and} \quad \sum_{i=1}^{k} N_i = N$$

n_i is expected destroyed area of forest within the age class (i)

N_i - expected area of forest within the age class (i)

k - number of assumed age classes

Problem:

Observed destruction probabilities related to the age of forest stands prove to be significantly different .

Solution:

Weibull probability distribution W(c,γ) described by its distribution function *F(t)* as proposed by KOUBA (2002) and von GADOW (2000):

$$F(t) = 1 - e^{-c.t^{\gamma}}$$

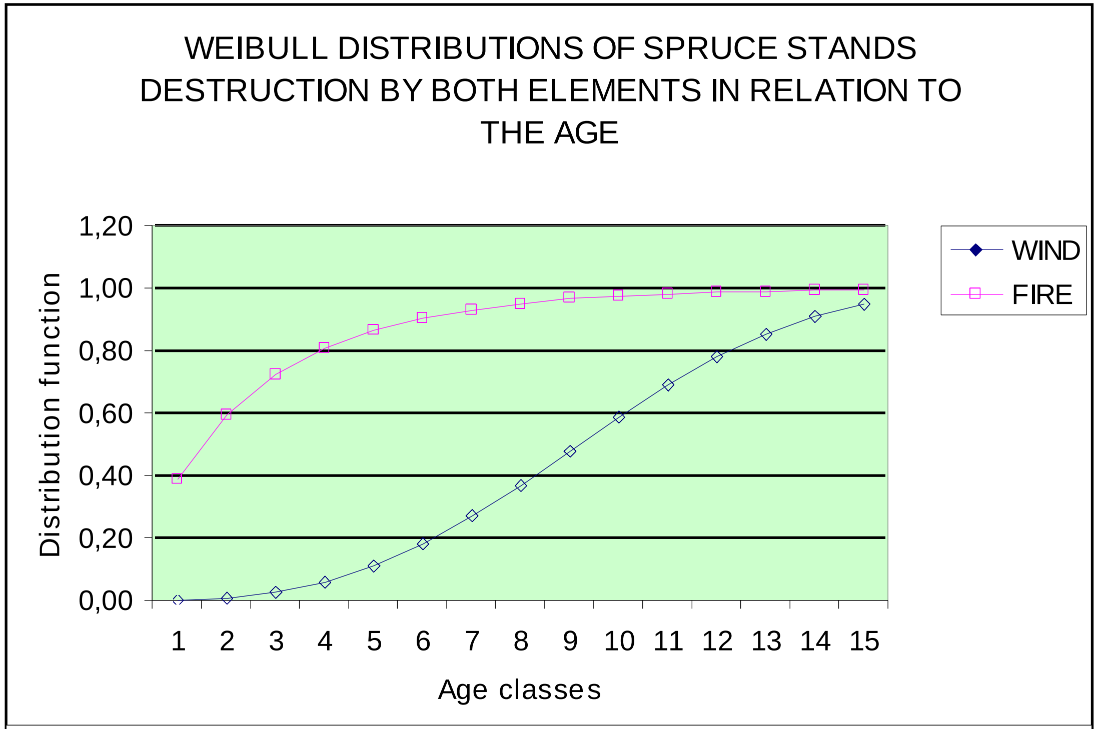
where (*t*) denotes the age of a forest stand.

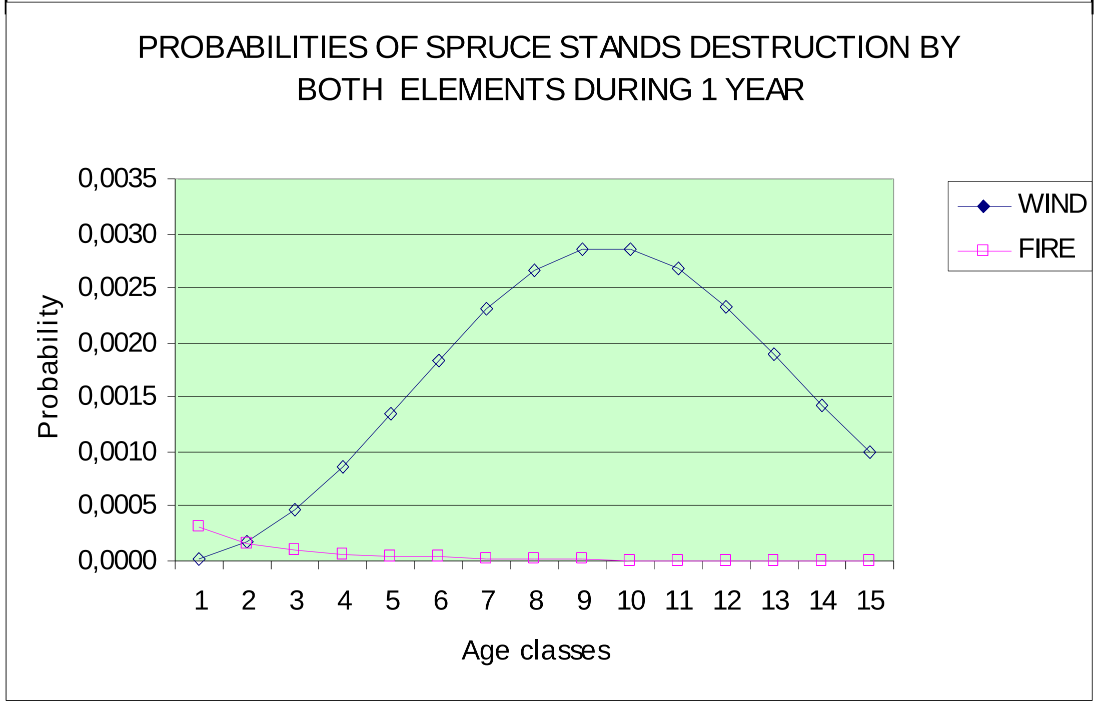
Probability of destruction related to the age of forest stand (*t*) is presented by point estimates of probabilities *p(t)* expressed in terms of the following relation:

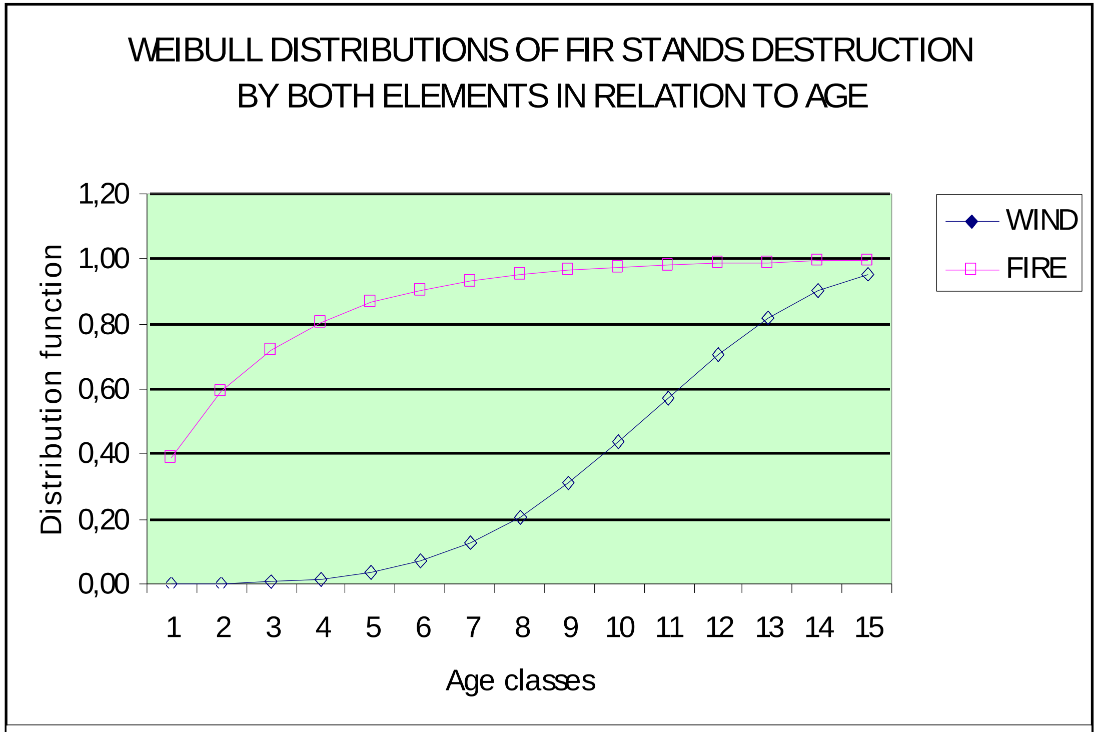
$$\frac{p(t)}{k} = \frac{\Delta F(t).n}{N}$$

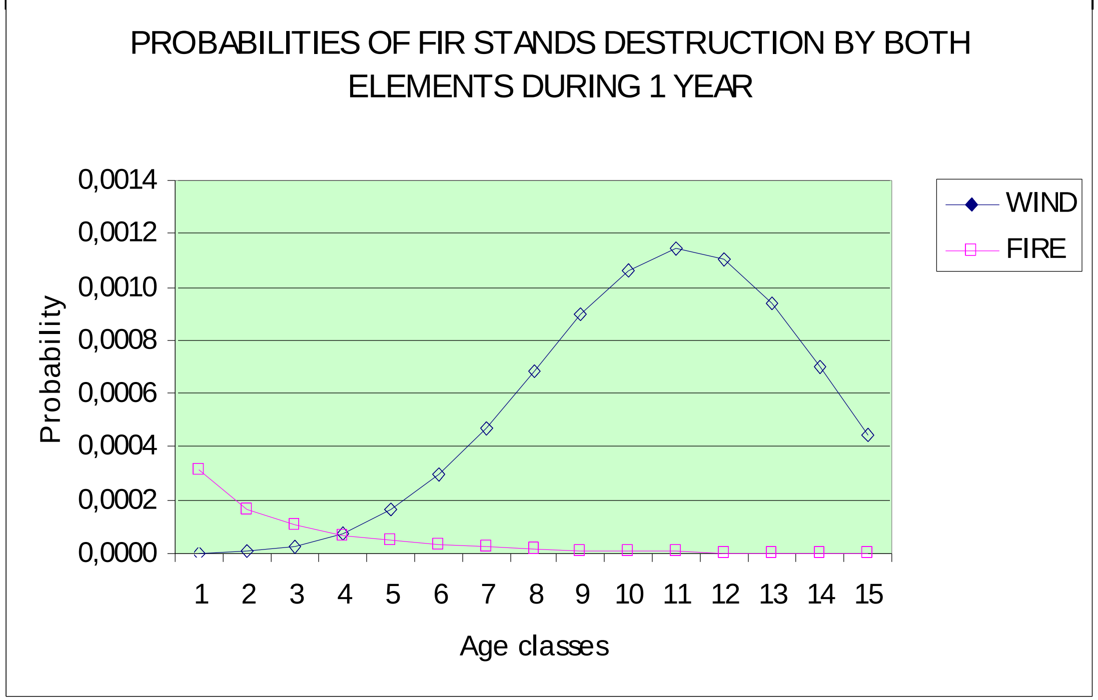
, i. e.

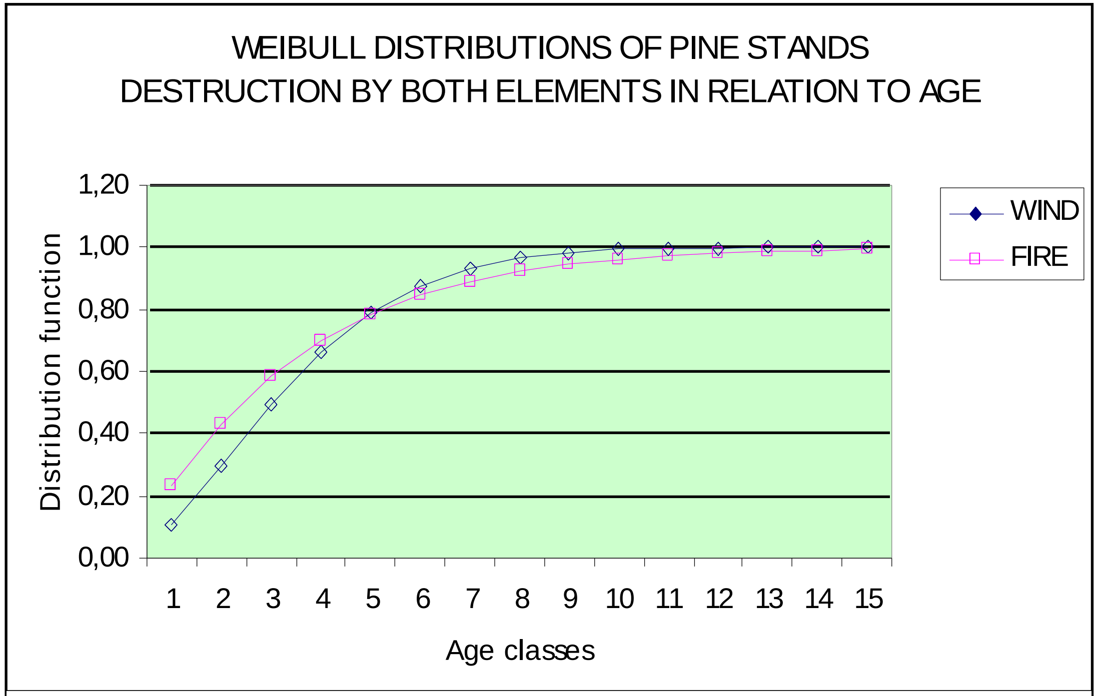
$$p(t) = k.\Delta F(t).p$$

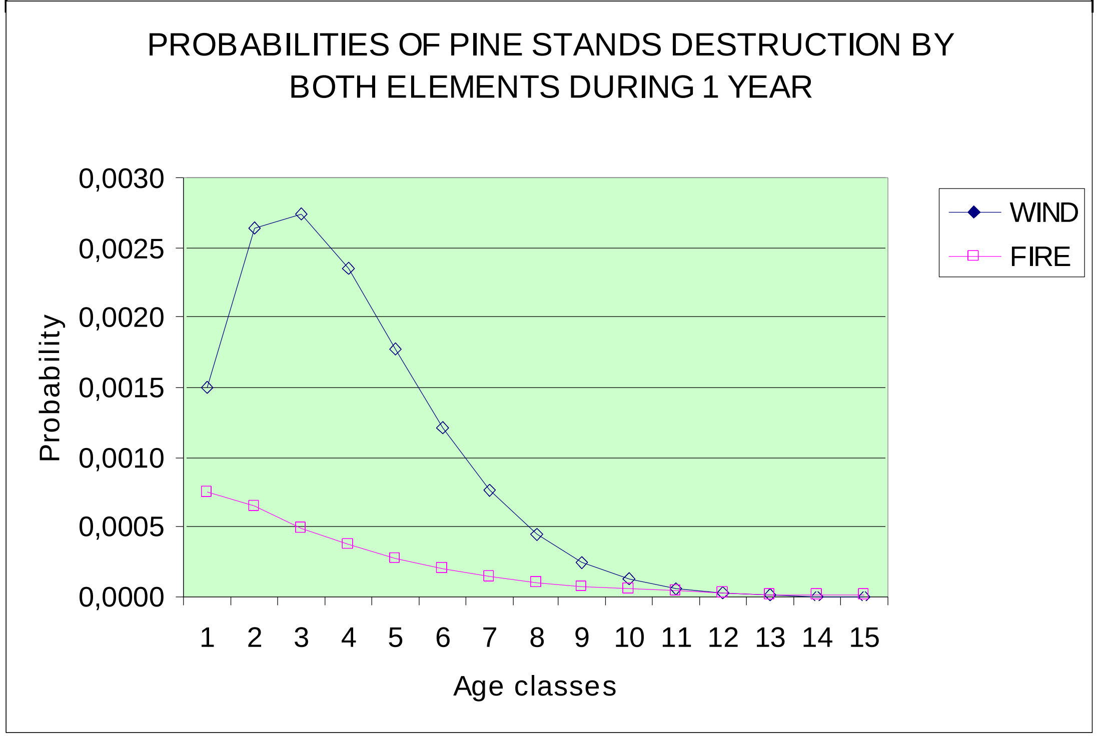

WEIBULL DISTRIBUTIONS OF SPRUCE STANDS DESTRUCTION BY BOTH ELEMENTS IN RELATION TO THE AGE
Distribution function
1,20
1,00
0,80
0,60
0,40
0,20
0,00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Age classes
WIND
FIRE

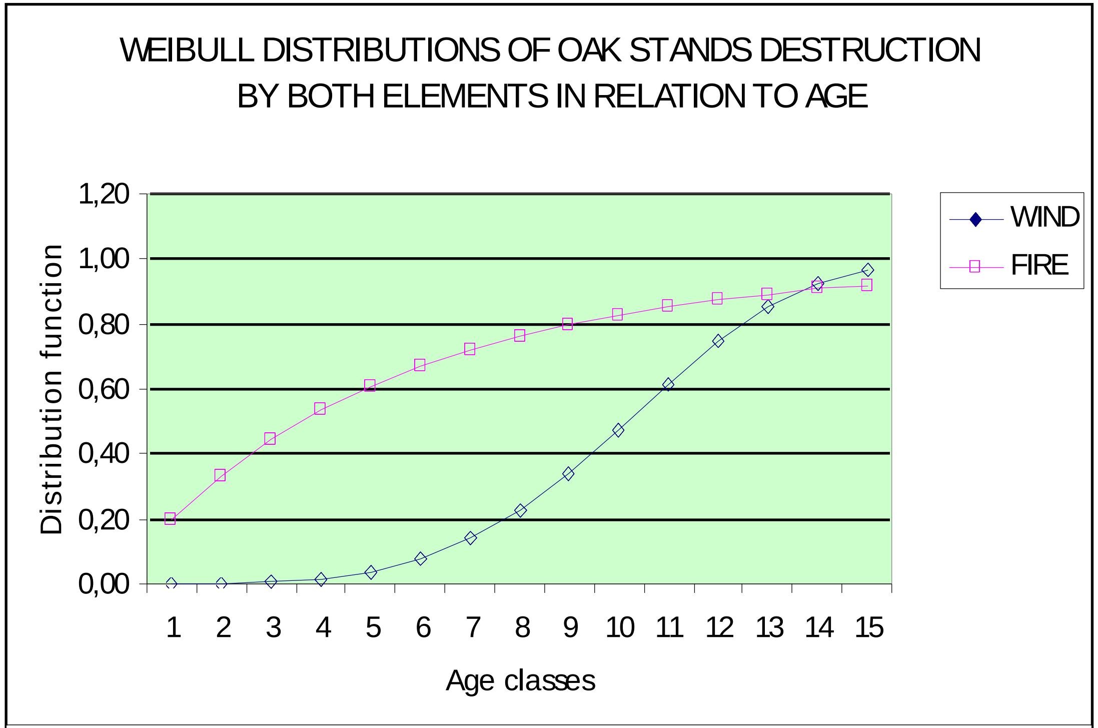

PROBABILITIES OF SPRUCE STANDS DESTRUCTION BY BOTH ELEMENTS DURING 1 YEAR
Probability
0,0035
0,0030
0,0025
0,0020
0,0015
0,0010
0,0005
0,0000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Age classes
WIND
FIRE

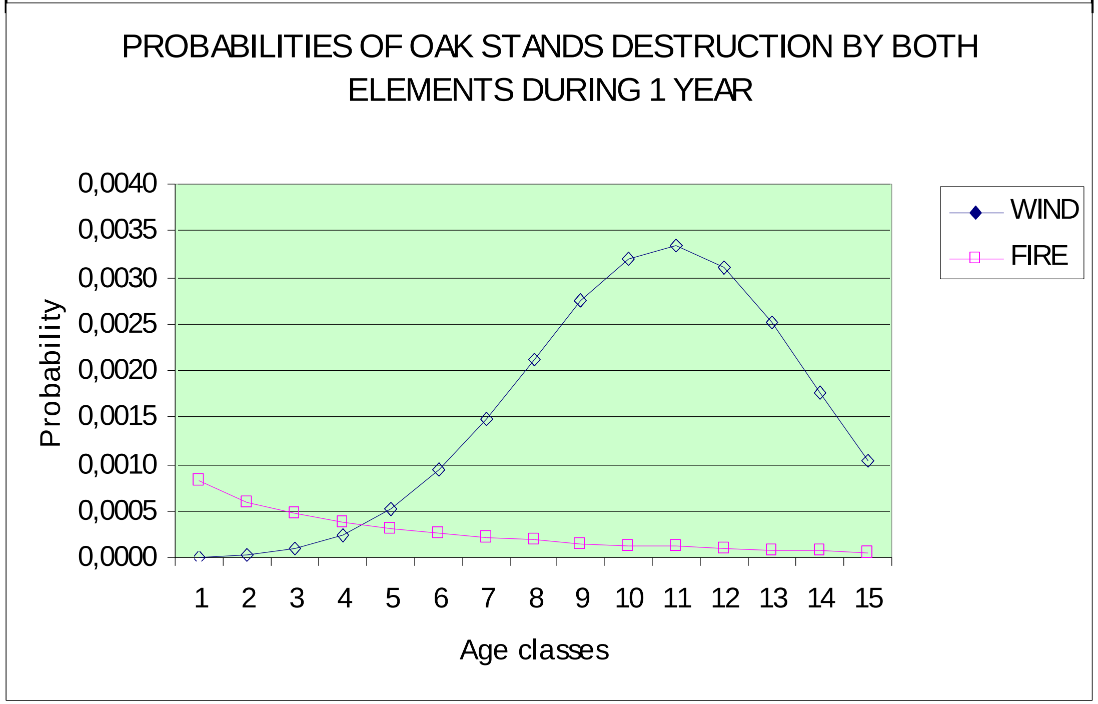

WEIBULL DISTRIBUTIONS OF FIR STANDS DESTRUCTION BY BOTH ELEMENTS IN RELATION TO AGE
Distribution function
1,20
1,00
0,80
0,60
0,40
0,20
0,00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Age classes
WIND
FIRE

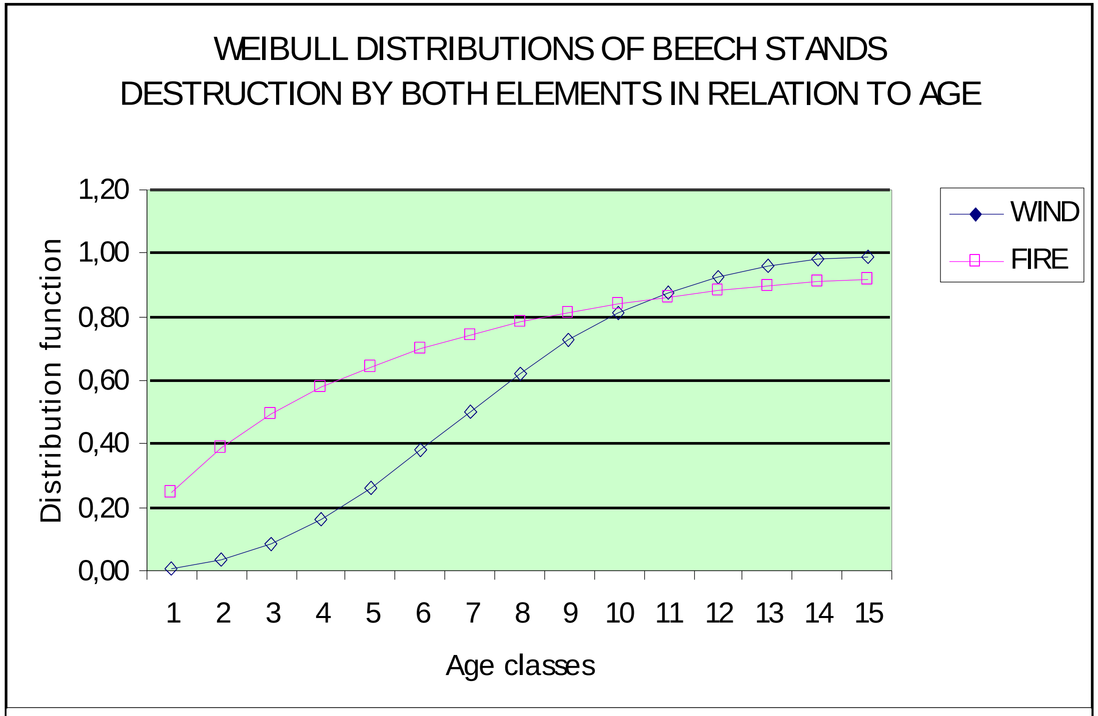

PROBABILITIES OF FIR STANDS DESTRUCTION BY BOTH ELEMENTS DURING 1 YEAR
Probability
0,0014
0,0012
0,0010
0,0008
0,0006
0,0004
0,0002
0,0000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Age classes
WIND
FIRE

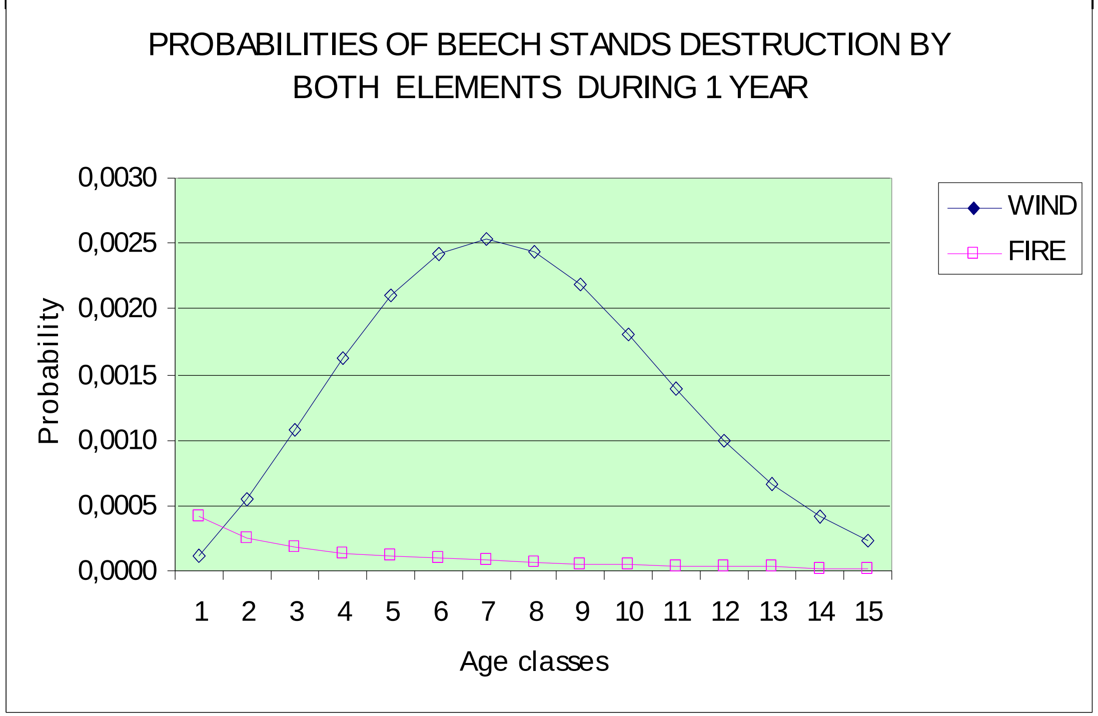

WEIBULL DISTRIBUTIONS OF PINE STANDS
DESTRUCTION BY BOTH ELEMENTS IN RELATION TO AGE
Distribution function
1,20
1,00
0,80
0,60
0,40
0,20
0,00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Age classes
WIND
FIRE


PROBABILITIES OF PINE STANDS DESTRUCTION BY
BOTH ELEMENTS DURING 1 YEAR
Probability
0,0030
0,0025
0,0020
0,0015
0,0010
0,0005
0,0000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Age classes
WIND
FIRE


WEIBULL DISTRIBUTIONS OF OAK STANDS DESTRUCTION BY BOTH ELEMENTS IN RELATION TO AGE
Distribution function
1,20
1,00
0,80
0,60
0,40
0,20
0,00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Age classes
WIND
FIRE


PROBABILITIES OF OAK STANDS DESTRUCTION BY BOTH ELEMENTS DURING 1 YEAR
Probability
0,0040
0,0035
0,0030
0,0025
0,0020
0,0015
0,0010
0,0005
0,0000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Age classes
WIND
FIRE


WEIBULL DISTRIBUTIONS OF BEECH STANDS
DESTRUCTION BY BOTH ELEMENTS IN RELATION TO AGE
Distribution function
1,20
1,00
0,80
0,60
0,40
0,20
0,00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Age classes
WIND
FIRE


PROBABILITIES OF BEECH STANDS DESTRUCTION BY
BOTH ELEMENTS DURING 1 YEAR
Probability
0,0030
0,0025
0,0020
0,0015
0,0010
0,0005
0,0000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Age classes
WIND
FIRE

THE ECONOMIC ANALYSIS OF RISK CONCERNING THE NATURAL ELEMENTS OCCURRENCE

Inputs:

- NPV(u) NET PRESENT VALUE of projects concerning growing particular tree-species in (€.ha^{-1}).
- SV(t) SALVAGE VALUE of a (t) years old forest stand after its destruction by a natural element in (€.ha^{-1}).
- SEV(u) RISK-ADJUSTED SOIL EXPECTATION VALUE at growing particular tree-species in (€.ha^{-1}).
- SEV_f(u) RISK-FREE SOIL EXPECTATION VALUE at growing particular tree-species in (€.ha^{-1})

1. Net present value of a forestry project *NPV(u)*

$$NPV(u) = \sum_{t=0}^{u} \frac{R_t - C_t}{(1+r)^t}$$

2. Risk adjusted soil expectation value *SEV(u)*

$$SEV(u) = \frac{NPV(u) . (1+\mathrm{r})^{\mathrm{u}}}{(1+\mathrm{r})^{\mathrm{u}} - 1}$$

TREE-SPECIES: SPRUCE			YIELD-CLASS:	28	r = 0,01 p.a.	
AGE	STUMPAGE VALUE	THINNINGS VALUE	REVENUES	COSTS	NET PRESENT VALUE	SOIL EXPECTATION VALUE
(t)	ST(t)	TH(t)	R(t)	C(t)	NPV(t)	SEV(t)
(years)	($€.ha^{-1}$)	($€.ha^{-1}$)	($€.ha^{-1}$)	($€.ha^{-1}$)	($€.ha^{-1}$)	($€.ha^{-1}$)
0	0	0	0	1209	-1209	
10	0	0	0	918	-2083	-42908
20	0	0	0	210	-2264	-16328
30	668	103	103	76	-1722	-7817
40	1487	219	219	76	-1092	-3713
50	2602	331	331	76	-316	-876
60	3684	393	393	76	335	795
70	4323	405	405	76	641	1346
80	5126	404	404	76	962	1830
90	5621	385	385	76	1077	1887
100	6271	393	393	76	1224	2002
110	6762	369	369	76	1270	1959
120	7692	382	382	76	1438	2110
130	8054	367	367	76	1394	1959
140	8506	345	345	76	1363	1844
150	8863	321	9184	76	1294	1695

TREE-SPECIES: FIR			YIELD-CLASS:	26	r = 0,01 p.a.	
AGE	STUMPAGE VALUE	THINNINGS VALUE	REVENUES	COSTS	NET PRESENT VALUE	SOIL EXPECTATION VALUE
(t)	ST(t)	TH(t)	R(t)	C(t)	NPV(t)	SEV(t)
(years)	(€.ha^{-1})	(€.ha^{-1})	(€.ha^{-1})	(€.ha^{-1})	(€.ha^{-1})	(€.ha^{-1})
0	0	0	0	2295	-2295	
10	0	0	0	1481	-3704	-76324
20	0	0	0	221	-3894	-28087
30	393	59	59	76	-3601	-16353
40	1308	226	226	76	-2879	-9790
50	2891	406	406	76	-1744	-4831
60	3905	520	520	76	-1075	-2552
70	5749	649	649	76	-23	-49
80	6227	611	611	76	172	326
90	6813	591	591	76	364	639
100	8845	694	694	76	1117	1827
110	10613	748	748	76	1650	2545
120	12207	784	784	76	2030	2978
130	11810	697	697	76	1726	2425
140	11426	625	625	76	1447	1957
150	11024	547	11571	76	1181	1546

TREE-SPECIES: PINE			YIELD-CLASS:	26	r = 0,01 p.a.	
AGE	STUMPAGE VALUE	THINNINGS VALUE	REVENUES	COSTS	NET PRESENT VALUE	SOIL EXPECTATION VALUE
(t)	ST(t)	TH(t)	R(t)	C(t)	NPV(t)	SEV(t)
(years)	(€.ha^{-1})	(€.ha^{-1})	(€.ha^{-1})	(€.ha^{-1})	(€.ha^{-1})	(€.ha^{-1})
0	0	0	0	3104	-3104	
10	0	0	0	362	-3448	-71048
20	0	0	0	241	-3656	-26366
30	811	92	92	76	-3011	-13671
40	1488	242	242	76	-2475	-8416
50	3215	448	448	76	-1233	-3416
60	5281	604	604	76	73	173
70	5423	528	528	76	95	199
80	6491	528	528	76	546	1038
90	7969	539	539	76	1088	1906
100	9082	587	587	76	1395	2282
110	9936	564	564	76	1533	2365
120	10405	523	523	76	1494	2191
130	11661	540	540	76	1676	2354
140	11369	489	489	76	1389	1879
150	11085	444	11529	76	1128	1476

TREE-SPECIES: OAK			YIELD-CLASS:	24	r = 0,01 p.a.	
AGE	STUMPAGE VALUE	THINNINGS VALUE	REVENUES	COSTS	NET PRESENT VALUE	SOIL EXPECTATION VALUE
(t)	ST(t)	TH(t)	R(t)	C(t)	NPV(t)	SEV(t)
(years)	($€.ha^{-1}$)	($€.ha^{-1}$)	($€.ha^{-1}$)	($€.ha^{-1}$)	($€.ha^{-1}$)	($€.ha^{-1}$)
0	0	0	0	2939	-2939	
10	0	0	0	1312	-4188	-86283
20	120	24	24	210	-4245	-30616
30	170	38	38	76	-4245	-19276
40	263	50	50	76	-4210	-14316
50	1463	165	165	76	-3404	-9431
60	3300	349	349	76	-2272	-5391
70	5236	407	407	76	-1265	-2657
80	7096	635	635	76	-378	-719
90	9491	628	628	76	568	996
100	10850	720	720	76	961	1572
110	12229	636	636	76	1244	1919
120	13494	557	557	76	1392	2043
130	15864	592	592	76	1817	2554
140	17729	602	602	76	2008	2717
150	19104	594	19699	76	2017	2641

TREE-SPECIES: BEECH			YIELD-CLASS:	24	r = 0,01 p.a.	
AGE	STUMPAGE VALUE	THINNINGS VALUE	REVENUES	COSTS	NET PRESENT VALUE	SOIL EXPECTATION VALUE
(t)	ST(t)	TH(t)	R(t)	C(t)	NPV(t)	SEV(t)
(years)	(€.ha^{-1})	(€.ha^{-1})	(€.ha^{-1})	(€.ha^{-1})	(€.ha^{-1})	(€.ha^{-1})
0	0	0	0	1620	-1620	
10	0	0	0	722	-2307	-47539
20	0	0	0	158	-2444	-17624
30	153	35	35	76	-2356	-10700
40	340	70	70	76	-2239	-7614
50	895	153	153	76	-1858	-5148
60	2953	414	414	76	-526	-1249
70	4461	494	494	76	321	674
80	7365	490	490	76	1673	3181
90	9237	511	511	76	2332	4086
100	10411	519	519	76	2585	4228
110	11164	507	507	76	2618	4039
120	11838	495	495	76	2595	3807
130	12041	453	453	76	2405	3379
140	12057	388	388	76	2162	2925
150	11486	333	11820	76	1790	2343

3. Salvage value of a (t) years old forest stand $SV(t)$

4. Risk-free soil expectation value $SEV_f(u)$ (REED, 1984) but presented only in the form of a differential equation.

The algorithm of its calculation uses the transition probability matrix (W) as a tool for the description of age class structure dynamics in the presence of risk.

Transition probability matrix (W)

$$
W = \begin{vmatrix}
w_1 & 1-w_1 & 0 & 0 & \ldots & 0 \\
w_2 & 0 & 1-w_2 & 0 & \ldots & 0 \\
. & . & . & . & & \\
. & . & . & . & & \\
. & . & . & . & & \\
w_j & 0 & 0 & 1-w_j & \ldots & 0 \\
. & . & . & . & & \\
. & . & . & . & & \\
. & . & . & . & & \\
w_k & 0 & 0 & 0 & \ldots & 1-w_k
\end{vmatrix}
$$

(w_j) is the probability of a stand destruction in the age class (j)

(w_k) = 1.0

The share of particular age classes (j) on 1 ha originally planted during the assumed decades (i) of a forestry project is given by the elements of vector $p^{(i)}$:

$$p^{(i)} = p^{(0)} . W^{i}$$

where

$$p^{(0)} = [1, 0, 0,\ldots, 0]$$

KOUBA (1989)

The shares of expected destroyed areas are described by the elements of (q_{ij}):

$$q_{ij} = p_{ij} \,.\, g_j$$

$$g_{j+1} = \prod_{i=1}^{j}(1-w_j).w_{j+1} \quad \text{pre} \quad g_1 = w_1$$

Gentan probabilities (g_j) were proposed by SUZUKI (1983)

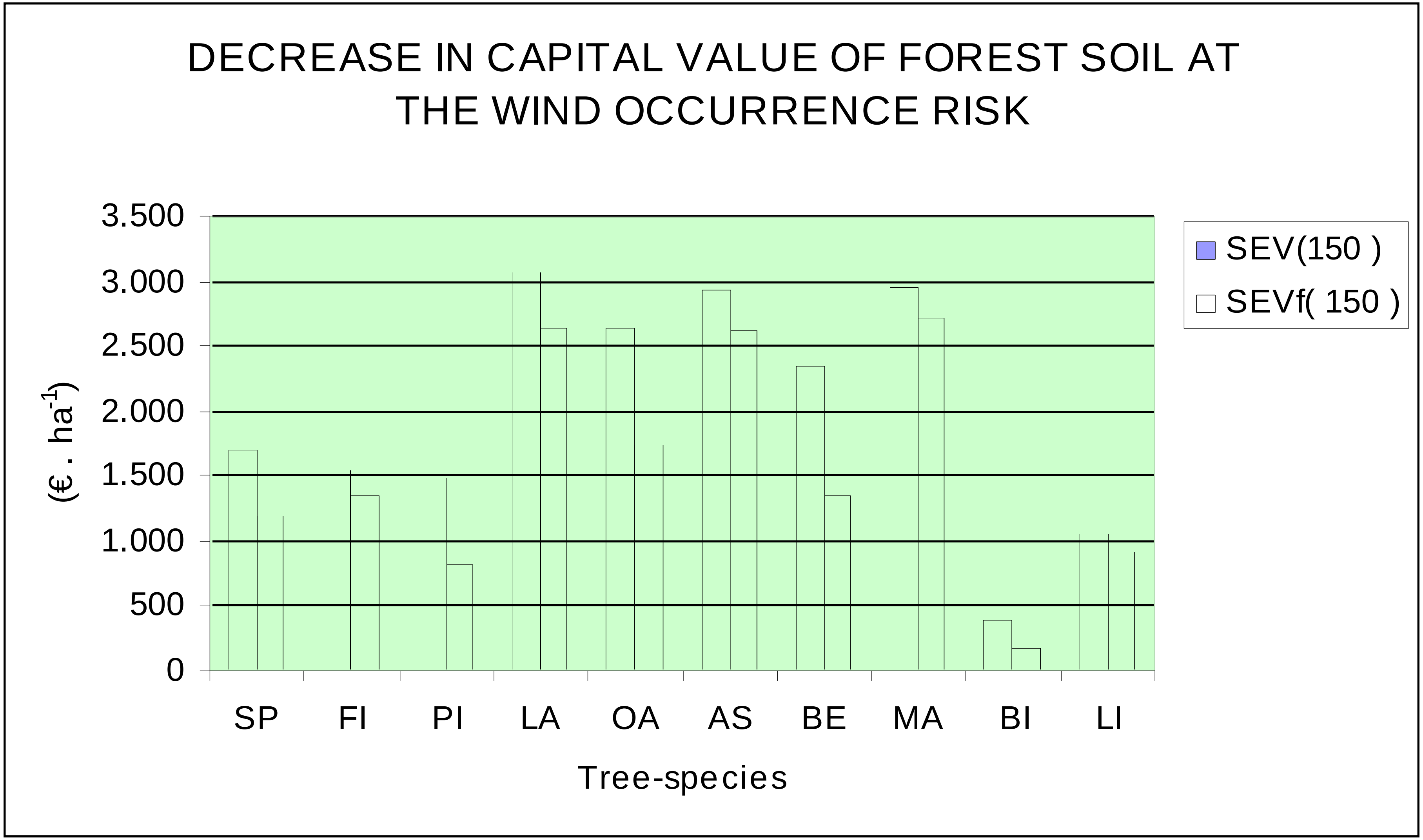
Algorithm of computing the *SEV*$_f$*(u):*

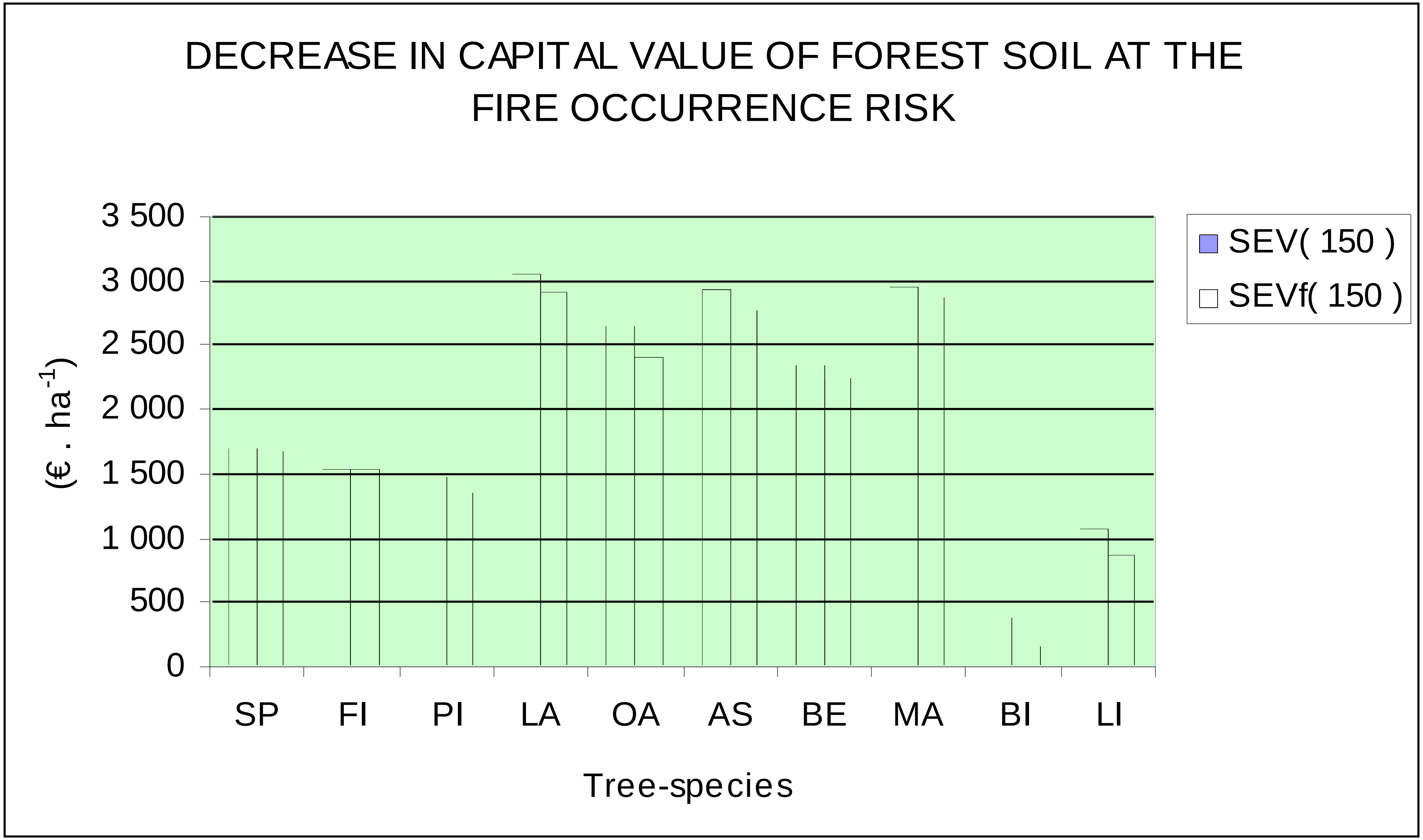
1. Shares of areas (p_{ij}) and (q_{ij}) are valuated by particular revenues and costs of a project.

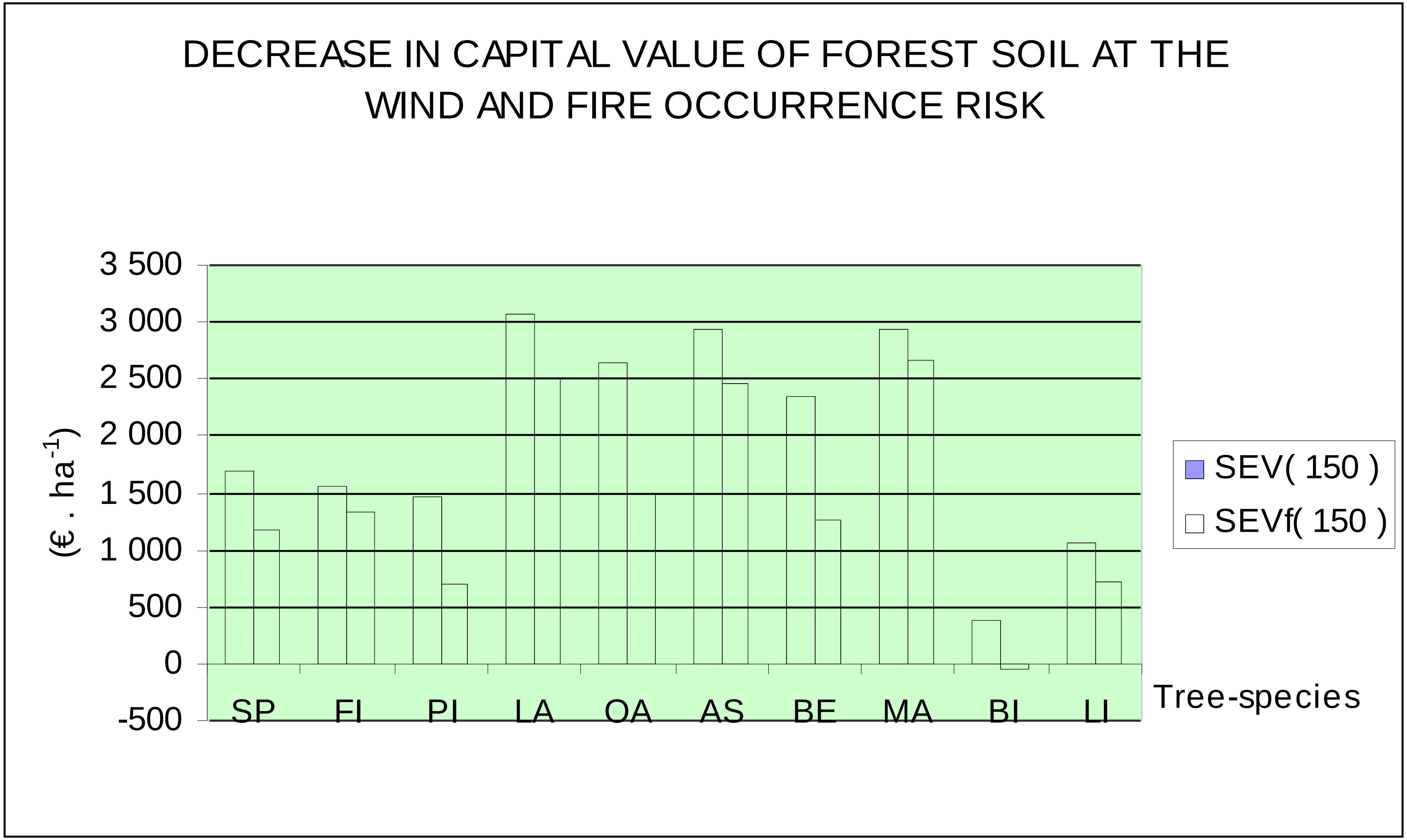
2. Calculating the *NPV(u)* of a never-ending forest management project.

3. Algorithm ends when the increment *?LNPV(u)* for the last assumed rotation period of (u) years is less than € 0,01. (HOLECY, 2005)

PRELIMINARY RESULTS




DECREASE IN CAPITAL VALUE OF FOREST SOIL AT THE FIRE OCCURRENCE RISK
3 500
3 000
2 500
2 000
1 500
1 000
500
0
(€ . ha-1)
SP
FI
PI
LA
OA
AS
BE
MA
BI
LI
Tree-species
SEV(150)
SEVf(150)


DECREASE IN CAPITAL VALUE OF FOREST SOIL AT THE WIND AND FIRE OCCURRENCE RISK
(€ . ha-1)
3 500
3 000
2 500
2 000
1 500
1 000
500
0
-500
SP
FI
PI
LA
OA
AS
BE
MA
BI
LI
Tree-species
SEV(150)
SEVf(150)

MEASURING THE ECONOMIC IMPACT OF NATURAL ELEMENTS OCCURRENCE RISK

Output:

- *RPSEV(u)* RISK PREMIUM ON THE FOREST SOIL management

$$RPSEV(u) = SEV(u) - SEV_f(u)$$

RESULTS OF THE $SEV_f(u)$ CALCULATION AT GROWING PARTICULAR TREE-SPECIES

TREE-SPECIES:	SPRUCE	FIR	PINE	LARCH	OAK	BEECH	MAPLE	ASH	BIRCH	LIME
Measures	(€.ha^{-1})	(€.ha^{-1})	(€.ha^{-1})	(€.ha^{-1})	(€.ha^{-1})	(€.ha^{-1})	(€.ha^{-1})	(€.ha^{-1})	(€.ha^{-1})	(€.ha^{-1})
SEV(u)	1 695	1 546	1 476	3 063	2 641	2 343	2 945	2 937	387	1 062
$RPSEV(u)_f$	16	17	117	145	244	88	68	158	221	193
$RPSEV(u)_W$	503	199	651	415	905	991	218	312	209	147
$SEV_f(u)$	1 176	1 331	708	2 502	1 492	1 264	2 660	2 467	-42	722

CONCLUSIONS

1. The risk of fire is considerably higher at the coniferous tree-species growing.

2. The impact of the wind and fire occurrence risk on the capital value of forest land is very strong at all investigated grown tree-species.

3. The risk of fire at growing pure coniferous stands could be decreased by planting mixed forests composed also of beech, maple and ash-tree.

4. The risk of wind-throw at growing pure coniferous stands could be decreased by admixture of ash-tree, maple and larch.

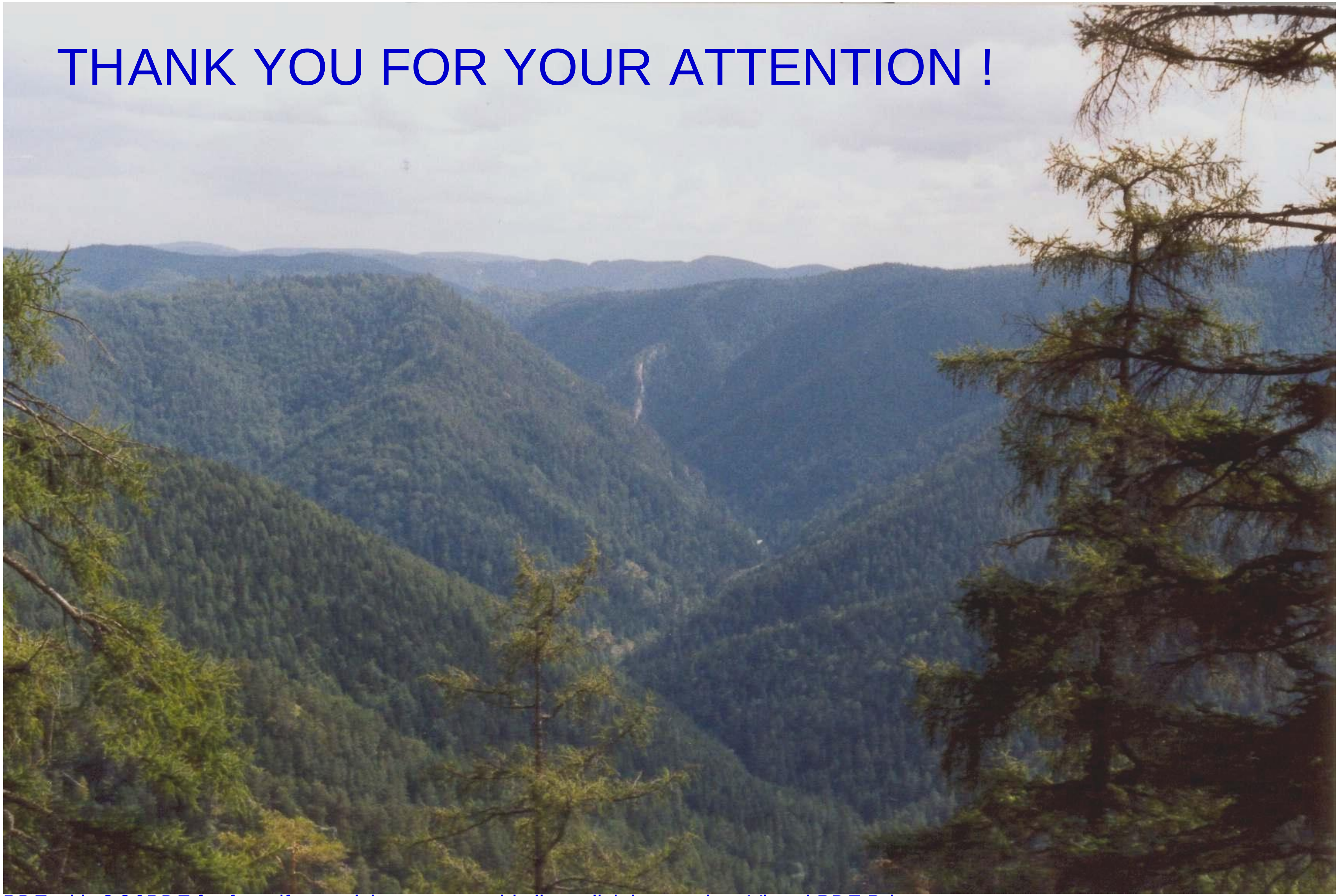
INSTITUTIONAL FRAMEWORK FOR ACCEPTING THE RISK IN FORESTRY

Negative impacts of risk attending the forest management:

- Deterioration of forest and other ecosystems
- Decreasing the quality of the environment
- Disturbing the sustainability of forestry
- Reduction of social benefits accruing from forestry
- Decreasing the profitability of forest enterprises
- Decreasing the financial stability of forest enterprises

Remedial interventions to cope the presence of risk in forestry:

- Ecosystem management approach.
- Planting the ecologically more stable mixed forests.
- Preservation and strengthening the biological diversity.
- Collaborative and participative planning approaches.
- Insurance of forests in order to strengthen the financial stability of forest land management.


THANK YOU FOR YOUR ATTENTION !