

MANAGEMENTOVÉ (PĚSTEBNÍ) SYSTÉMY A VÍCEÚČELOVÉ LESNICTVÍ EKOSYSTÉMOVÝCH SLUŽEB

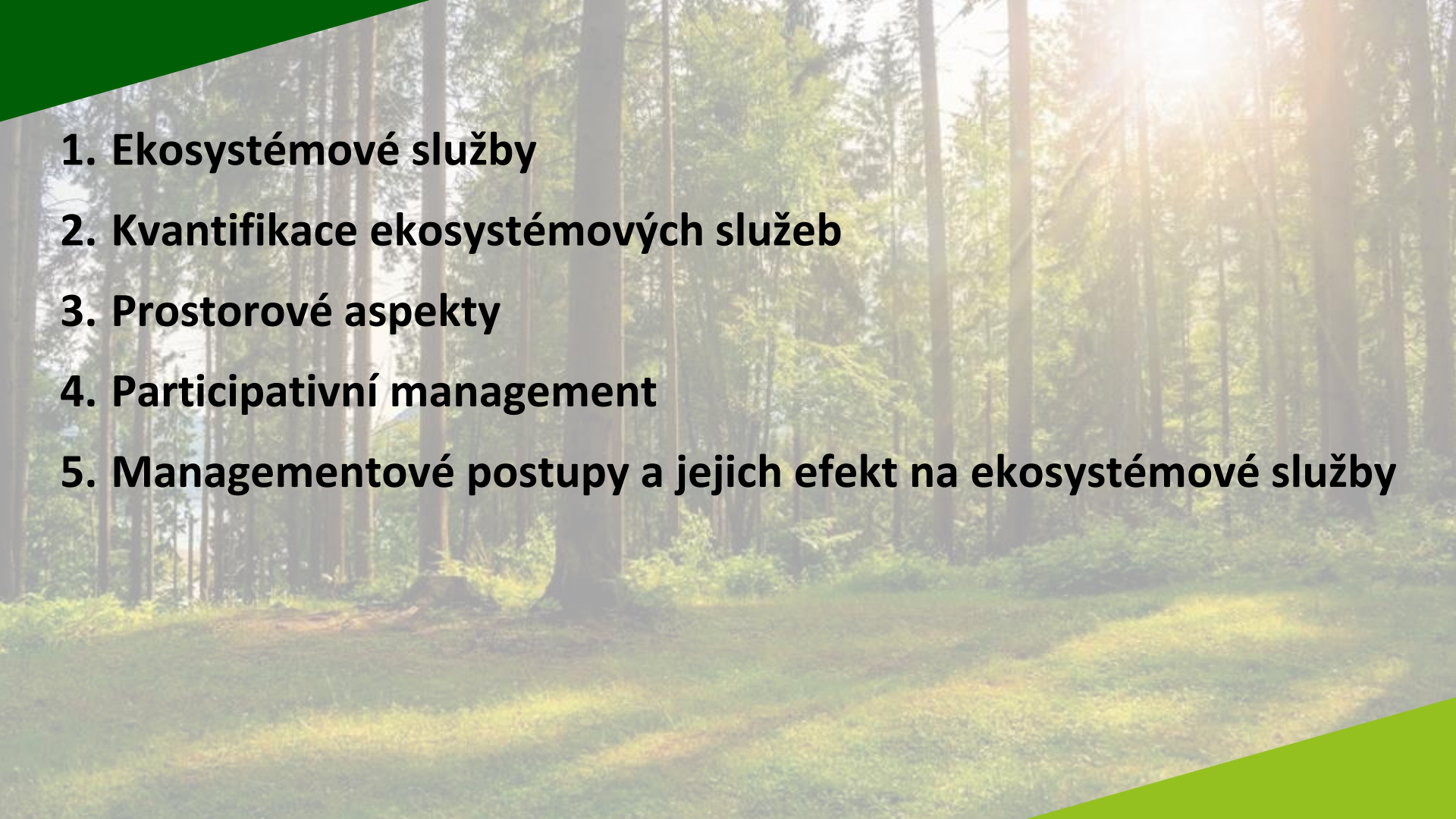
česká
zemědělská
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v Praze

doc. Ing. Jan Kašpar, Ph.D.

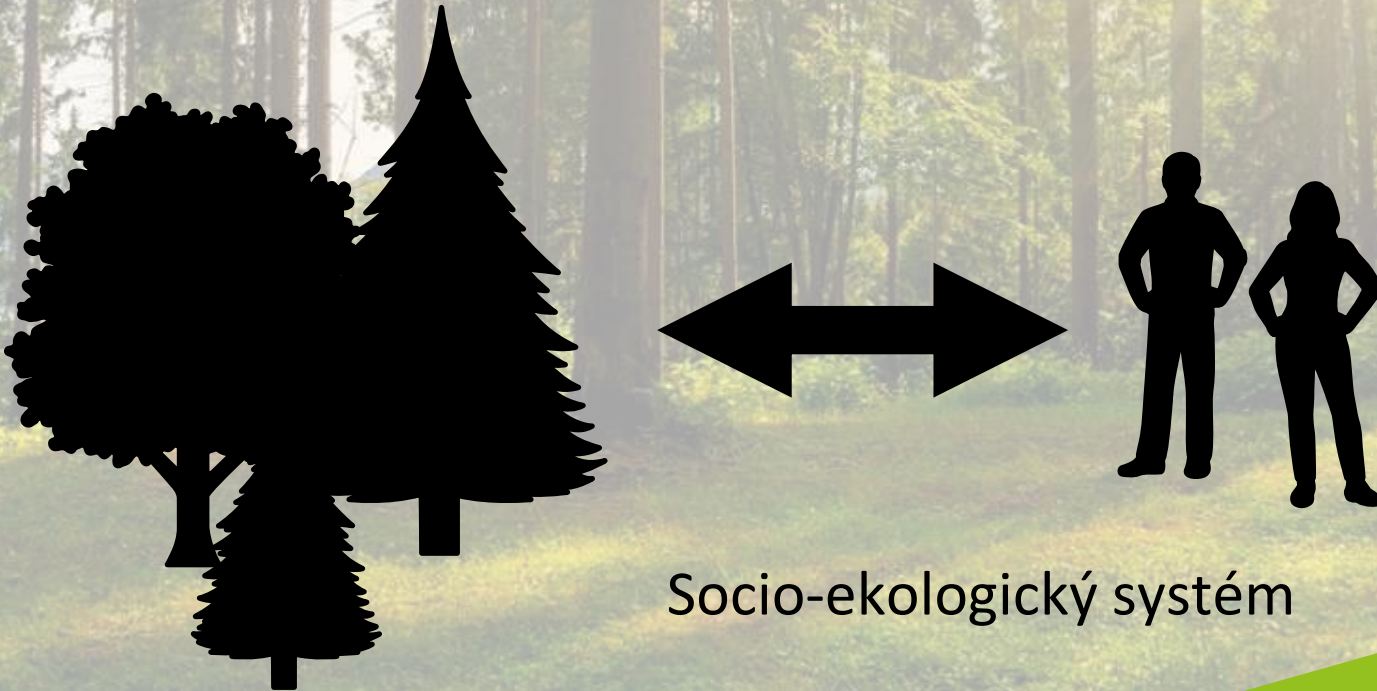
15.11.2023 (středa), 9:00 – 10:50 hod., učebna B32, budova B – LDF MENDELU



Fakulta lesnická
a dřevařská

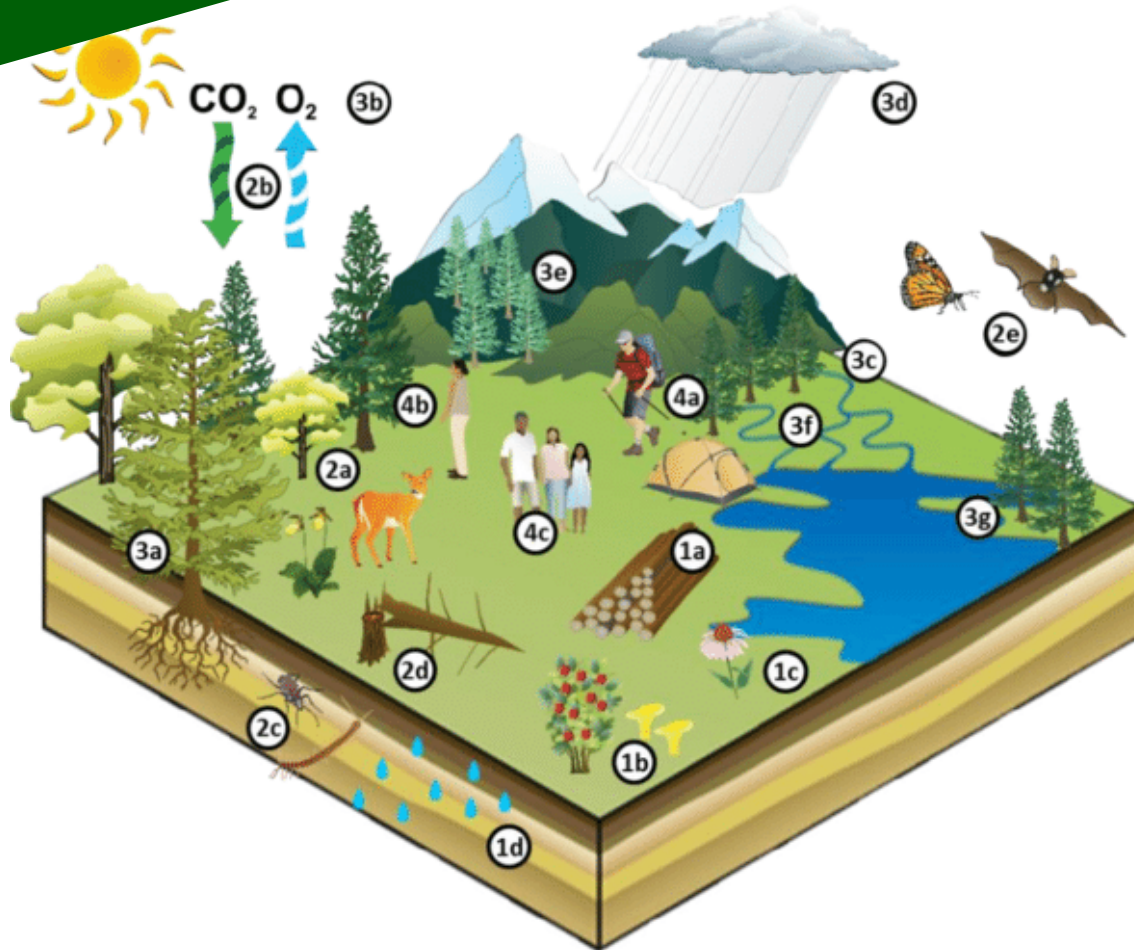
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- 1. Ekosystémové služby**
 - 2. Kvantifikace ekosystémových služeb**
 - 3. Prostorové aspekty**
 - 4. Participativní management**
 - 5. Managementové postupy a jejich efekt na ekosystémové služby**

Ekosystémové služby = benefity (přímé a nepřímé) přírody společnosti



Socio-ekologický systém

Ecosystem services of forests



1. Provisioning Services

- Timber/Fibre (construction, energy)
- Food (deer, fruits, herbs, seeds, honey)
- Chemical and medicinal products
- Water

2. Supporting Services

- Habitats for fauna and flora (biodiversity)
- Photosynthesis/Primary production
- Soil formation
- Nutrient cycling
- Pollination, seed dispersal

3. Regulating Services

- Carbon storage (above/below ground)
- Purification of air
- Purification of water
- Climate regulation
- Protection against erosion/avalanches
- Flood mitigation
- Protection against coastal erosion and storms

4. Cultural Services

- Recreation/Aesthetics
- Spirituality
- Education

Ekosystémové služby (ES)

- Nezbytná součást trvale udržitelného rozvoje
- Vhodný i pro dlouhodobý monitoring ekosystémů
- Založeny na principu ekologickém, ekonomickém i sociálním
- Bohužel ale kvantifikace a ohodnocení ES je stále kritickým bodem
- Prostorový aspekt a měřítko jsou dalšími kritickými body

Jak ekosystémové služby (ES) kvantifikovat?

- Regresní modely X indexy (proxy indexy)
- Nepřímé metriky
- Pochopit vývoje lesních ekosystémů a trade-offs je výzvou současnosti

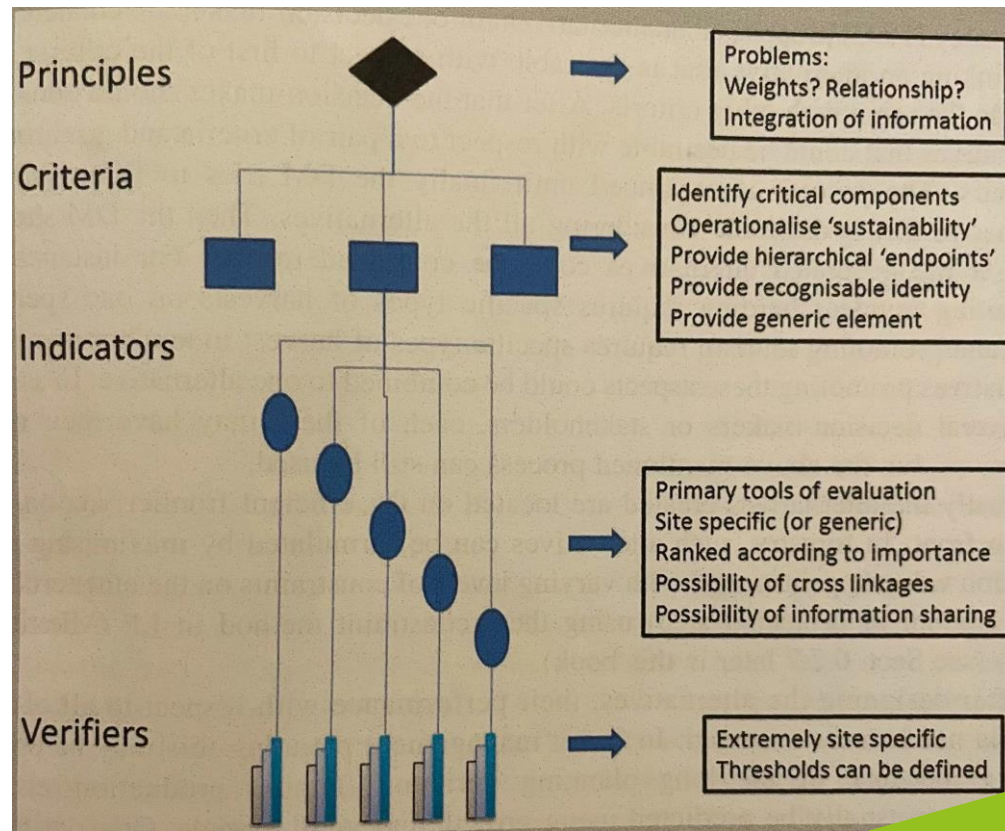
Příklady implementace ES do lesnického plánování

- **Vodní režim (Feller 2005, Baskent and Kicker 2010...)**
- **Biodiverzita a habitaty (Eriksson and Hammer 2006,...)**
- **Kulturní hodnoty (Lundholm et al. 2020)**
- **Snížení půdní eroze (Baskent 2019, Rodrigues et al. 2020)**
- **Sekvestrace uhlíku (Backeus et al. 2006, Dong et al. 2015)**

Rozhodovací model

Sada kritérií

1. Esenciálnost
2. Kontrolovatelnost
3. Komplexnost
4. Měřitelnost
5. Operativnost
6. Rozložitelnost
7. Potřebnost
8. Konzistentnost
9. Srozumitelnost



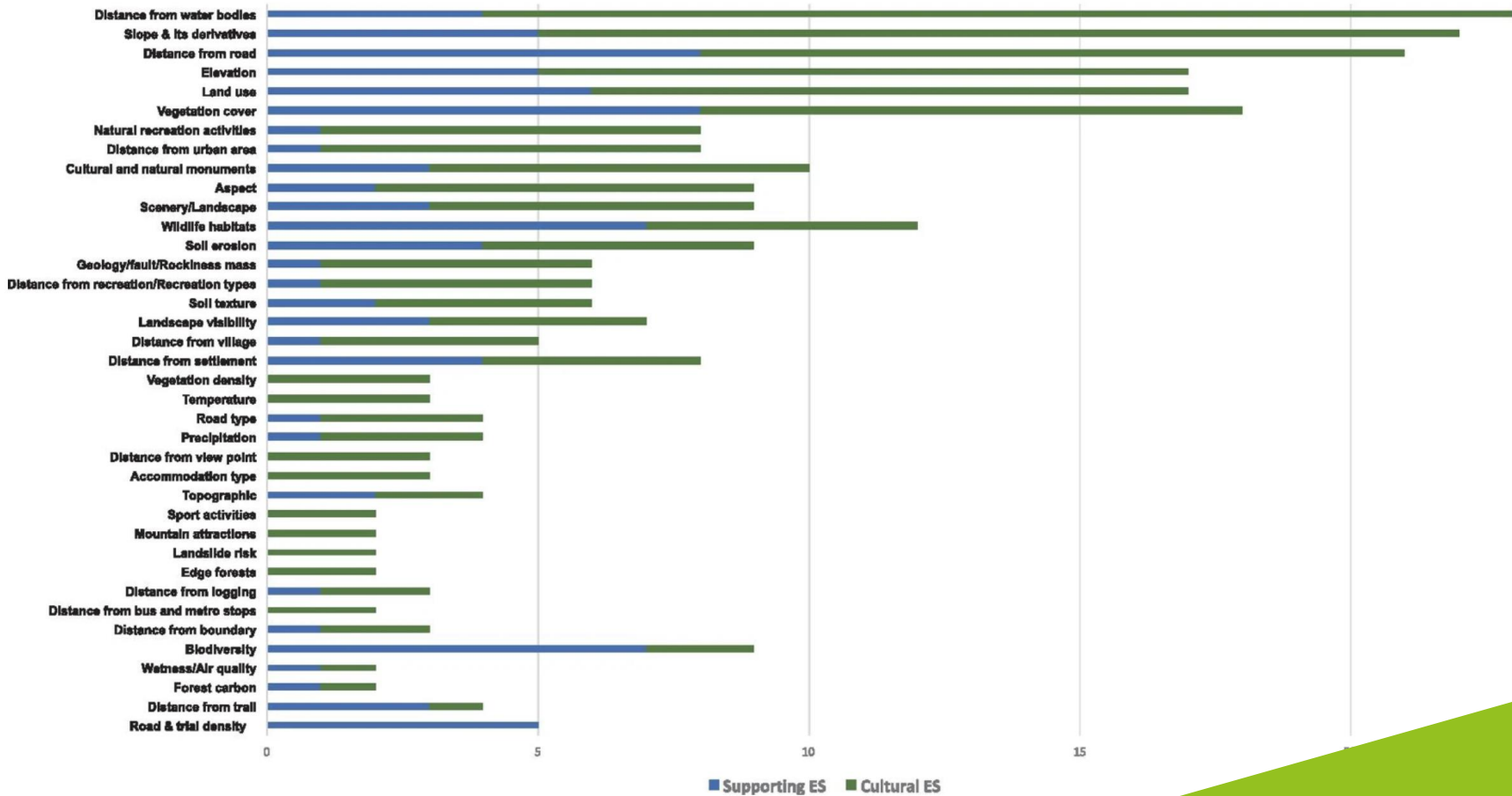
A photograph of a forest with tall, thin trees and a grassy clearing. Sunlight filters through the trees, creating a bright, hazy atmosphere. The text is overlaid on the image.

Utility / hodnotová funkce

Trade-offs

Prostorový aspekty a měřítko

Relevant criteria used in both ecosystem services



Participativní management

- **Problémy managementu lesů komplexní, často neúplně definované**
- **Musíme se soustředit na řešení „good enough“**
- **Skupinové rozhodování X participace veřejnosti**

Managementové postupy a jejich efekt na ekosystémové služby



Baskent, Kašpar 2022. Exploring the effects of management intensification on multiple ecosystem services in an ecosystem management context. Forest Ecology and Management 518, 120299

Baskent, Kašpar 2023. Exploring the effects of various rotation length on the ecosystem services within a multiple-use management framework. Forest Ecology and Management 538, 120974

Vybrané ekosystémové služby

- Produkce dříví – porostní zásoba a ČSH
- Sekvestrace uhlíku - Lundholm a kol. 2020 + IPCC
- Produkce vody $WP = 1797.97 * e^{-0,0196*BA}$
- Ztráta půdy $SL = 30.437 * e^{-0,0488*BA}$
- Ochrana biodiverzity - objem velkých stromů, zásoba původních dřevin, podíl starých porostů, počet dřevin, zastoupení listnatých dřevin, přirozená obnova, rozkládající se dřevo
- Kulturní hodnoty - RAFL index

List of indicators and attributes for all dimensions and concepts with the specific value functions including the upper and lower limits in averaging the score to create the RAFL-index (Adopted from [Lundhol et al., 2020](#)).

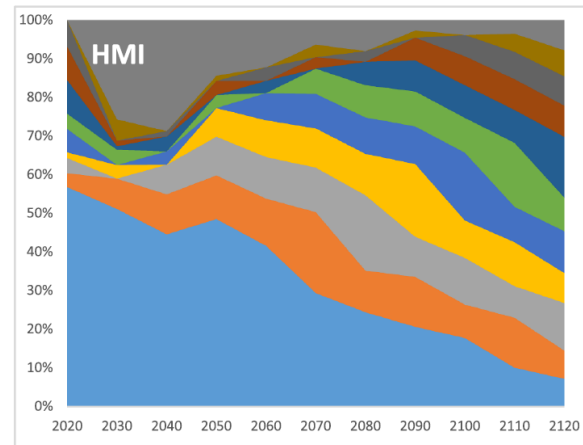
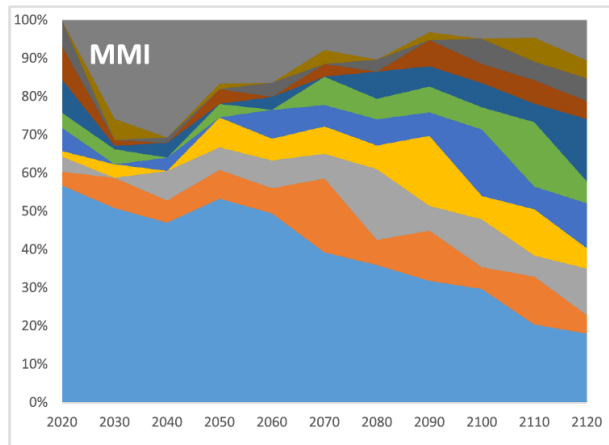
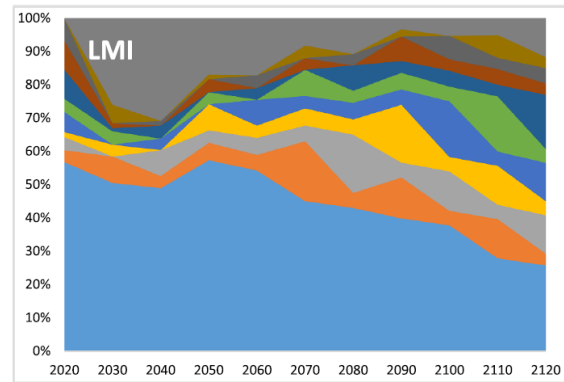
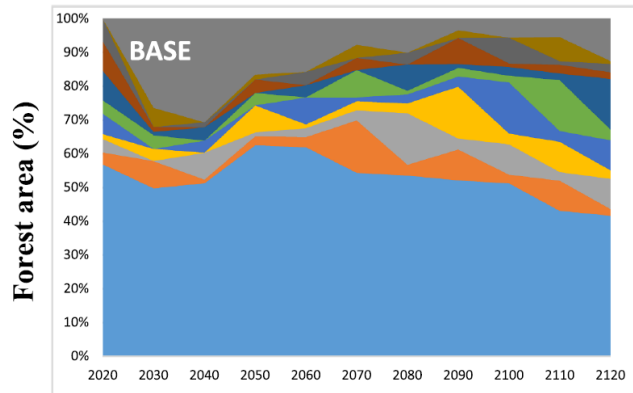
Concepts	Dimensions	Attribute (following template)	Indicator (units)	Direction of attribute	Value-function (Linear)
Stewardship	Sense of care / upkeep	Harvest residues	$\text{m}^3 \text{ha}^{-1}$	-	$0 \text{ m}^3 = 0$, $>=6 \text{ m}^3 = 1$
Naturalness / disturbances	Alteration/ impact	Area harvested (final felling area)	% of forest area harvested	-	$0\% = 0$, $5\% = 1$,
	Wilderness	Mortality volume	$\text{m}^3 \text{ha}^{-1}$	+	$0 \text{ m}^3 \text{ha}^{-1} = 0$, $5 \text{ m}^3 \text{ha}^{-1} = 1$, linear
Complexity	Intrusion	Naturalness (Hemeroby index)	$0 = \text{natural, non-disturbed forest, } 0.33 = \text{close to natural, } 0.66 = \text{semi-natural, } 1 = \text{far from natural (monocultures, plantation)}$	-	linear
	Diversity	Shannon index (species, standing volume)		+	$0.5 = 0$ $2 = 1$,
	Variety	Evenness of tree sizes on landscape level (dbh)	0-1	+	linear
Visual scale	Spatial structure	Patch (stand) size variation	% of total forest landscape occupied by largest forest stand	-	$0.001\% = 0$, $5\% = 1$,
	Openness	Mean tree number	Stems ha^{-1}	-	$800 = 0$, $1500 = 1$, linear
Historicity / imageability	Visibility	Understory	% of forest stands with understory	-	linear
	Historical richness	Mean stand age	years	+	$20 \text{ yr} = 0$, $80 \text{ yr} = 1$,
Ephemera	Historical continuity	Change in forest location (afforestation, deforestation)	% of forest area that changed location (afforestation and deforestation)	-	$0\% = 0$, $10\% = 1$,
	Seasonal change	Share broadleaves	% broadleaf volume of total	+	$0\% = 0$, $6\% = 1$,

Management units (working circles)	Productive forests (ha) (*)	Degraded areas(**) (ha)	Total forest area (ha)	Bare forest lands(**) (ha)	Other areas (ha)	Total area (ha)
A:Max. round wood production (Red Pine)	258.9	16.4	275.3	0.0	47.9	323.2
B:Max. round wood production (Black Pine)	424.5	43.4	467.9	43.1	2.2	513.2
C:Nature protection	44.8	292.4	337.2	2,161.0	257.8	2,756.0
D:Wildlife protection	1,864.1	976.5	2,831.6	5.4	8.3	2,845.3
E:Wildlife development	5,281.5	4,852.7	10,134.2	7,026.0	3,426.3	20,586.5
F:Soil Protection	1,839.7	3,117.1	4,956.8	5,367.1	3,021.2	13,345.1
G:Recreation	0.0	6.7	6.7	0.0	57.6	64.3
Total	9,713.5	9,296.2	19,009.7	14,602.6	6,821.3	40,433.6

(*) Forest stands over %10 of crown closure is defined as productive primarily in terms of wood production ES.

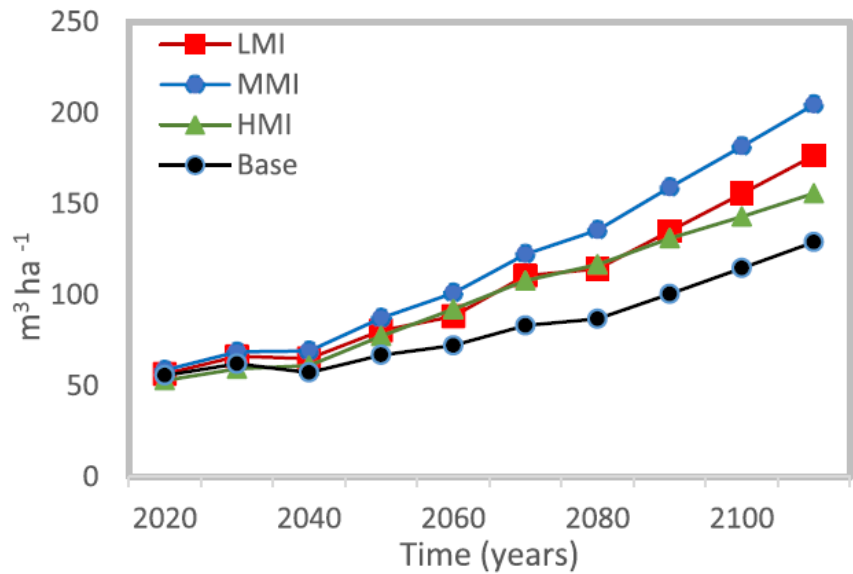
(**) These areas are potential for afforestation (crown closure less than 10% and bare forest areas).

- BSA – obmýtí 60/120, 9 %/periodu výměry určeno k obnově, 15 % / 10 %
- LMI – obmýtí 80/160, 30 %/periodu výměry určeno k obnově, 15 % / 10 %
- MMI – obmýtí 70/140, 60 %/periodu výměry určeno k obnově, 25 % / 15 %
- HMI – obmýtí 50/100, 100 %/periodu výměry určeno k obnově, 45 % / 25 %

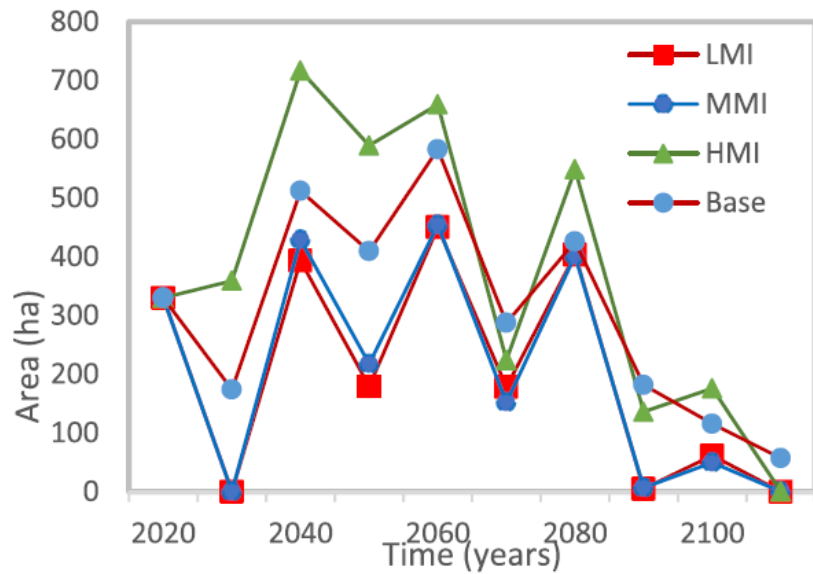


Age-class (years)

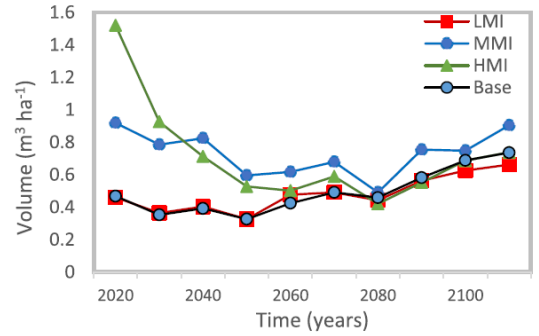
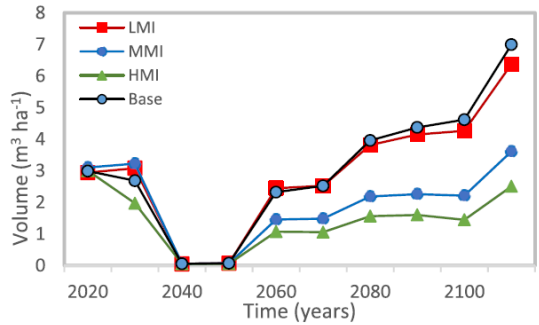
- 0-10
- 11-20
- 21-30
- 31-40
- 41-50
- 51-60
- 61-70
- 71-80
- 81-90
- 91-100
- >100



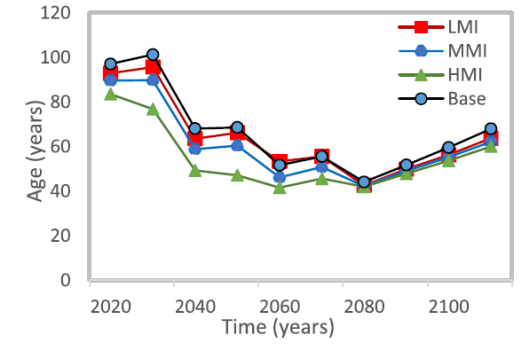
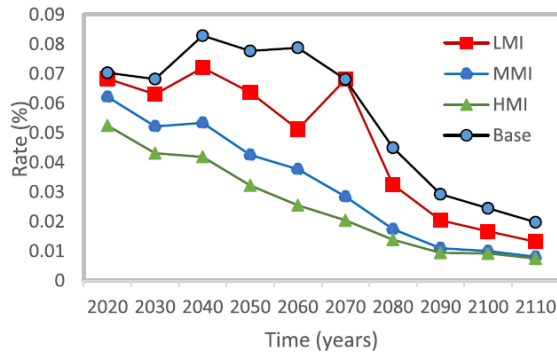
(a)



(b)



(a) (b)
Fig. 3. Largest stand volume over 40 cm dbh (a) and the deadwood over 30 cm dbh (b) over 100 years.



(a) (b)
Fig. 4. The rate (%) of broadleaved species (a) and the mean stand age (b) over 100 years.

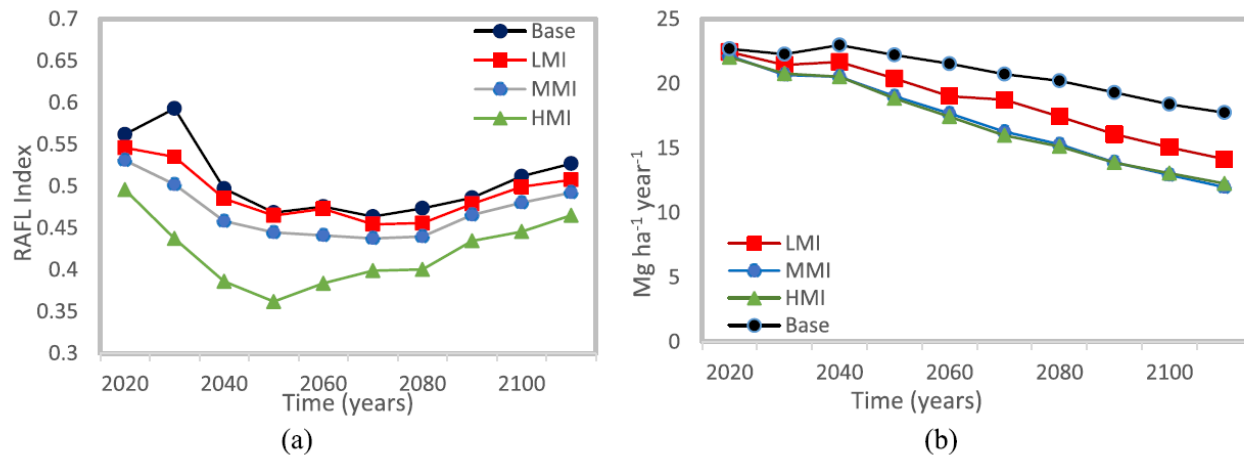


Fig. 8. Ten-year average RAFL-index, (a) and soil loss (b) over time.

The mean values of various indicators of ecosystem services for the four scenarios over 100 years of simulation: cumulative carbon storage change, soil loss, ground water run-off, RAFL index and Shannon diversity index, in addition to some performance indicators such as NPV, harvest volume and harvested area.

Scenario	NPV (TL m ⁻³)	Harvest volume (m ³ ha ⁻¹)	Area harvested (%)	Cumulative carbon storage (Mg year ⁻¹)	Soil loss (Mg ha ⁻¹ year ⁻¹)	Water prod (Mg ha ⁻¹ year ⁻¹)	RAFL- Index	Shannon diversity index
Base	189.88	7.50	1.58	1.60	20.81	1483.85	0.51	1.42
LMI	161.49	5.92	1.00	2.45	18.65	1410.55	0.49	1.36
MMI	151.27	6.15	0.99	3.03	17.04	1351.13	0.47	1.30
HMI	130.21	7.89	1.65	2.82	16.99	1377.74	0.42	1.22

Characterization of the case study area based on the management units (OGM, 2014).

Management units* (working circles)	Productive forests (ha)**	Degraded areas*** (ha)	Bare forest lands*** (ha)	Total forest area (ha)	Other areas (ha)	Total area (ha)
A:Timber production (Turkish/Red Pine)	1,409	60	29	1,499	32	1,531
B:Round wood production (Anatolian Pine)	584	50	11	644	7	651
C:Afforestation (Walnut)	1	0	0	1	0	1
D:NWFP Production (Walnut)	73	0	14	87	4	91
E:Nature Conservation (Red pine, Anatolian pine, Cedar)	1,801	1,050	612	3,464	61	3,525
F:Nature protection (Anatolian Pine, Cedar)	784	230	1,227	2,241	0	2,241
G:Soil protection (Red Pine, Anatolian Pine)	277	30	6	313	0	313
H:Aesthetic (Anatolian Pine, Cedar)	617	211	98	927	17	944
I:Recreation (Red Pine, Anatolian Pine, Junipers)	495	159	0	654	757	1,411
Total	6,041	1,792	1,998	9,831	880	10,711

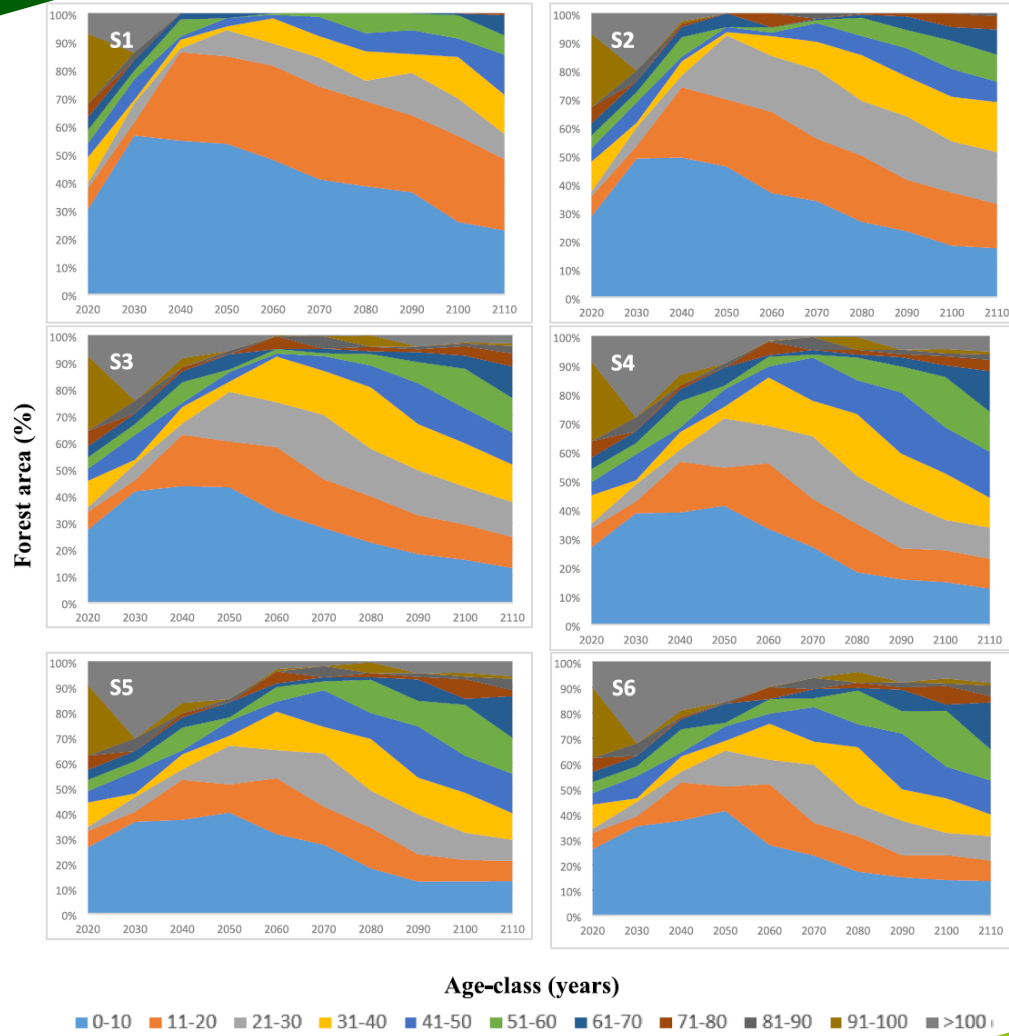
* Management units are formed by the spatially independent group of similar stands where the same ecosystem service (i.e., management objective) is provided by the dominant tree species.

** The stands over %10 of crown closure is classified as productive in terms of timber production.

*** The areas are appropriate for afforestation (crown closure less than 10% and bare forest areas).

Various rotation lengths (years) used in six management strategies across nine management units.

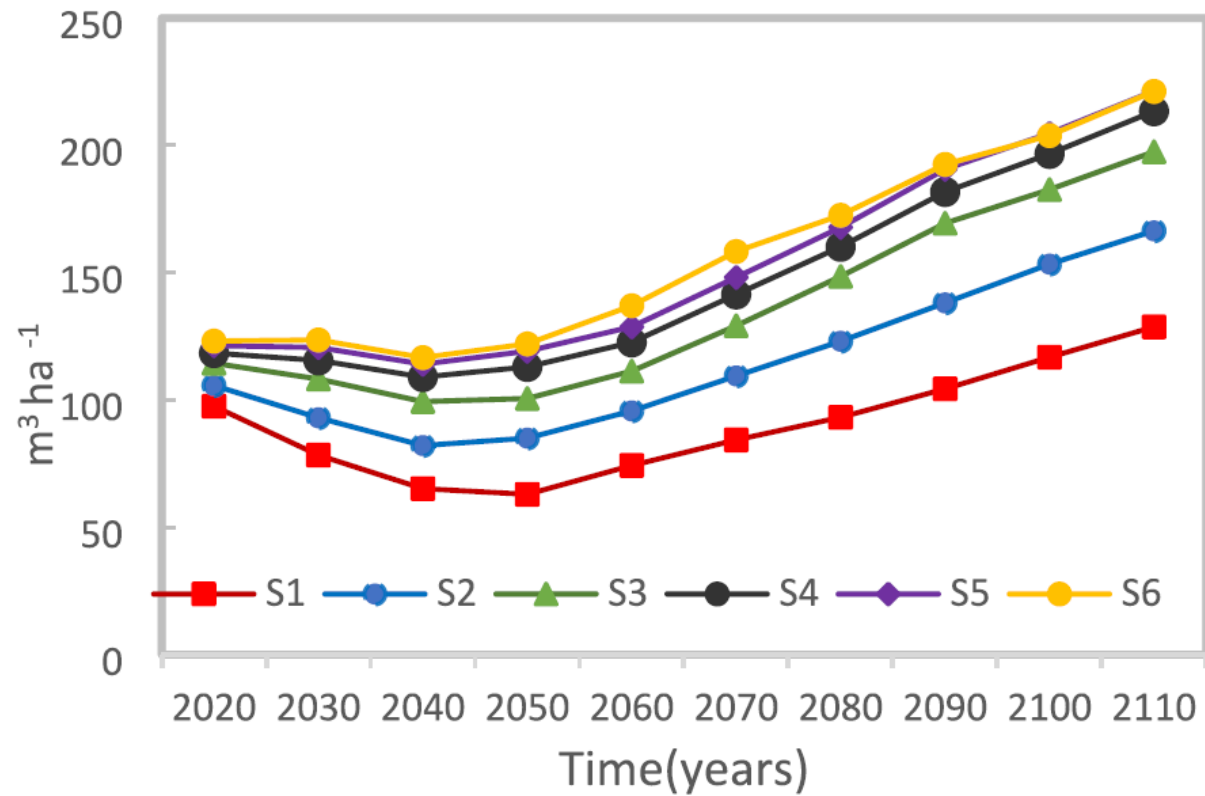
Management Units	Management Strategies					
	S1	S2	S3	S4	S5	S6
A:Round wood production (Red Pine)	30	35	45	55	60	65
B:Round wood production (Anatolian Pine)	55	70	90	110	120	130
C:Afforestation (Walnut)	55	70	90	110	120	130
D:NWFP Production (Walnut)	55	70	90	110	120	130
E:Nature Conservation (Red Pine, Anatolian Pine, Cedar)	35	45	55	65	70	75
F:Nature protection (Anatolian Pine, Cedar)	70	90	110	130	140	150
G:Soil protection (Red Pine, Anatolian Pine)	35	45	55	65	70	75
H:Aesthetic (Anatolian Pine, Cedar)	70	90	110	130	140	150
I:Recreation (Red Pine, Anatolian Pine, Junipers)	35	45	55	65	70	75

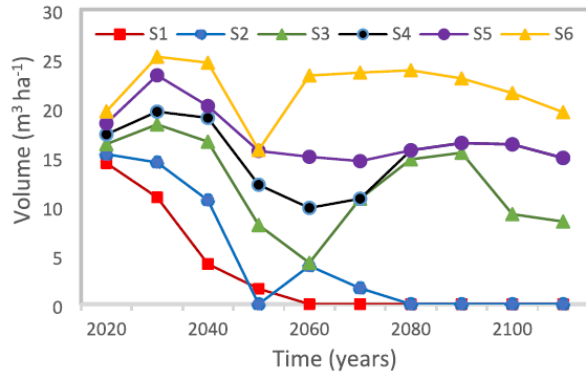


Forest area (%)

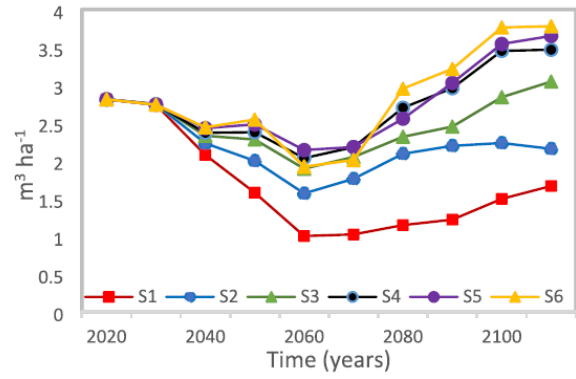
Age-class (years)

- 0-10
- 11-20
- 21-30
- 31-40
- 41-50
- 51-60
- 61-70
- 71-80
- 81-90
- 91-100
- >100



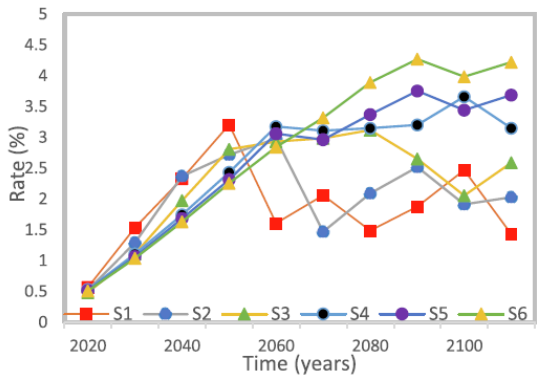


(a)

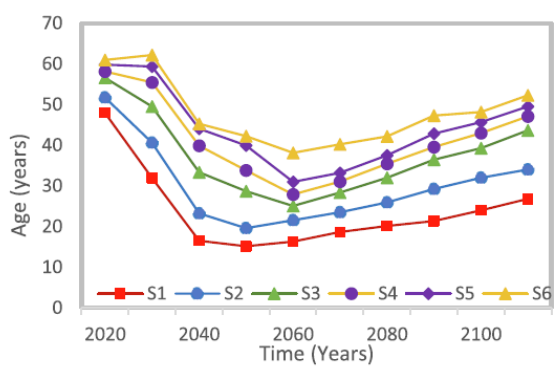


(b)

Fig. 3. Largest stand volume over 40 cm DBH (a) and the total deadwood volume (b) over 100 years.

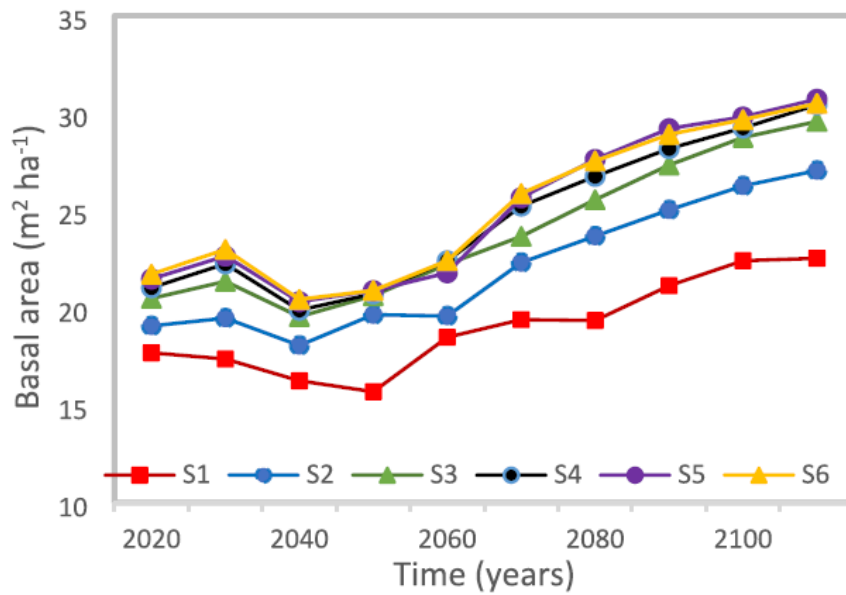


(a)

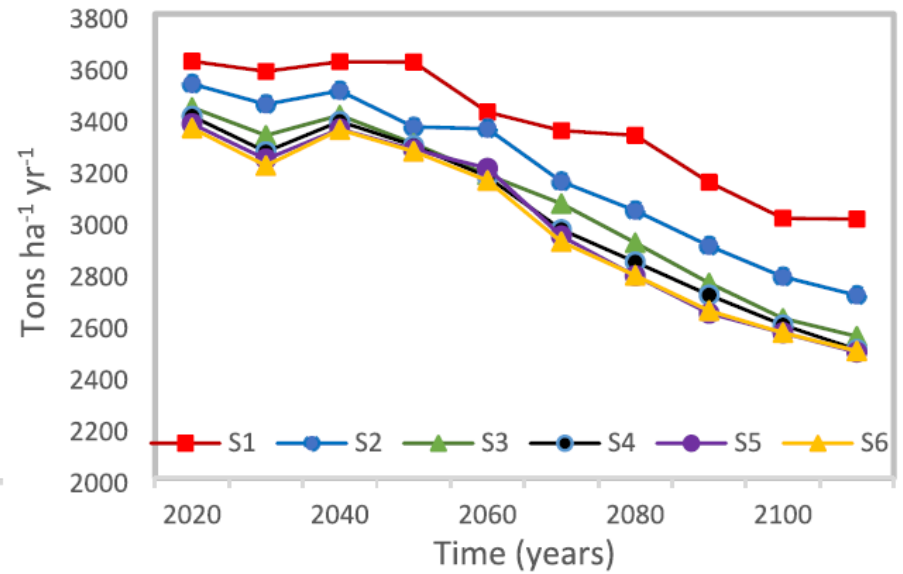


(b)

Fig. 4. The rate (%) of broadleaved species (a) and the average stand age (b) over 100 years.



(a)



(b)

Fig. 6. The temporal change in basal area (a) and surface water (b) over 100 years.

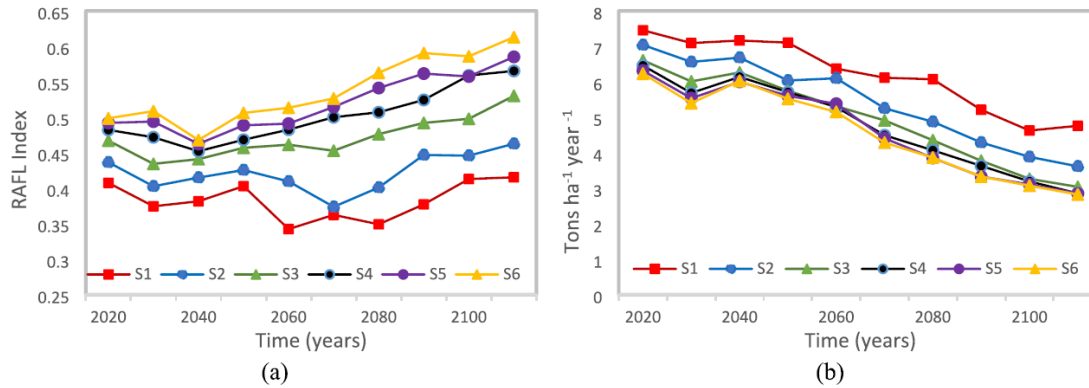


Fig. 8. The trend of RAFL-index (a) for cultural values and per ha soil loss (b) over 100 years of simulation across six scenarios.

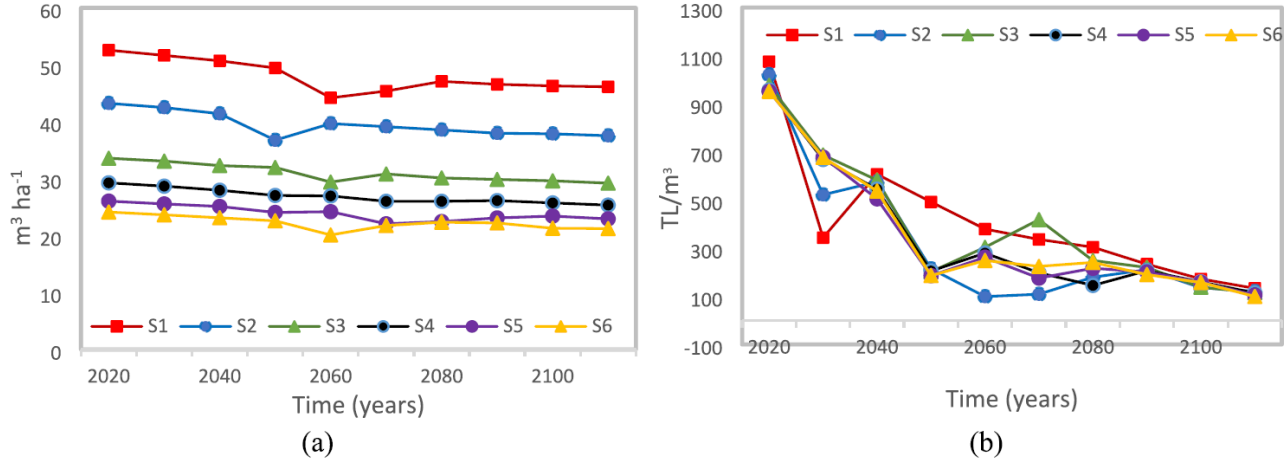


Fig. 9. Mean harvested volume per ha (a) and NPV (b) over 100 years for the six scenarios.

The average values of ES indicators for the six scenarios over time: cumulative carbon storage change, soil loss to erosion, surface water, RAFL index and Shannon diversity index, and some performance indicators such as harvested areas, harvest volume and the NPV.

Scenarios	NPV (TLm ⁻³)	Harvest volume (m ³ ha ⁻¹)	Area Harvested (%)	Cumulative Carbon storage (Mg ha ⁻¹ year ⁻¹)	Soil loss (Mg ha ⁻¹ year ⁻¹)	Water Prod (Mg ha ⁻¹ year ⁻¹)	RAFL- Index	Shannon diversity index
S1	407.89	48.01	19.86	1.28	6.20	3367.63	0.383	0.998
S2	318.89	39.47	13.67	1.91	5.43	3177.30	0.422	1.006
S3	389.40	31.01	9.24	2.39	4.93	3054.88	0.471	1.013
S4	347.98	26.93	7.55	2.66	4.75	3011.36	0.501	1.017
S5	343.94	23.91	6.38	2.80	4.64	2985.23	0.519	1.018
S6	351.50	22.26	5.72	2.88	4.57	2974.77	0.537	1.019



Revoluce??

A photograph of a forest with tall, thin trees and a grassy clearing. Sunlight filters through the trees, creating a bright, hazy atmosphere. The text "Děkuji za pozornost!" is overlaid in the center.

Děkuji za pozornost!