RESILIENCE AND SYNERGISM IN LARCH-BEECH-SPRUCE MIXED FORESTS

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Mendel University in Brno

EGU General Assembly 2023

I. MOTIVATION

We are now witnesses to the abnormal mortality of *P. abies* in regions of central Europe caused by longer and more intense droughts and unevenly distributed precipitation. Is well known that the mixing of species can increase stand productivity and they can better mitigate the effects of stressful conditions. However, the effects of mixing larch (*Larix decidua* Mill.) with spruce (*Picea abies* (L.) Karst.) and beech (*Fagus sylvatica* L.) have not been assessed by systematic empirical studies in middle areas of central Europe yet.

II. HYPOTHESIS

✓ Larche's growth will be less sensitive to extreme conditions compared to spruce or beech.

✓ Larches growing in mixtures will be less sensitive to extreme conditions compared to monoculture.

III. MATERIAL AND METHODS

- 4 research sites with similar environmental conditions in the highlands of the Czech Republic - Drahanská vrchovina (around 500 m a.s.l.) were established.

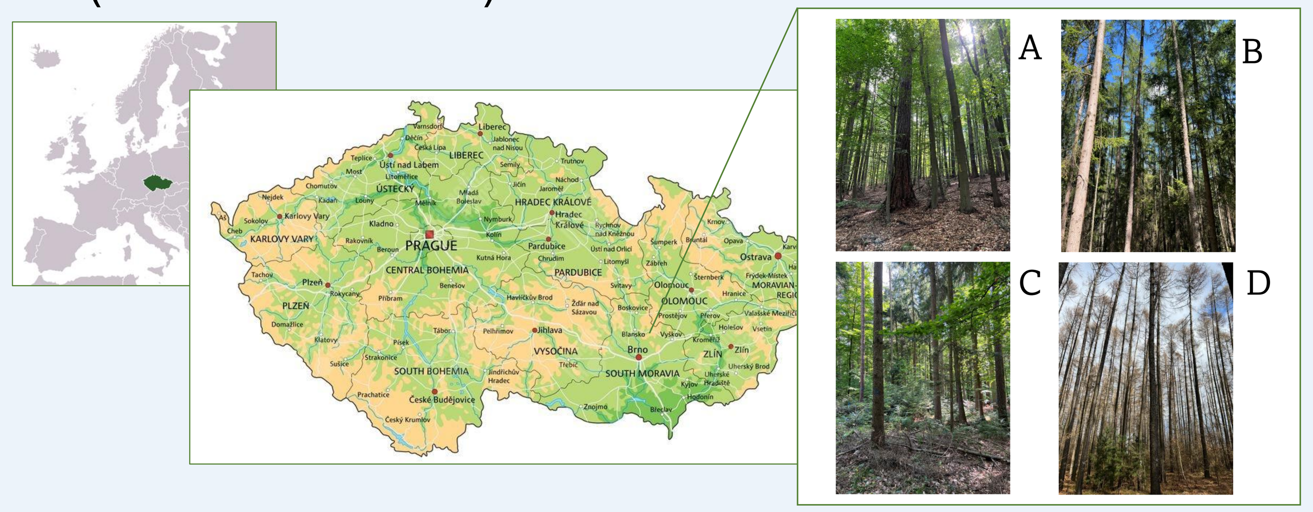

Fig. 1: The geographic location of research sites on highlands Drahanská vrchovina in the Czech Republic (https://cs.wikipedia.org/).

Research site				Age	Area	BA	Mean DBH	Mean Height	Coordinates
Code	Sign	Composition of tree species	%	(years)	(ha)	(m^2/ha)	(cm)	(m)	
A	BL	Beech *(F. sylvatica)*	71	58	0.09	51.09	21.5	15.66	49.314431 16.781064
		Larch *(L. decidua)*	25			15.73	31.4	27.63	
		Other tree species	4			5.23	22.9	-	
B	SL	Spruce *(P. abies)*	75	58	0.09	50.20	33.8	27.71	49.313660 16.781260
		Larch *(L. decidua)*	25			16.44	28.0	25.14	
C	SLB	Spruce *(P. abies)*	32	80	0.12	19.84	33.6	21.15	49.315875 16.766475
		Larch *(L. decidua)*	31			19.47	35.5	19.39	
		Beech *(F. sylvatica)*	29			18.45	26.4	16.28	
		Other tree species	8			4.90	29.9	-	
D	L	Larch *(L. decidua)*	99	62	0.09	72.66	29.9	26.77	49.315271 16.791965
		Other tree species	1			0.57	17.3	-	

Tab. 1: Site characteristics. *BA* represents the basal area at 1.3 m of trees and the *Other tree species* represent admixtured tree species.

- Positions of trees were measured with a Field-Map system (IFER, Czech Republic).
- 10 wood cores were collected at breast height from each tree species at the site - a total of 80 samples.
- Cores were measured and cross-dated by the software TSAP-Win.
- The radial increment of target trees with respect to the competition of the 10 nearest neighbouring trees was evaluated for the most affected year 2018.
- The competition indexes *(Ci)* were calculated as the ratio between the DBH of the target tree *(Di)* and of the competitor *(Dj)* divided by the distance *(Rij)* between them (Hegyi, 1974):

$$C_i = \sum_j \frac{D_j/D_i}{R_{ij}} .$$

- The resistence, resilience and recovery of target trees were calculated for the most affected year 2018 (Lloret et al., 2011):
  - Resistance *(Rt)* – growth reduction during the extreme year
    $$Rt = \frac{Dr}{PreDr} ,$$
  - Recovery *(Rc)* – growth response after the extreme year
    $$Rc = \frac{PostDr}{Dr} ,$$
  - Resilience *(Rs)* – capacity to reach pre-disturbance growth
    $$Rs = \frac{PostDr}{PreDr} ,$$

  where *PreDr*, *Dr*, and *PostDr* indicate growth performance before, during and after disturbance/drought (low-growth period).
- Data were administered and analysed in MS Excel 2010 using the general worksheet function. Analysis of variance (ANOVA) was used (Statistica 12).

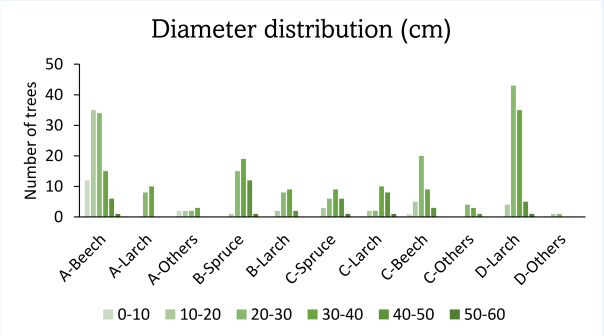

Fig. 2: Diameter distribution (cm) of tree species. The letter means the code of the research site, *Other* means a minority representation of tree species (see Tab. 1).

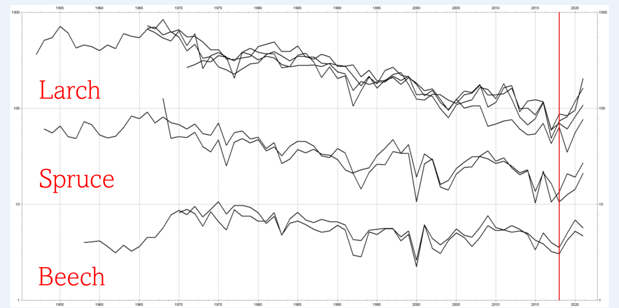

Fig. 3: Tree-ring means series of larch, spruce and beech in cross-dated position ended by date 2021. The observed year 2018 is indicated by red stick.

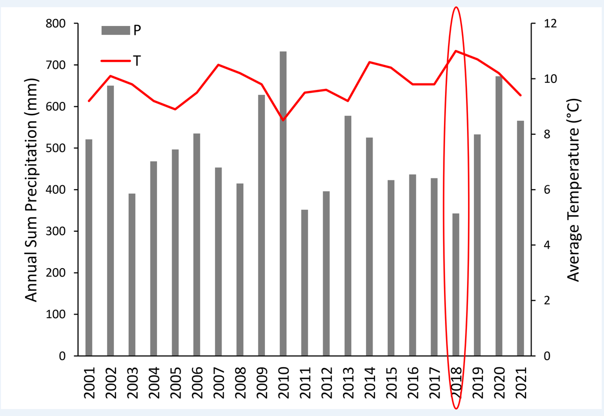

Fig. 4: Climograph represents climatic conditions in the locality of Drahanská vrchovina according to data from Czech Hydrometeorological Institute (CHMI.cz, 2021). As the most disturbed period has been indicated the year 2018 (annual sum of precipitation 342,8 mm and average annual temperature 11 °C).

IV. RESULTS

a) EVALUATION OF THE TREE COMPETITION

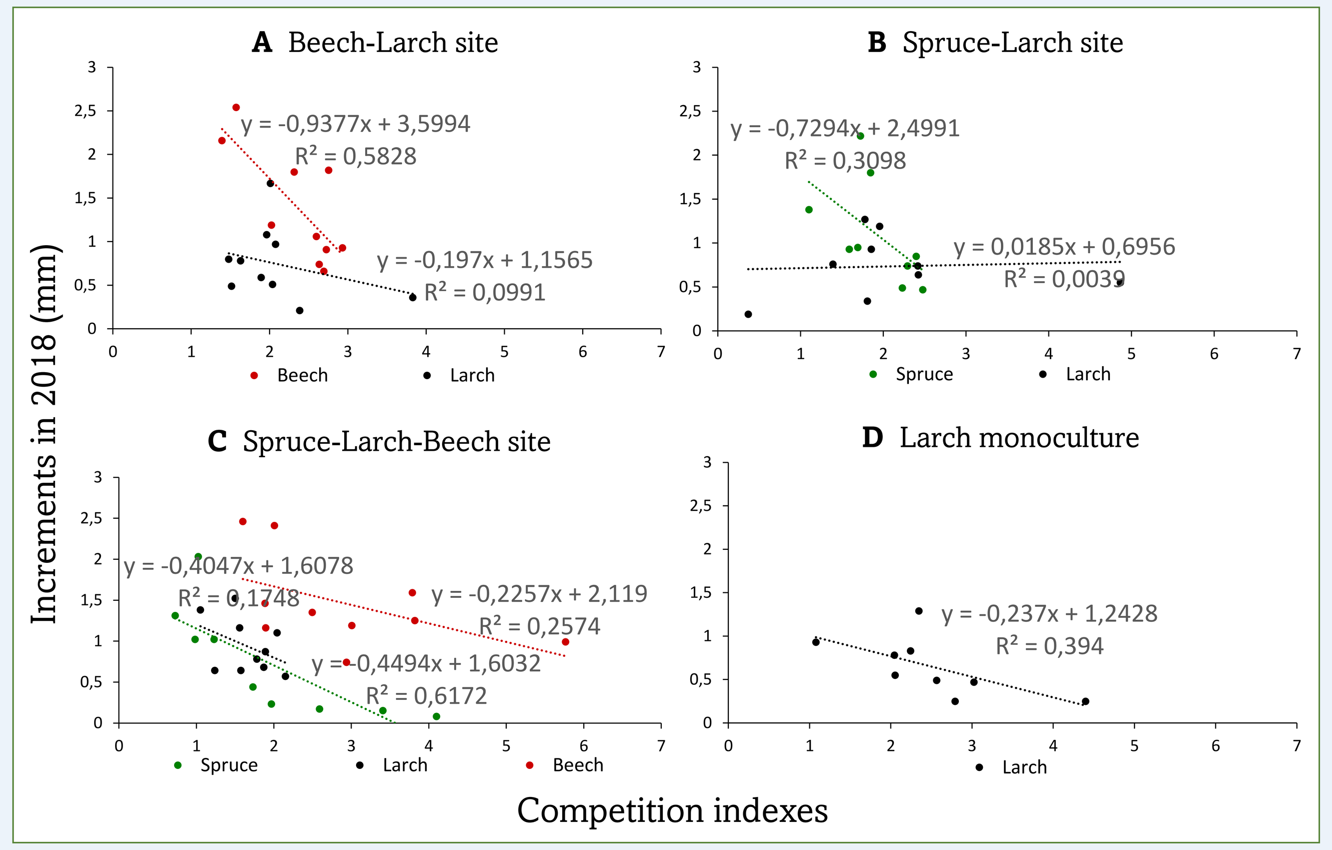

Fig. 5: Linear regression of competition indexes (x-axis; dimensionless number) and radial increments (y-axis; mm) of the most affected year 2018.

In 2018, the tree species exhibited a different growth response under the same climatic conditions. Linear regression of competition indexes and radial increments during the most affected years 2018 (Fig. 5) showed decreasing tree growth with increasing competition in spruces and beeches. Surprisingly, this does not occur in larches growing in mixtures. The result showed that larches respond to competition only in the monoculture.

b) EVALUATION OF RESISTANCE

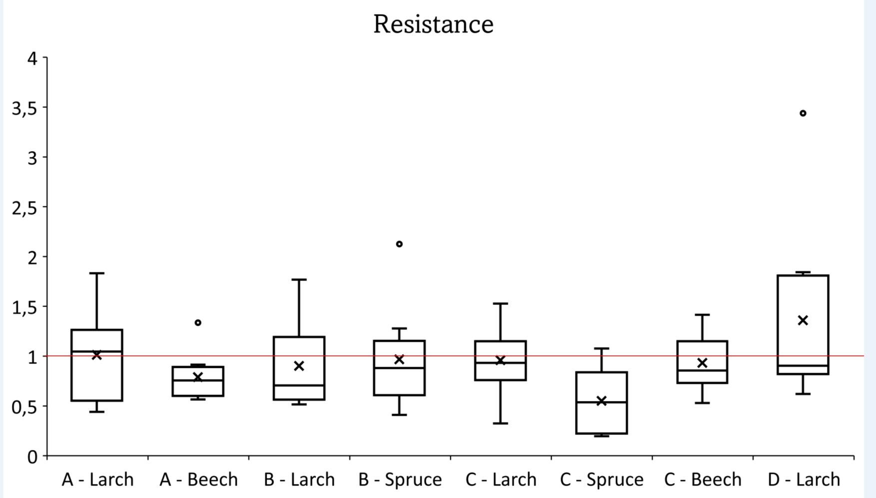

Fig. 6: Resistance (y-axis; dimensionless number) of larches, spruces, and beeches in 2018.

The upper bars represent the maximum value in the data, lower bars the minimum value in the data. Crosses represent mean value, dots out layers, and lines median of the whole. The median of the 1st quartile represents the lower part of the box, and the median of the 3rd quartile represents the upper part of the box.

Tree resistance to environmental conditions in 2018 was lower than a value of 1 for all spruces and beeches. Larches growing with beeches (A – Larch) reached the same increment as before the affected year and surprisingly, larches in monoculture (D –Larch) grew even better. Beeches growing in the triple mixed stand (C – Beech) were more resistant than beeches in the Beech-Larch stand (A – Beech). The lowest resistance performed spruces in the triple mixed stand (C – Spruce).

c) EVALUATION OF RECOVERY

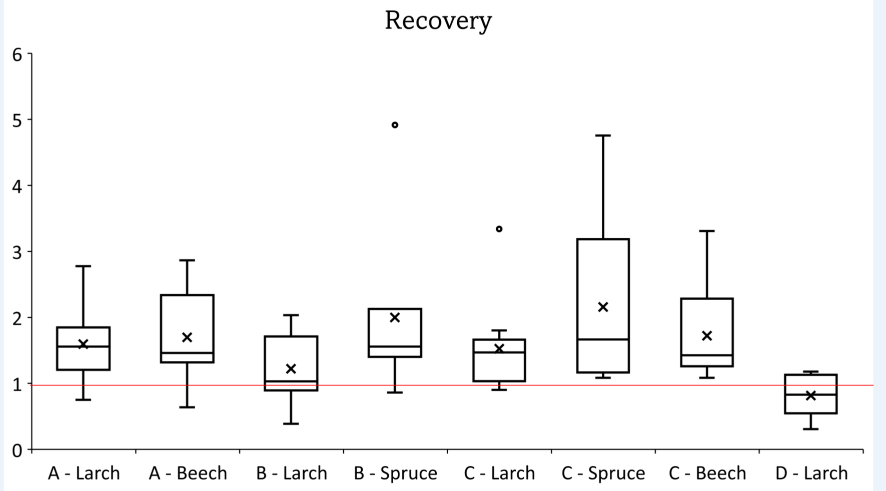

Fig. 7: Recovery (y-axis; dimensionless number) of larches, spruces, and beeches in 2018.

The upper bars represent the maximum value in the data, lower bars the minimum value in the data. Crosses represent mean value, dots out layers, and lines median of the whole. The median of the 1st quartile represents the lower part of the box, and the median of the 3rd quartile represents the upper part of the box.

High recovery of larches after the extreme conditions of 2018 were observed in all variations of mixed stands. On the other hand, larches in a monoculture (D – Larch) performed the lowest growth in the period 2019-2021 which can be caused by their delayed reaction to stressful conditions.

d) EVALUATION OF RESILIENCE

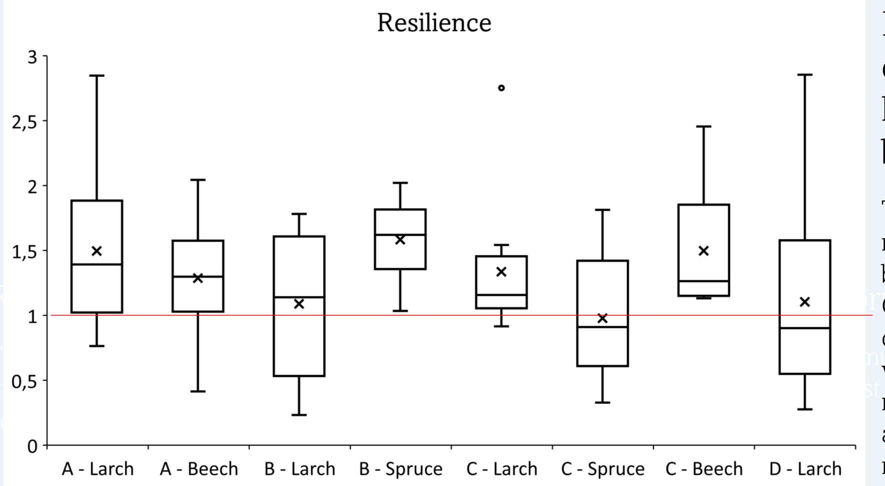

Fig. 8: Resilience (y-axis; dimensionless number) of larches, spruces, and beeches in 2018.

The upper bars represent the maximum value in the data, lower bars the minimum value in the data. Crosses represent mean value, dots out layers, and lines median of the whole. The median of the 1st quartile represents the lower part of the box, and the median of the 3rd quartile represents the upper part of the box.

After 2018, larches growing with beeches (A – Larch) performed the highest wood increment compared to the other larches sites. Spruces and beeches also reached their previous (2015-2017) increments. The resilience was high in all research sites, so we can assume a positive effect of larch presence.

V. CONCLUSION

We determined that the larches are not significantly influenced by competition with their neighbours. Furthermore, larches in monoculture performed the highest resistance, and delayed reaction to stressful conditions. Larches growing in mixtures were more resilient with superior recovery.

ACKNOWLEDGEMENT

Thanks to Individual student project IGA-LDF-22-IP-019 - *Resilience and synergy effect in larch, spruce and beech mix forests,* and to Project QK21010335 - *The potential how to employ European larch in the Czech forests under the global climate change*. Applied „ZEMĚ“ research programme of the Ministry of Agriculture for the period of 2021–2025.

REFERENCES

CHMI.cz. (2021). Měsíční a roční data dle zákona 123/1998 Sb. https://www.chmi.cz/historicka- data/pocasi/mesicni-data/mesicni-data-dle-z.-123-1998-Sb?fbclid=IwAR0lR597ybnZXzfsDEuvAvQ58CJ1hOEUv8hpRq4t-NOxV-YblqRlU-VzzIo#

Hegyi F. (1974). A Simulation Model for Managing Jack-pine Stands. In Fries, J. (Ed.) Growth Models for Tree and Stand Simulation. Royal College of Forestry, Department of Forest Yield Research, Research Notes 30. Stockholm, Sweden, 74–90.

Lloret, F., Keeling, E. G., & Sala, A. (2011). Components of tree resilience: effects of successive low-growth episodes in old ponderosa pine forests. Oikos, 120(12), 1909–1920. https://doi.org/10.1111/j.1600-0706.2011.19372.