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SECTION: BOTANY AND FORESTRY

FIRE RESISTANCE OF TREE SPECIES IN FOREST ECOSYSTEMS UNDER GLOBAL CLIMATE CHANGE

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Fire resistance of tree species is a crucial factor shaping the consequences of forest fires and the trajectories of post-fire ecosystem dynamics. The response of trees to high temperatures depends on a complex of morphological and physiological traits, including bark thickness, stem structure, wood moisture content, type of root system, ability to regenerate through sprouting, and stress tolerance mechanisms, and global climate change (rising temperatures, droughts, extreme weather events) significantly reduce their resilience and increase the risk of large-scale wildfires [1, 2].

Since the average age of forest stands in Ukraine is about 60 years, the ability of mature trees to adapt to rapid climate changes is limited, as they are less flexible to environmental transformations compared to younger plants [3]. Rising temperatures and prolonged droughts lead to reduced soil and wood moisture, increasing the risk of ignition. The accumulation of dry biomass creates ‘fuel material’ for fires. Thermophilic and fast-growing species displace traditional ones, which are often less fire-resistant. Disruption of ecological cycles results in fires becoming more frequent and intense, affecting biodiversity and the carbon balance.

Coniferous species, particularly Scots pine (Pinus sylvestris L.), exhibit medium to low tolerance to surface and ground fires. Young pine stands (up to 15 years old) are especially vulnerable due to thin bark, high resin saturation, and the presence of dry branches that ignite easily [4]. According to Ukrainian studies, mortality in pine stands under 10 years of age after moderate-intensity fires may reach 60–90%. In middle-aged stands (30–60 years), survival is significantly higher owing to thicker bark; after low-intensity surface fires, part of the trees remain viable and continue growth [5].

Among conifers, European larch (Larix decidua Mill.) and Japanese larch (L. kaempferi) demonstrate greater resistance, explained by their thick bark and ability to produce new shoots after damage [6].

Broadleaved species show considerable variability in their response to fire. Pedunculate oak (Quercus robur L.) in the Forest-Steppe of Ukraine is one of the most fire-resistant species due to its thick bark, strong sprouting capacity, and rapid regeneration after stem scorching. Following low and moderate fires, oak produces abundant sprouts, ensuring its dominance in post-fire succession [7].

Silver birch (Betula pendula Roth) is a typical pioneer species with high ecological plasticity. Its seeds germinate readily on mineralized soil after fire. Although mature trees have low fire resistance, birch regenerates effectively and often forms the first closed canopy after fire [8].

Aspen (Populus tremula L.) is characterized by strong sprouting and rhizomatous regeneration. After moderate-intensity fires, dense young stands may develop within 2–3 years [9].

Hornbeam, linden, and ash exhibit low fire resistance due to thin bark and weak sprouting ability. They rarely dominate after fires but may occur in mosaic patches where fire intensity is reduced. Fire resistance of tree species is determined by several traits: bark thickness (oak > larch > pine > birch > aspen), cambial growth rate after damage, presence of dormant buds at the root collar, depth of the root system, wood structure, and resin content [10].

Reviews of Ukrainian forests confirm that species with thick bark (oak, larch) are most tolerant to low-intensity fires, whereas young pine and birch stands are highly sensitive to soil overheating and stem scorching [7].

It has been established that young pure pine stands are the most vulnerable to fire, while mixed oak and broadleaved stands demonstrate higher resistance and faster recovery [11].

Table. Comparative Fire Resistance of Major Tree Species in the Forest-Steppe of Ukraine (Compiled by the author)

Species	Resistance to Surface Fires	Resistance to Ground Fires	Resistance to Crown Fires	Main Regeneration Mechanism
Quercus robur L.	high	medium	low	sprouting
Pinus sylvestris L.	low	low–medium	very low	seed (limited)
Larix	medium–high	medium	low	shoot regeneration
Betula pendula Roth	low	low	very low	seed
Populus tremula L.	low	medium	very low	rhizomatous/sprouting

Conclusion

Oak and larch exhibit the highest fire resistance due to thick bark and sprouting/shoot regeneration mechanisms. Young pine and birch stands are the most vulnerable (thin bark, easy ignition). Birch and aspen act as pioneer species after fires, regenerating rapidly through seed or sprouting. Hornbeam, linden, and ash play a minor role in post-fire succession due to low resistance and weak regeneration capacity.

Understanding fire resistance of tree species is essential for planning restoration measures, assessing stand viability, creating mixed post-fire plantations, and forecasting successional pathways in forest ecosystems.

Thus, fire resistance depends on the morphology and composition of the wood. Global climate change reduces the natural resilience of forests. It is necessary to implement adaptation measures, namely the establishment of mixed stands, control of dry biomass, use of species with high fire resistance, and integration of traditional knowledge into forest management.

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