S1. Additional results

Table S1: Total disturbed area by disturbance type, age class, and period. Total forest area disturbed (in million hectares, Mha) by harvest and natural disturbances across Europe, disaggregated by age class (1-60 and >60 years old) and period. The periods 2011-2016 and 2017-2023 reflect early and recent disturbance phases, respectively. Only 100 m pixels with at least 30% forest cover were retained, and among those, only pixels where at least 50% of the forested area was disturbed by a specific agent were considered.

	2011-2016		**2017-2023**	
	1-60 years	>60 years	1-60 years	>60 years
Natural disturbance	0.35	0.38	0.56	1.06
Harvest	2.57	2.36	2.91	3.84

Table S2: Total disturbed area by disturbance type, genus group, and period. Total forest area disturbed (in million hectares, Mha) by harvest and natural disturbances across Europe, disaggregated by genus group and period. Genus groups include Spruce, Other needleleaf (e.g., Pinus, Larix, and other needleleaf), and Broadleaf (e.g., Fagus, Quercus, and other broadleaf). The periods 2011-2016 and 2017-2023 reflect early and recent disturbance phases, respectively. Only 100 m pixels with at least 30% forest cover were retained, and among those, only pixels where at least 50% of the forested area was disturbed by a specific agent were considered.

	2011-2016			**2017-2023**		
	Spruce	Other needleleaf	Broadleaf	Spruce	Other needleleaf	Broadleaf
Natural disturbance	0.07	0.26	0.30	0.46	0.53	0.46
Harvest	0.28	1.85	2.2	0.90	2.8	2.4

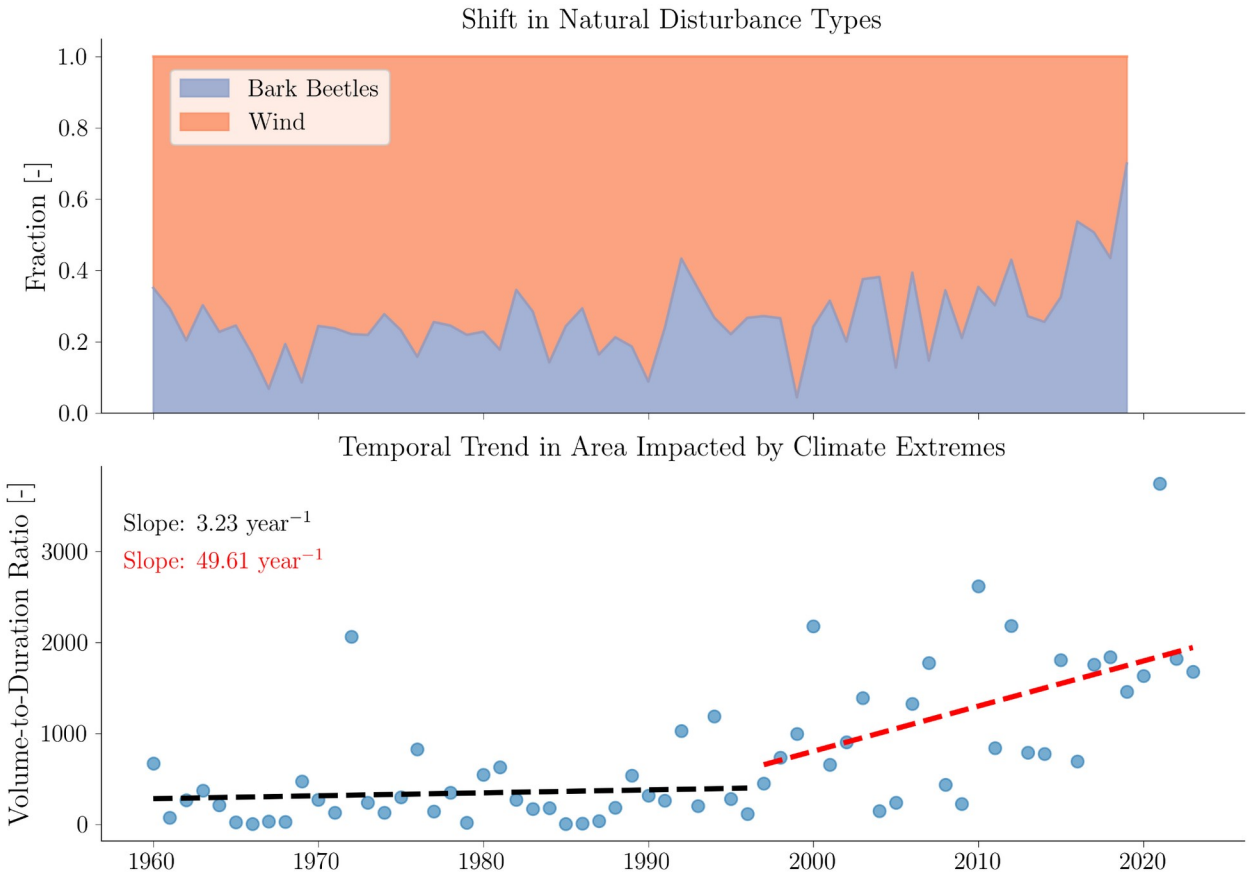

Figure S1: Shifting disturbance agents and climate extremes in European forests. (a) Relative contribution of wind and bark beetle damage to total natural disturbance volume in European forests from 1960 to 2023, based on national inventory records[6]. (b) Total annual area impacted by compound climate extremes (heat and drought) across Europe from 1960 to 2023 derived from the Dheed database[8].

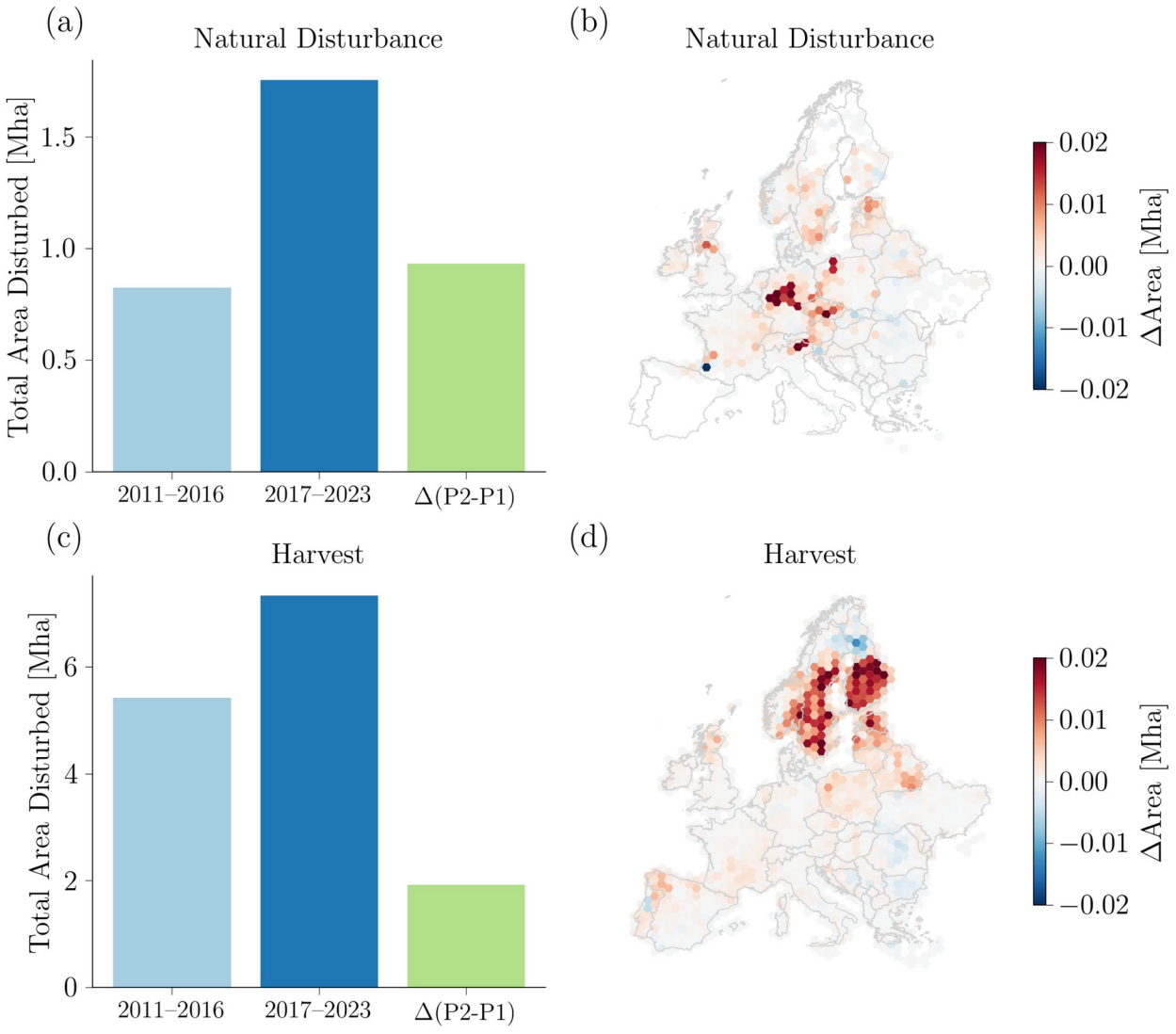

Figure S2: Changes in forest disturbance area across Europe between 2011-2016 and 2017-2023. (a) Total area affected by natural disturbances (wind and bark beetle) during early (2011-2016) and late (2017-2023) periods, along with the absolute change in disturbed area. (b) Spatial distribution of the shift in natural disturbance area across 100km diameter hexagons. Positive values indicate an expansion of natural disturbances, particularly in Northern and Central Europe. (c) Total area affected by harvest during the early and late periods, and the corresponding absolute change. (d) Spatial distribution of the change in harvested area. Only 100 m pixels with at least 30% forest cover were retained, and among those, only pixels where at least 50% of the forested area was disturbed by a specific agent in a given year were considered. Hexagons represent aggregated changes in the disturbed area expressed in Mha. Each hexagon has a diameter of 100 km.

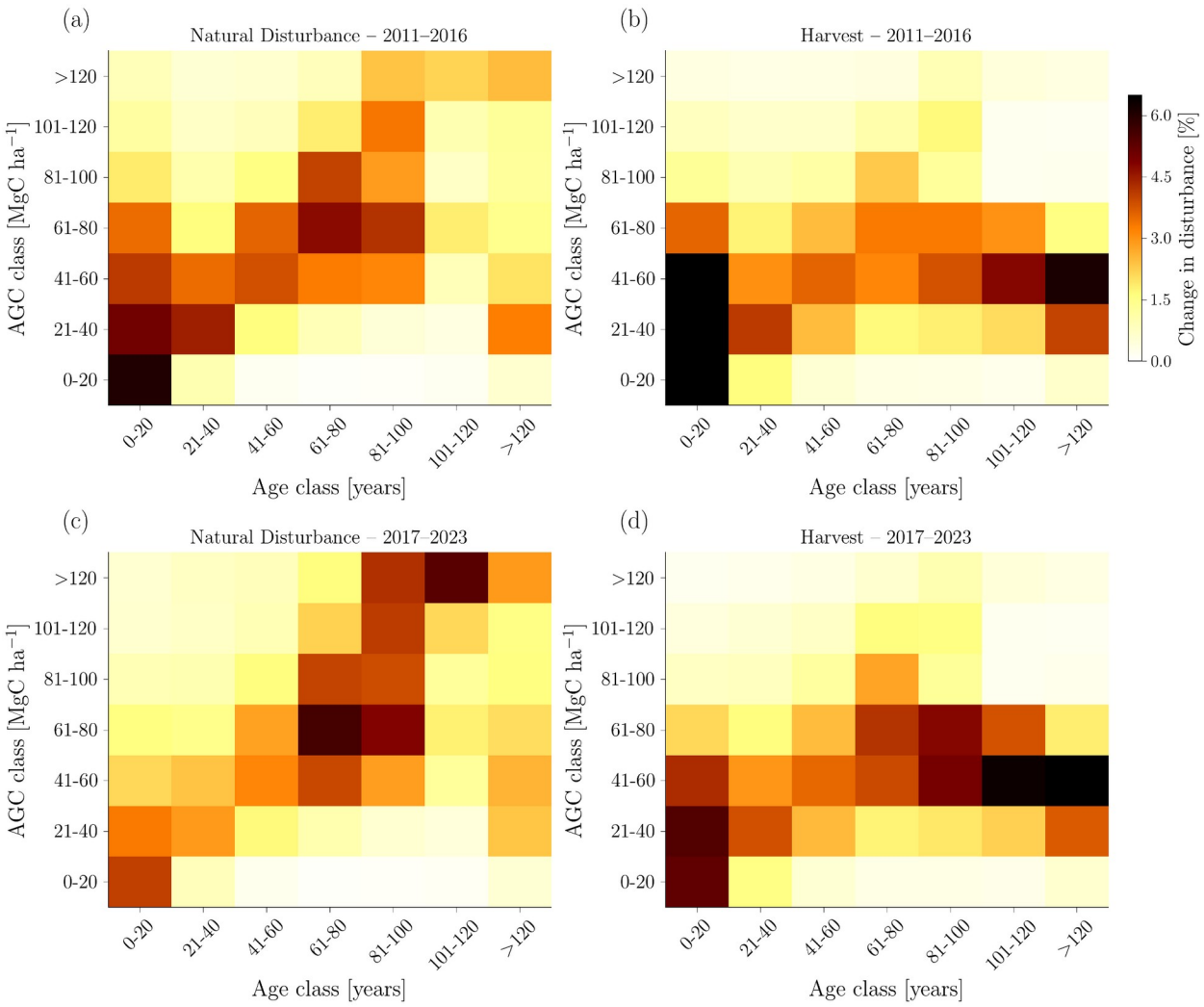

Figure S3: Structural profile of disturbed forests by disturbance type. Fraction of disturbed forests by aboveground carbon (AGC) class (MgC ha^{-1}) and age class (years) for natural disturbances and harvest across Europe (2011-2016). (c-d) Same as (a-b), but for 2017-2023. Only 100 m pixels with at least 30% forest cover were retained, and among those, only pixels where at least 50% of the forested area was disturbed by a specific agent in a given year were considered.

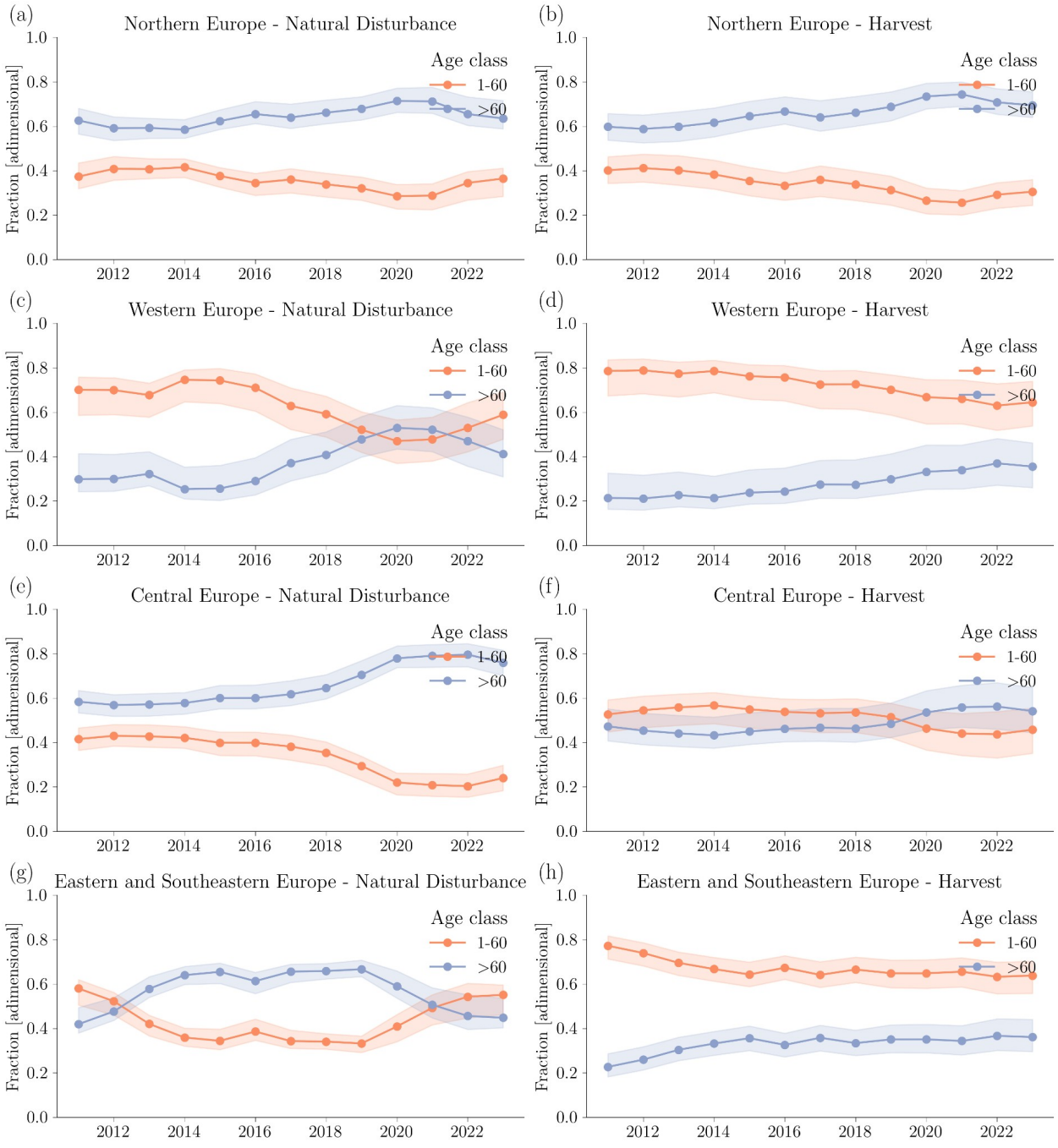

Figure S4: Temporal trends in the fraction of forest disturbances across age classes for harvest and natural disturbances (2011-2023), shown at the regional scale. Panels display the annual fraction of disturbed pixels by age class for each disturbance type across four regions: Northern Europe (Finland, Sweden, Norway, Denmark, Estonia, Latvia, Lithuania), Central Europe (Germany, Switzerland, Austria, Czechia, Poland), Western Europe (United Kingdom, Ireland, France, Belgium, Netherlands, Luxembourg), and Eastern & Southeastern Europe (Hungary, Slovakia, Slovenia, Ukraine, Turkey, Croatia, Bosnia and Herzegovina, Serbia, Montenegro, Kosovo, Albania, North Macedonia, Moldova, Bulgaria, Romania). Shaded ribbons represent the 95% quantile range across the 20-member forest age ensemble, and lines show the

median trajectory. Only 100 m pixels with at least 30% forest cover were retained, and among those, only pixels where at least 50% of the forested area was disturbed by a specific agent in a given year were considered.

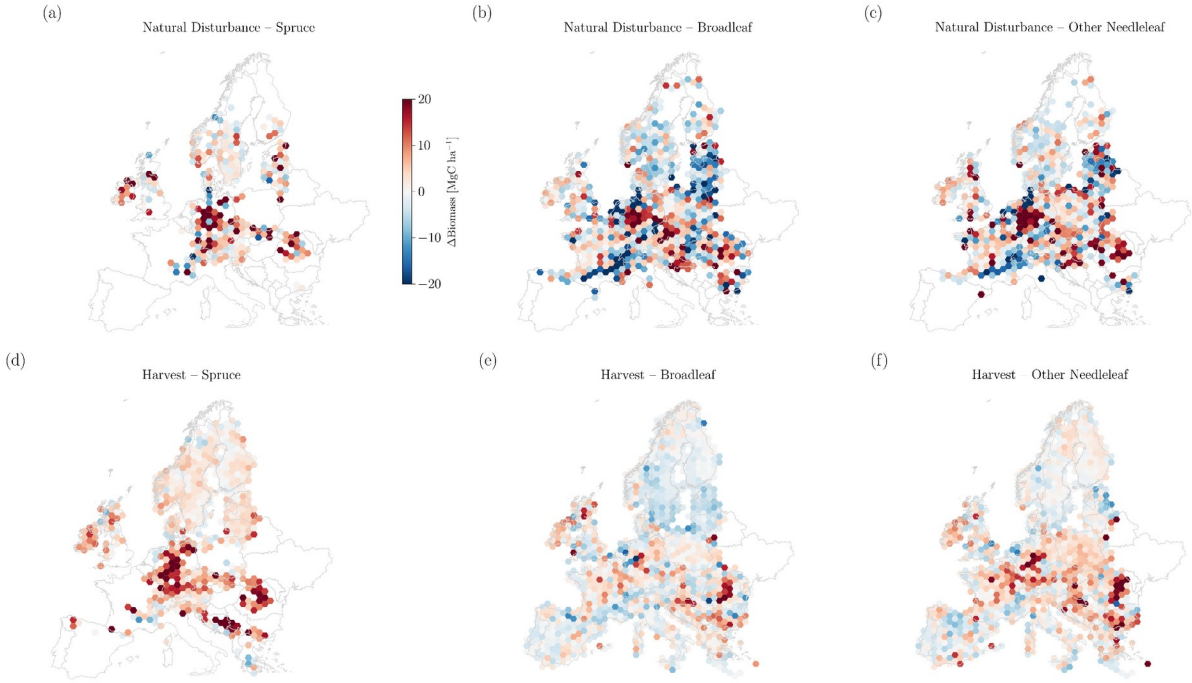

Figure S5: Changes in biomass loss by genus and disturbance type. Changes in average biomass loss (Δbiomass in MgC ha^{-1}) between 2011-2016 and 2017-2023 across Europe, separated by disturbance type (natural disturbances vs. harvest) and dominant genus (spruce, broadleaf, other needleleaf). Each hexagon represents the spatially aggregated difference in biomass of affected forest areas between the two periods. Negative values (blue) indicate a relative decrease in biomass between the two periods, while positive values (red) reflect an increase. Only 100 m pixels with at least 30% forest cover were retained, and among those, only pixels where at least 50% of the forested area was disturbed by a specific agent in a given year were considered. Each hexagon has a diameter of 100 km.

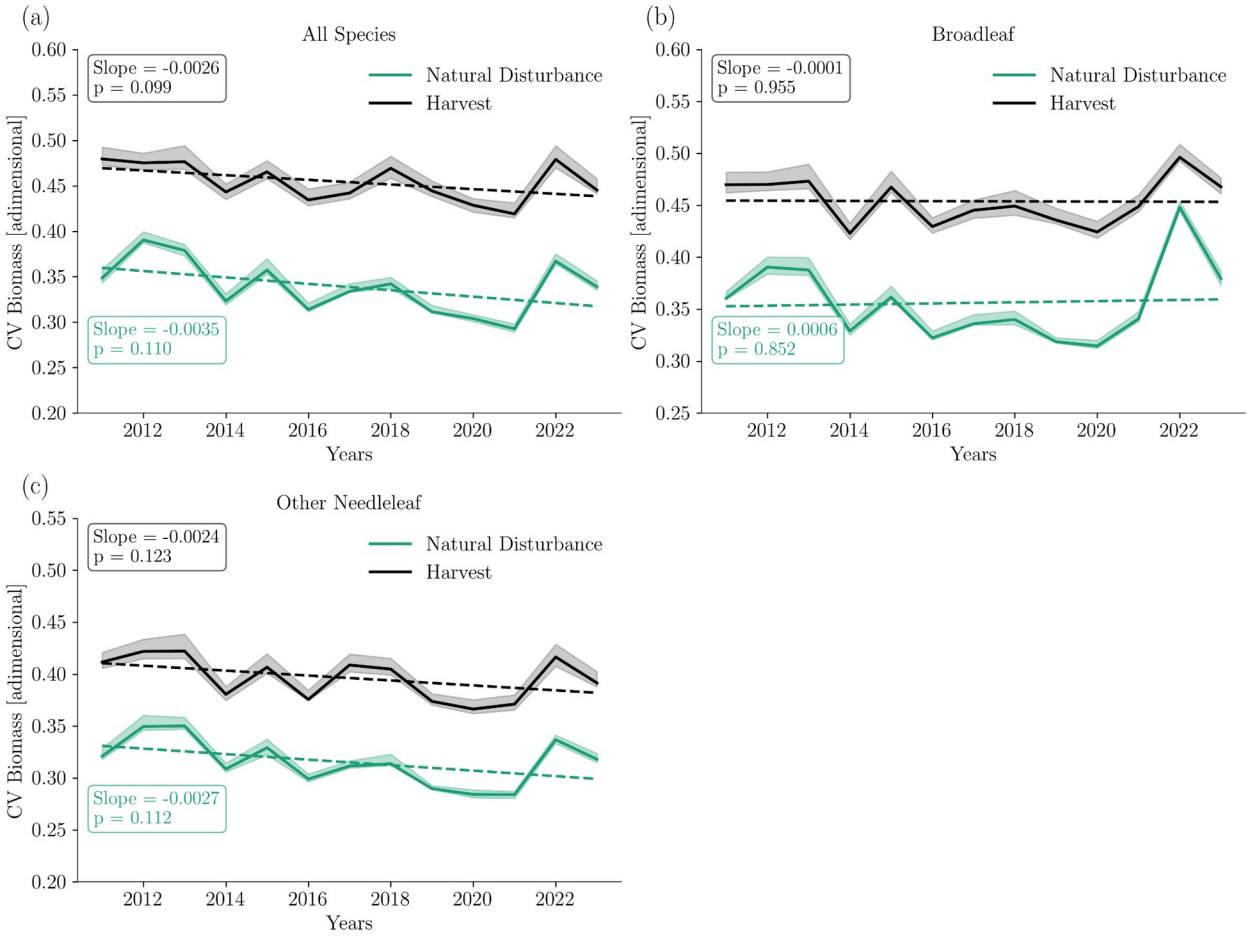

Figure S6: Temporal trends in structural heterogeneity (CV of biomass) by genus type. Coefficient of variation (CV) in pre-disturbance biomass (2010 baseline) for stands affected by natural disturbances (green) and harvest (black) between 2011 and 2023, partitioned by genus group: (a) all species, (b) broadleaf, and (c) other needleleaf. Lines represent the annual median CV across hexagons; shaded ribbons indicate the 5th to 95th percentile range across biomass members.