Supplemental Information

Ozone Risk to Forests and Crops under Drought Modulation: A 15 years Flux-Based and Economic Loss Assessment for Saxony, Germany

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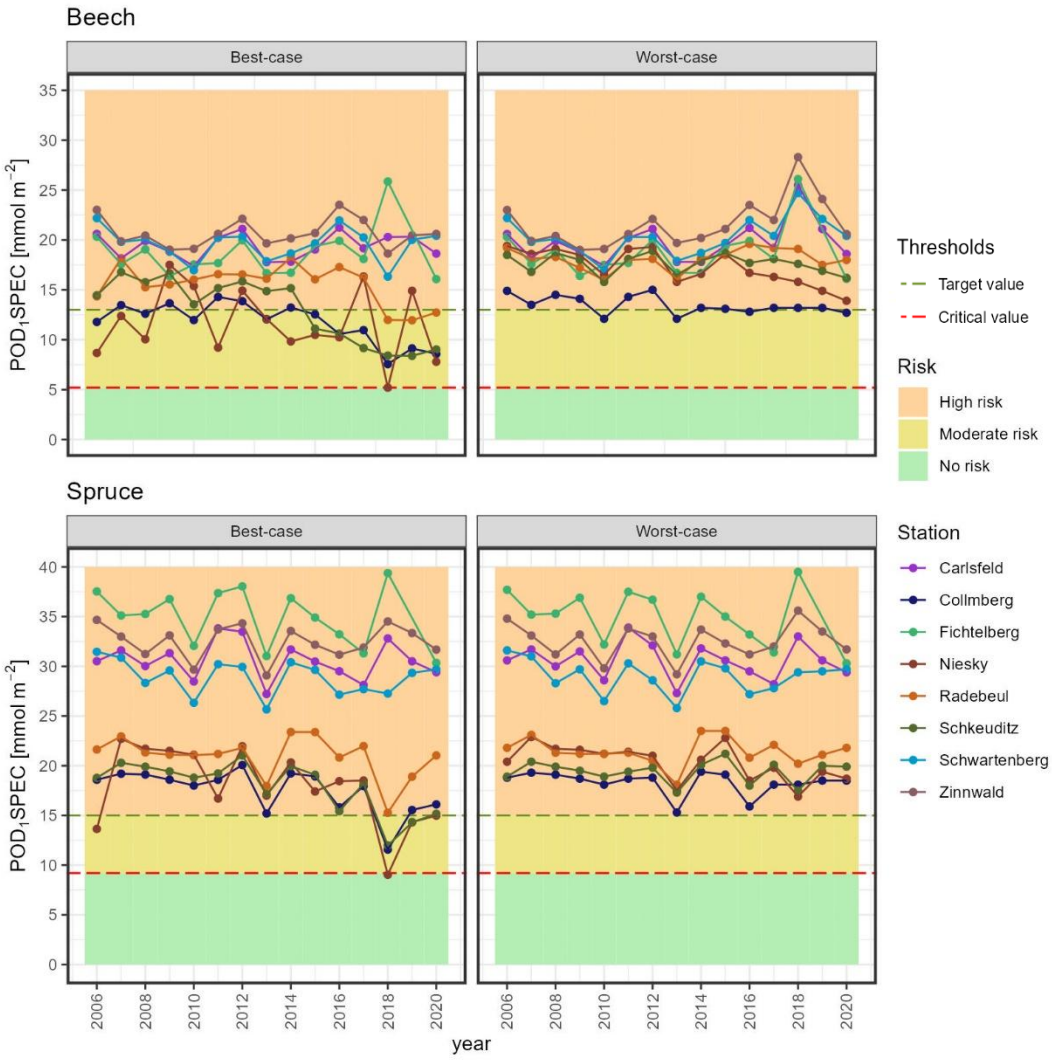

Figure S1. Time series of the accumulated POD_1SPEC (mmol O_3 per m^{-2} leaf area, PLA) per year, for the time frame (2006-2020) with and without plant available water approach (best-case and worst-case scenarios), for beech and spruce in the upper and lower panel, respectively, at each evaluated mountain and rural background site in Saxony, Germany

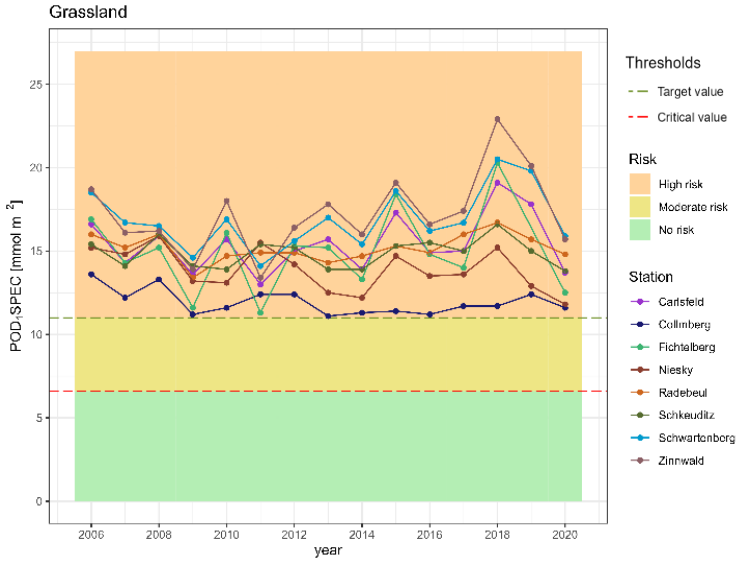

Figure S2. Time series of the accumulated POD_1SPEC (mmol O_3 m^{-2} per leaf area, PLA) per year, for the time frame (2006-2020) without plant available water approach (worst-case scenario), for grassland, at mountain and rural background sites in Saxony, Germany

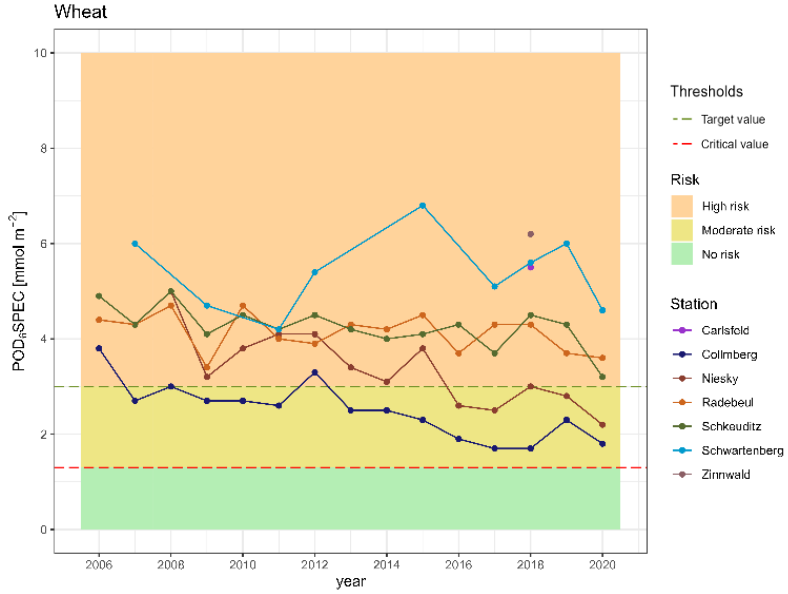

Figure S3. Time series of the accumulated POD_1SPEC (mmol O_3 m^{-2} per leaf area, PLA) per year, for the time frame (2006-2020) without plant available water approach (worst-case scenario), for wheat, at mountain and rural background sites in Saxony, Germany

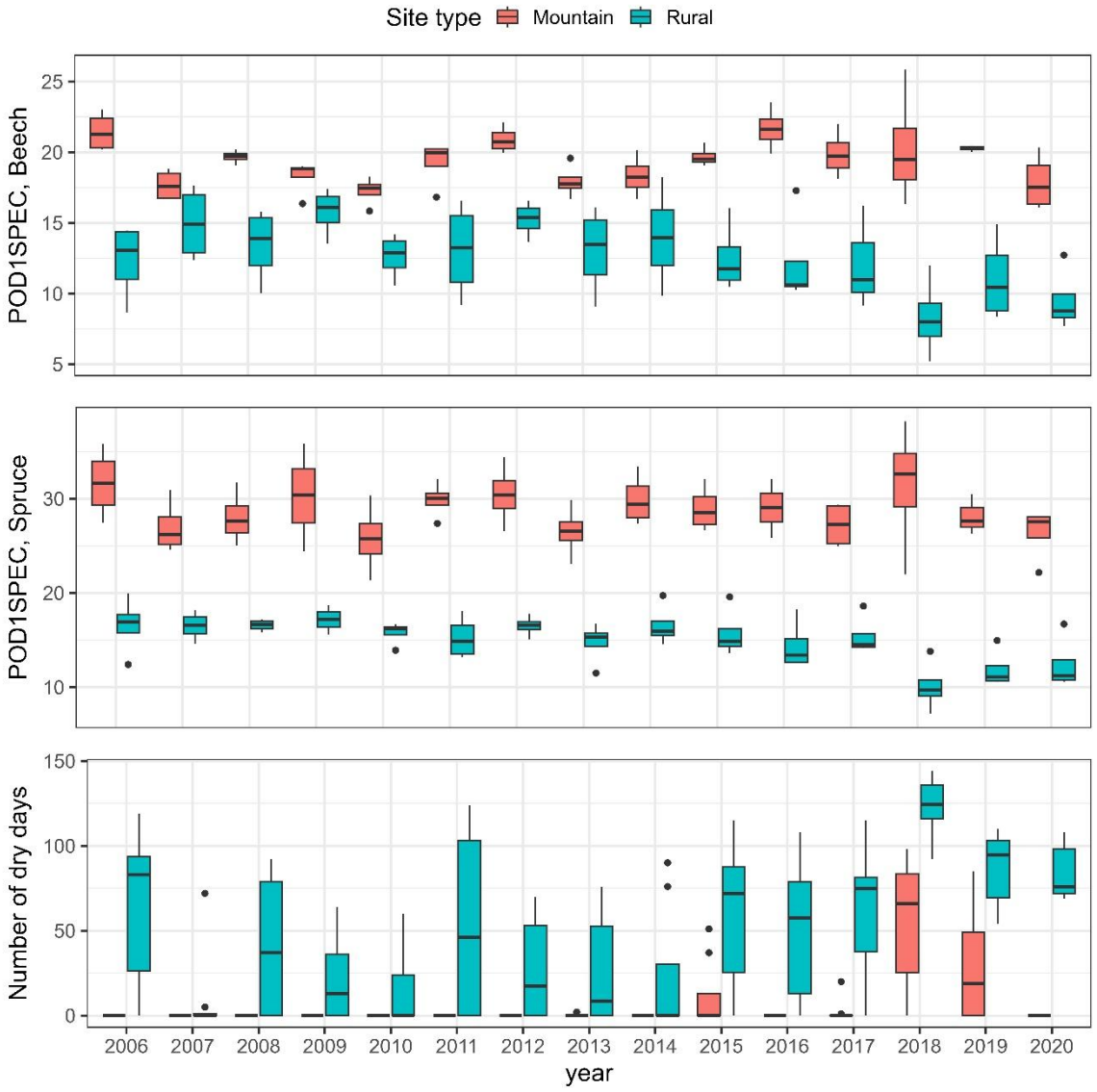

Figure S4. Boxplots showing the yearly accumulated POD_1SPEC (mmol O_3 per m^{-2} leaf area, PLA) from 2006 to 2020 at mountain and rural background sites in Saxony, Germany, for coniferous and deciduous forests. Values represent best-case scenarios based on the plant available water approach, with beech and spruce results shown in the upper and middle panels, respectively. The lower panel displays the distribution of the number of dry days per year across site types. Each box represents the interquartile range (25th–75th percentile), the line inside the box shows the median, and whiskers extend to 1.5 times the interquartile range. Outliers are shown as individual points.

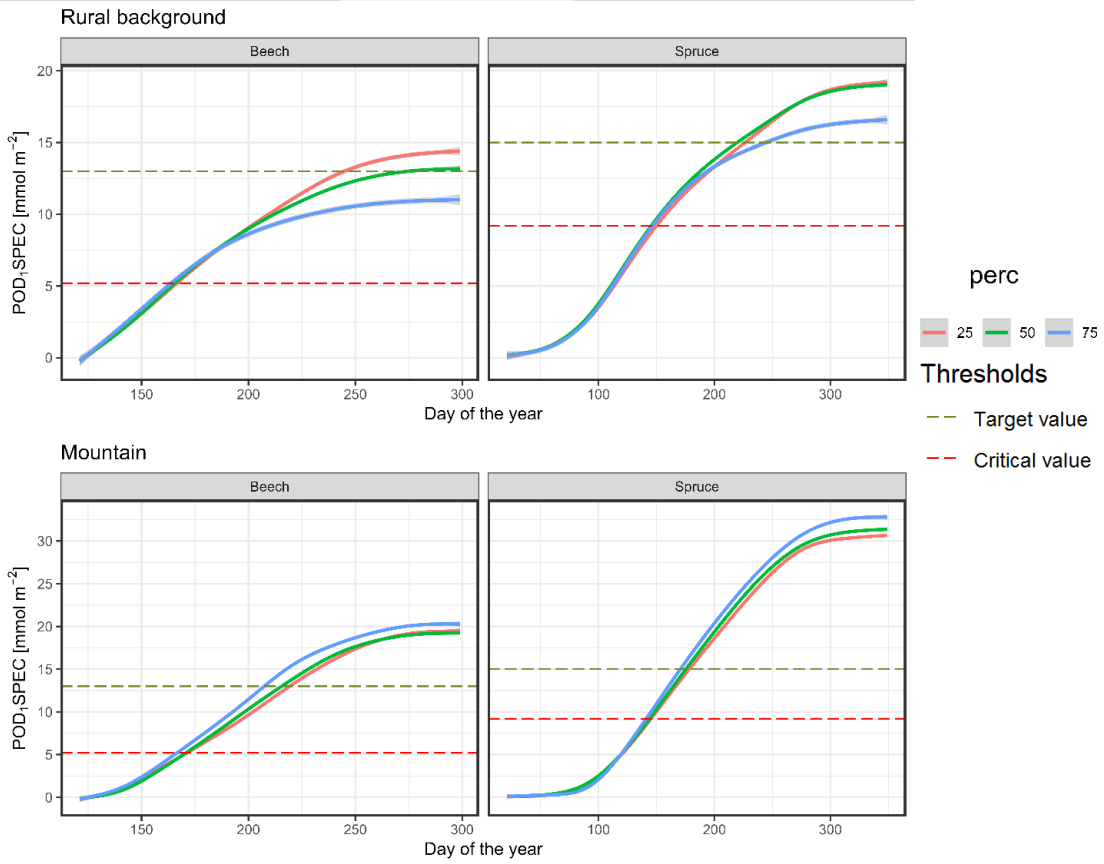

Figure S5. Evolution of the mean accumulated POD_1SPEC (mmol O_3 per m^{-2} leaf area, PLA) per day of the year (DOY) during the accumulation period for mountain and rural background stations from 2006 to 2020 for the best-case scenario of beech and spruce, per percentiles 25, 50 and 75 of the daytime O_3 concentration.

Table S1. Receptors and their specific protection goals

Plant receptor	Objective
Wheat	Agriculture: productivity, food security
Beech	Forests: Productivity, C storage as a first approximation
Grassland	Grassland vegetation: productivity, reproductive capacity, biodiversity in a first approximation
Spruce	Grassland vegetation: productivity, reproductive capacity, biodiversity in a first approximation

Table S2. Ref_{10}PODySPEC values and potential maximum reduction rates (in %) per mmol · m^{-2} PODySPEC for various biological endpoints from the receptors winter wheat, beech, spruce, and species-rich grassland.

Receptor	Biological endpoint	Ref10PODySPEC (mmol m^{-2})	Potential Maximum Reduction Rates (%) per mmol m^{-2} PODySPEC
Wheat	Grain yield	0	3.85
	1000-grain yield	0	3.85
	Protein yield	0	2.54
Beech	Annual growth of whole-tree biomass	0.9	0.93
Spruce	Annual growth of whole-tree biomass	0.1	0.22
Grassland	Number of flowers	0.1	1.54
	Above-ground biomass	0.1	0.99
	Total biomass	0.1	0.62

Table S3. Critical levels (CL_{POD_ySPEC}) and deduced target values (TV_{POD_ySPEC}) according to the UNECE-CLRTAP mapping manual related to the PLA for the representative species wheat, beech, spruce, and grassland {Clrtap, 2017}.

Representative specie	**Effect parameter**	**CL_{POD_ySPEC} (mmol m^{-2})**	**TV_{POD_ySPEC} (mmol m^{-2})**
Wheat	Grain yield	CL_{POD_6SPEC} = 1.3	TV_{POD_6SPEC} = 3
	1000-grain yield	CL_{POD_6SPEC} = 1.5	
	Protein yield	CL_{POD_6SPEC} = 2	
Beech	Annual growth of whole-tree biomass	CL_{POD_1SPEC} = 5.2	TV_{POD_1SPEC} = 13
Spruce	Annual growth of whole-tree biomass	CL_{POD_1SPEC} = 9.2	TV_{POD_1SPEC} = 15
Grassland	Number of flowers	CL_{POD_1SPEC} = 6.6	TV_{POD_1SPEC} = 11
	Above-ground biomass	CL_{POD_1SPEC} = 10.2	
	Total biomass	CL_{POD_1SPEC} = 16.2	

Table S4. Mean values, standard deviations (Mean ± SD), and annual trends (Mann-Kendall test) of stomatal ozone flux (PODySPEC) in all studied sites over the period 2006–2020.

				Full-time series		5-y (2016-2020)			
PODySPEC	Specie	Site type	Scenario	Mean ± SD ($mmol\ m^{-2}$)		Mean ± SD ($mmol\ m^{-2}$)		Mann Kendall p-value (< 0.05)	Sen slope
POD_1SPEC	Beech	Rural	Best-case	12.99	3.12	10.9	3.26	0.01	-0.34
			Worst-case	16.61	2.21	16.1	2.30	0.03	-0.13
		Mountain	Best-case	19.58	1.86	20.2	2.28	0.55	0.04
			Worst-case	20.11	2.42	21.8	3.02	0.17	0.13
	Spruce	Rural	Best-case	18.57	3.04	16.3	3.29	0.01	-0.35
			Worst-case	19.85	1.78	19.2	1.61	0.11	-0.06
		Mountain	Best-case	31.68	3.04	31.0	2.94	0.32	-0.16
			Worst-case	31.72	2.98	31.2	2.92	0.32	-0.16
	Grassland	Rural	Worst-case	13.97	1.58	14.0	1.8	0.49	0.1
		Mountain		16.14	2.27	17.0	2.77	0.40	-0.03
POD_6SPEC	Wheat	Rural	Worst-case	3.59	0.90	3.10	0.98	1	0.03
		Mountain		5.46	0.77	5.5	0.59	0.001	-0.1

Table S5. Pearson correlation coefficients between POD_1SPEC and soil water content, atmospheric water balance, and drought duration at all sites from 2006 to 2020.

Site; elevation (m.a.s.l.)	SWC	AWB	Drought duration
Rural background sites			
Schkeuditz; 111	0.49	-0.14	-0.42
Radebeul; 131	0.38	-0.25	-0.33
Niesky; 172	0.54	-0.07	-0.47
Collmberg; 312	0.39	-0.13	-0.42
Mountain sites			
Schwartenberg; 789	0.05	-0.30	-0.14
Zinnwald; 807	0.03	-0.34	-0.14
Carlsfeld; 837	-0.14	0.04	-0.12
Fichtelberg; 1215	-0.16	-0.22	-0.07