Supplementary Information for “Assessing changes in global fire regimes”

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*Affiliations are placed at the end of the document

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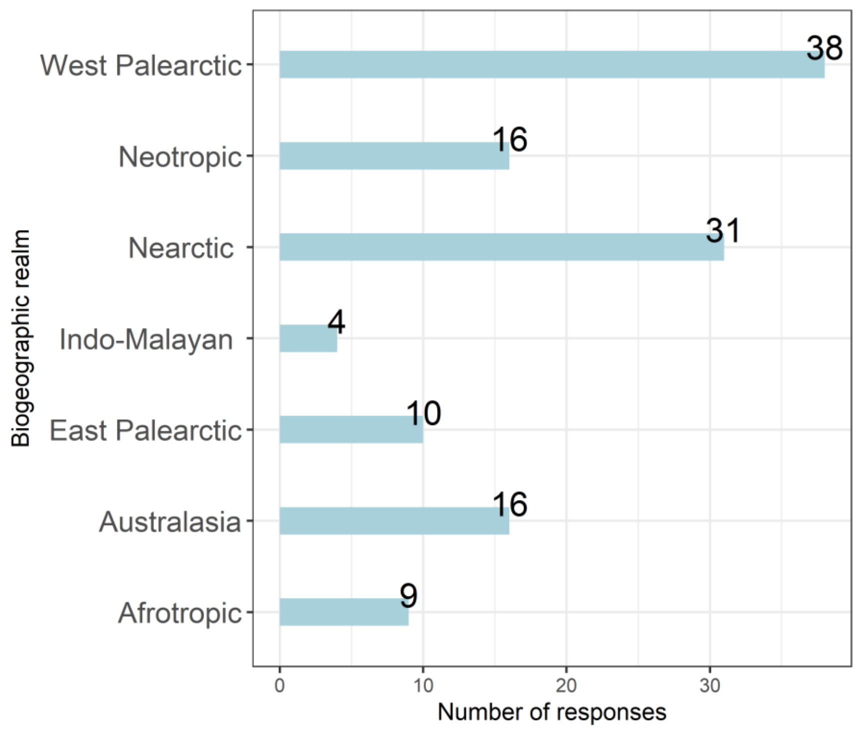
a)



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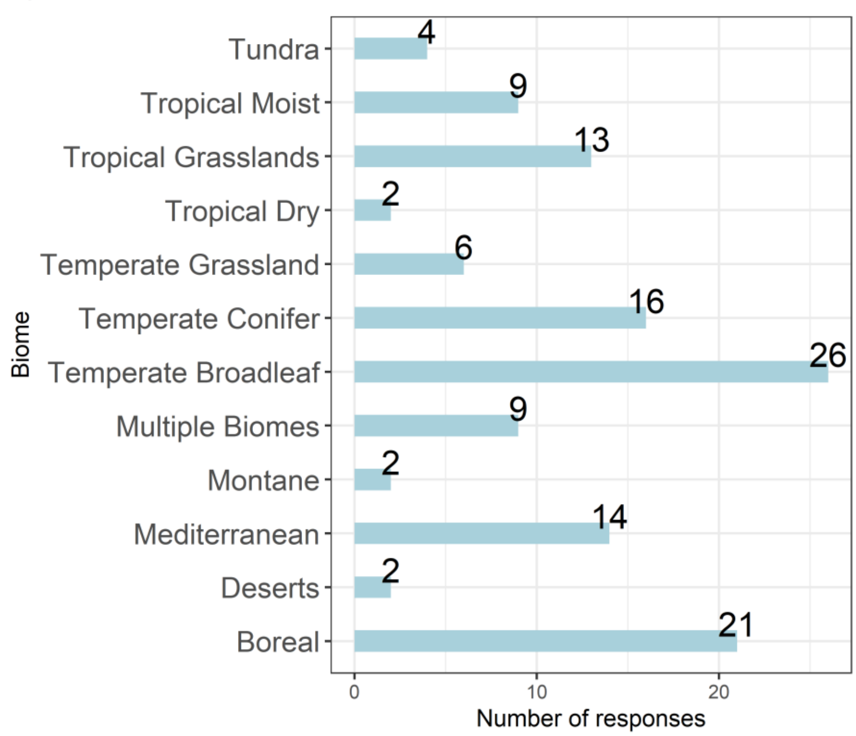
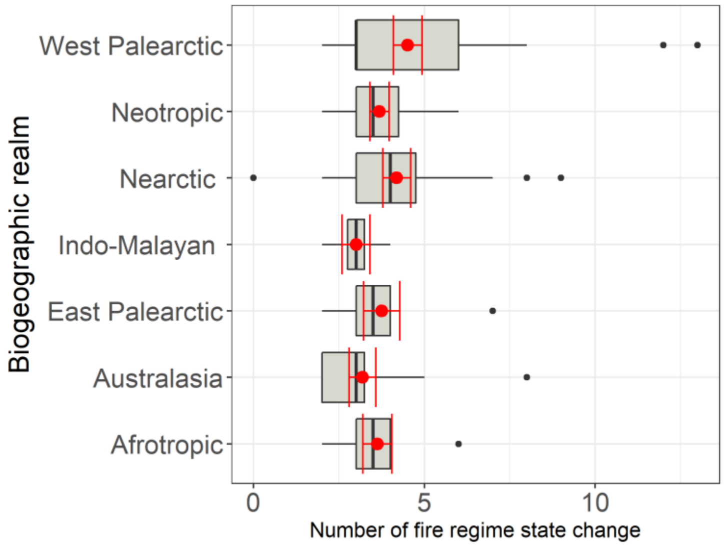


Fig. S1 Number of responses per a) Biogeographic realm and b) Biome a)



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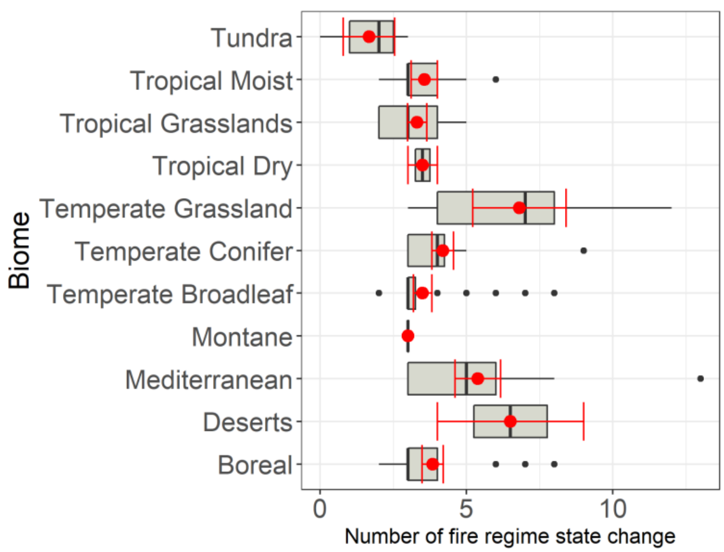


Fig. S2 Estimated number of fire regime state changes during the Holocene per a) Biogeographic realm and b) Biome by respondents. The boxplots represent the median (black line) and average values (red dots). Red lines represent standard error.

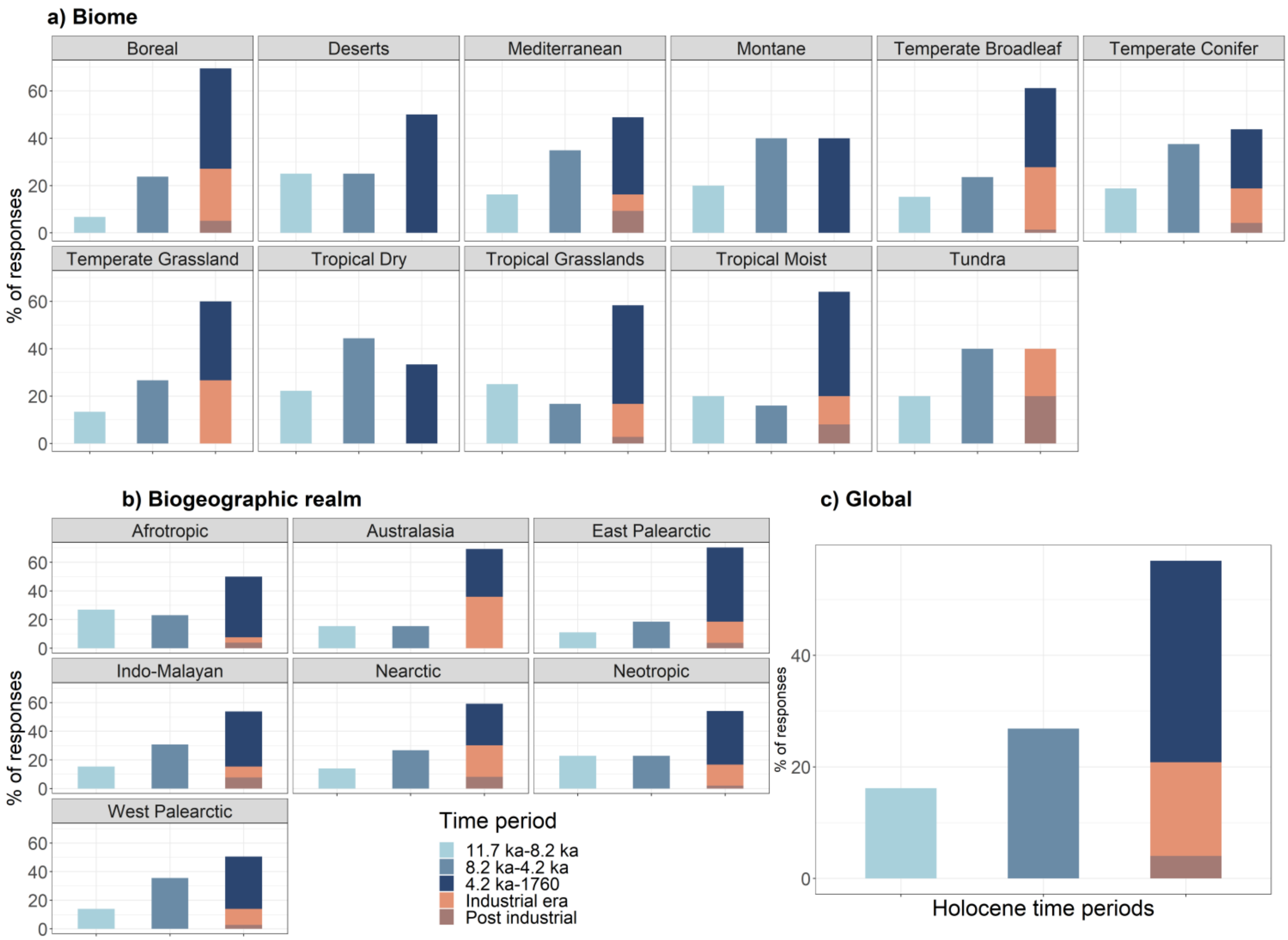


Fig. S3 Estimated occurrence of the three largest fire regime state changes during the Holocene by respondents. The following time periods were defined for the purpose of this study: 11700-8200 BP: Early Holocene; 8200-4200 BP: Mid Holocene; 4200-0 BP: Late Holocene; 262-70 BP: Industrial era; 70-0 BP: Postindustrial.

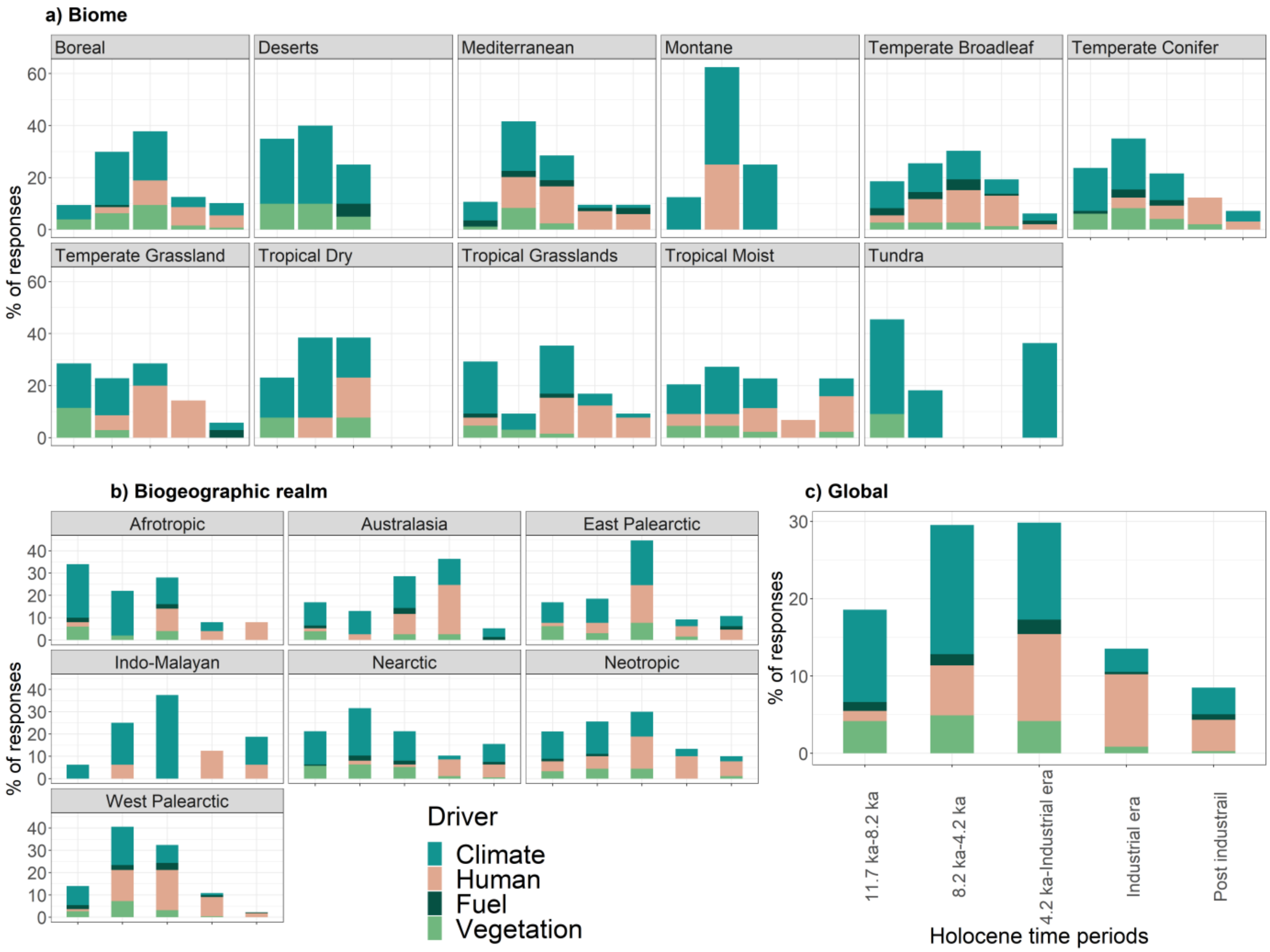
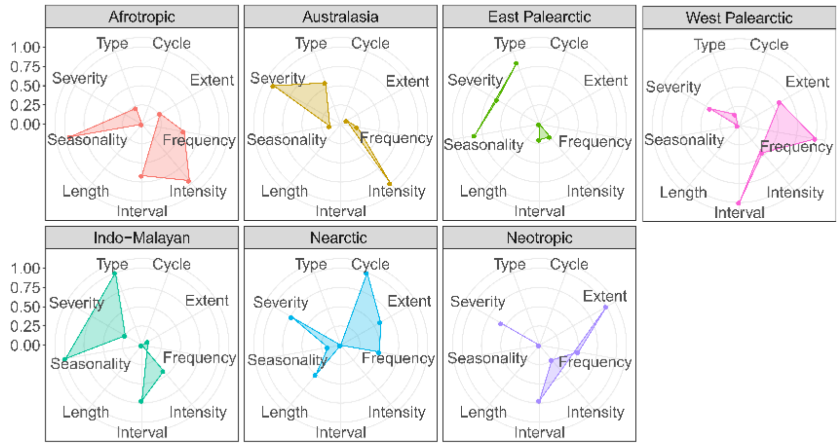


Fig. S4 Drivers of the three major fire regime state changes during the Holocene, identified by respondents (the sequence of time periods for all plots is similar to the global plot) .

a) Biogeographic realm



b) Biome

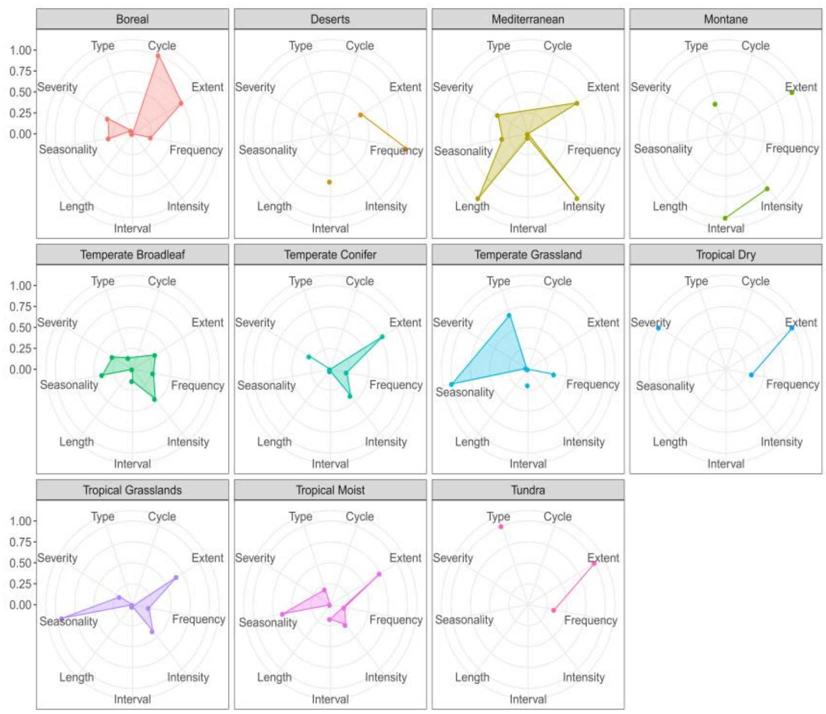


Fig. S5 Aspects of fire regimes most significantly influenced by post-industrial society, identified by respondents. The y-axis represents the percentage of responses. These aspects include spatial factors (extent, severity, type, and intensity) and temporal factors (frequency, seasonality, cycle, interval).

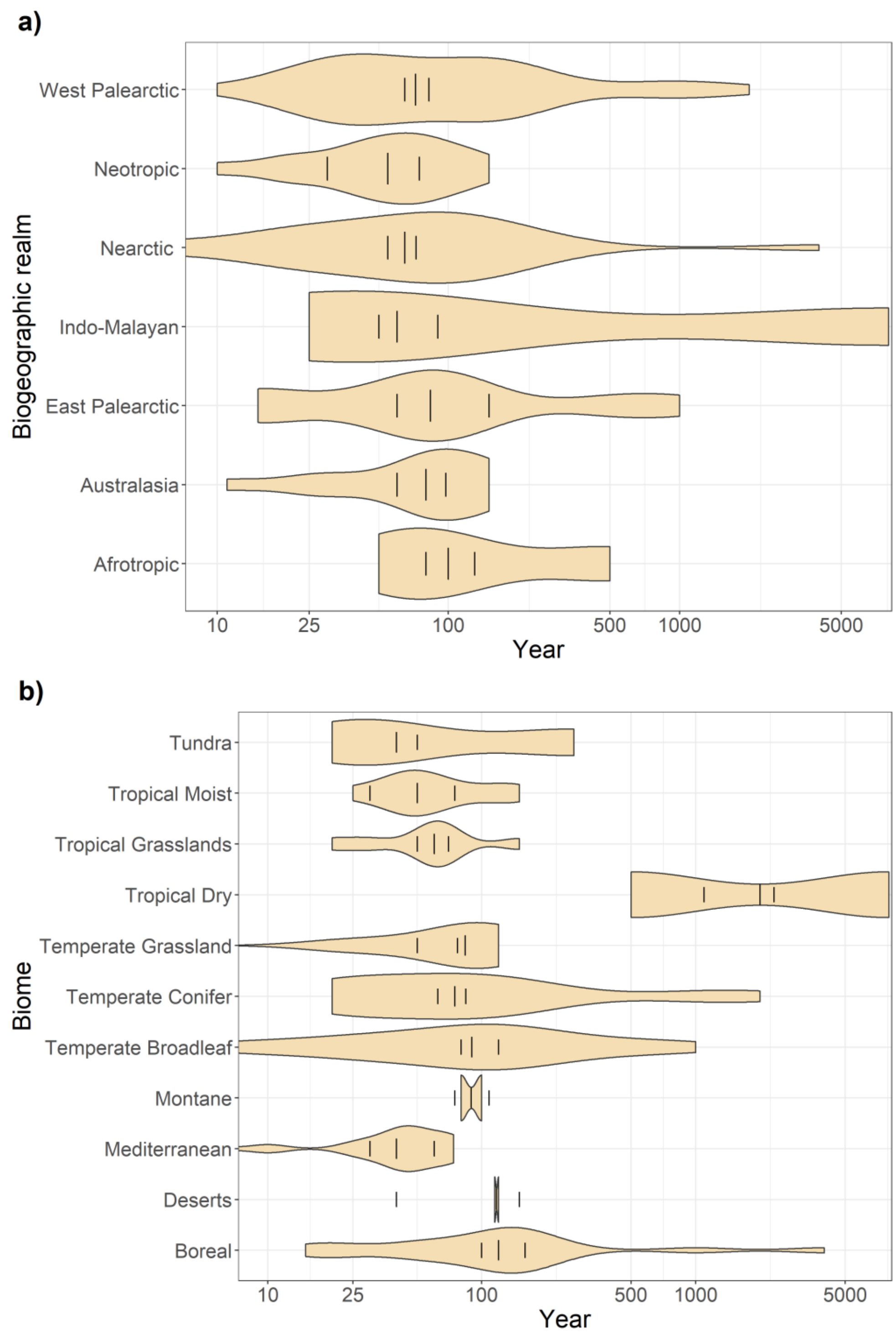


Fig. S6 Duration of the current fire regimes, estimated by respondents. The violin plots illustrate the distribution of central estimates among experts (the width indicates the number of estimates within that range). The horizontal black lines represent the median values among experts for the lower, central, and upper estimates.

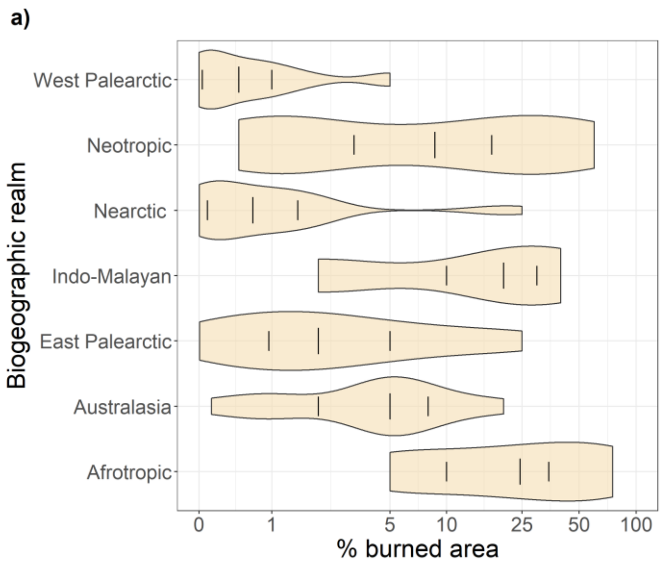


Fig. S7 Burned area of current fire regimes, estimated by respondents.

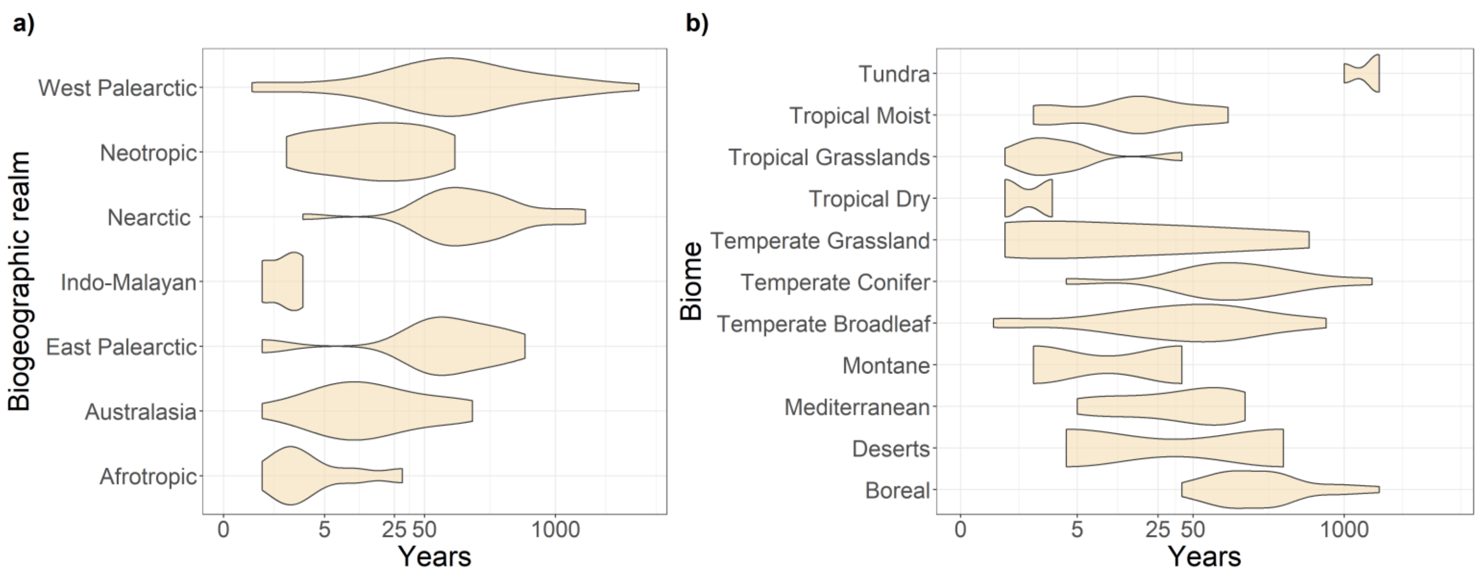


Fig. S8 Fire return interval for current fire regimes, estimated by respondents.

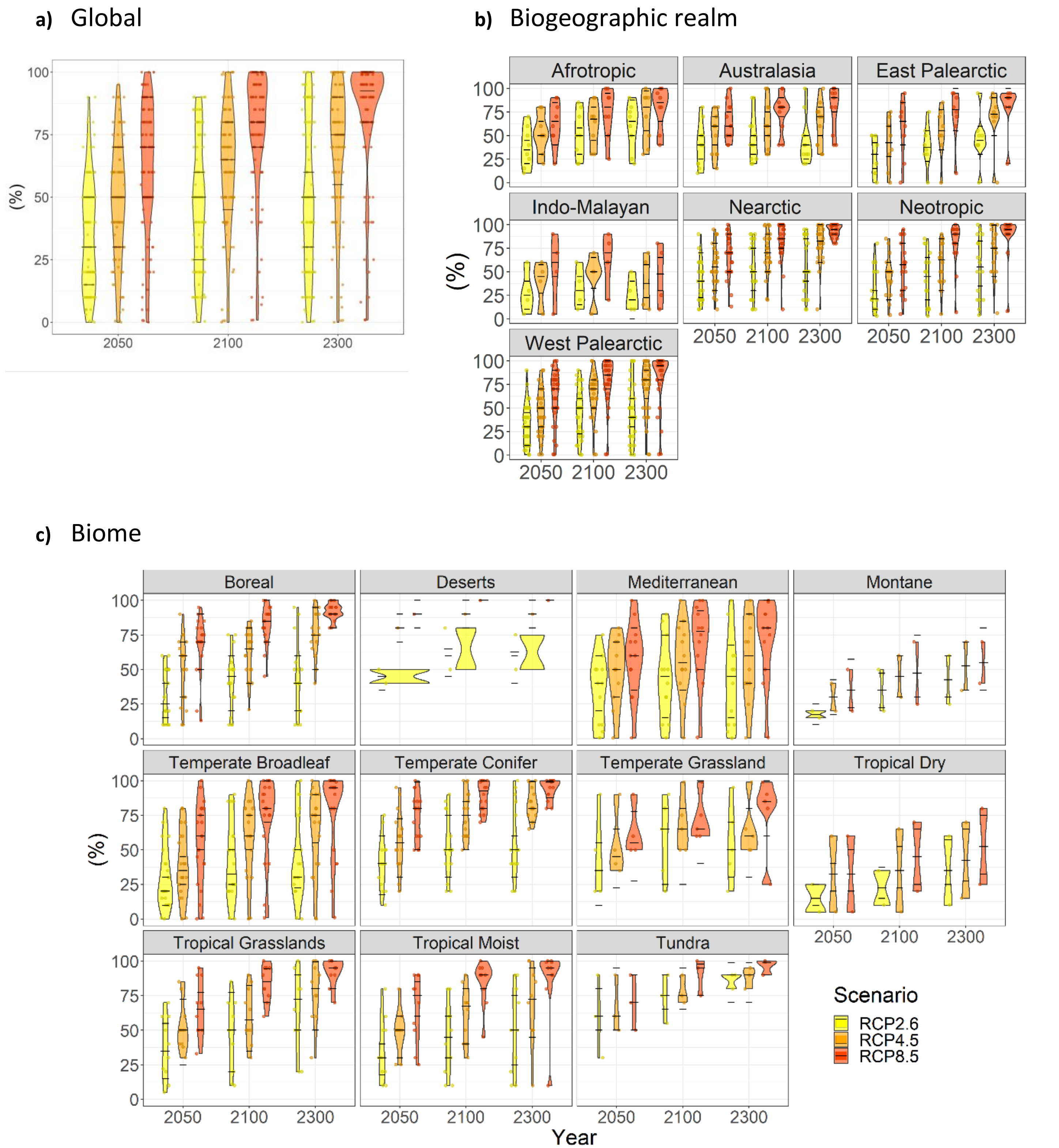


Fig. S9 Estimated likelihood of fire regime change for the years 2050, 2100, and 2300 under three RCP scenarios (RCP2.6, RCP4.5, and RCP8.5). The horizontal lines represent the median estimates for "lower," "central," and "upper" values, with a 90% confidence interval. The individual points and ranges depict the estimates for each expert.

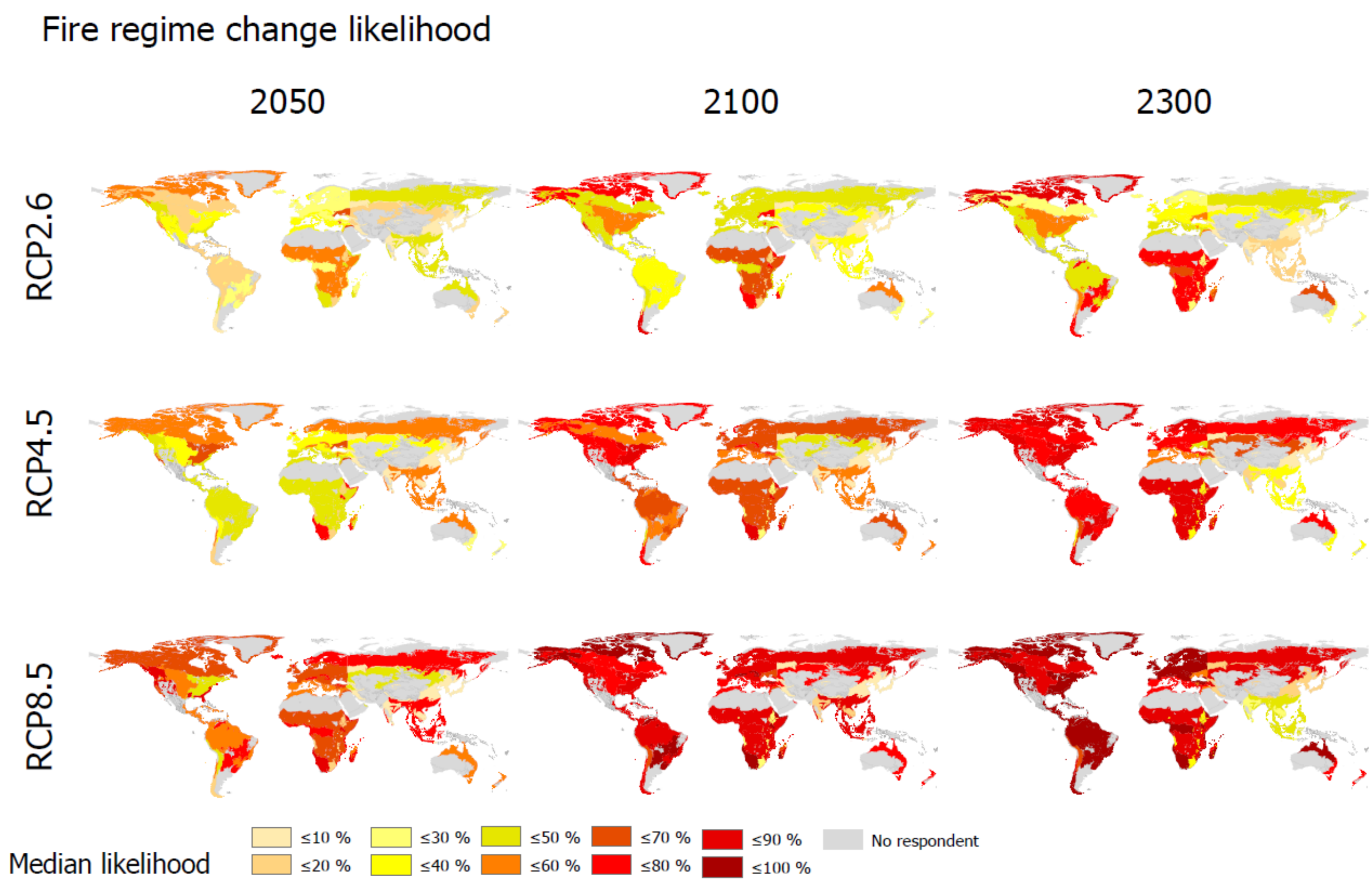


Fig. S10 Likelihood of fire regime changes for the years 2050-2300 under three RCP scenarios. Map illustrates median values of estimates by respondents.

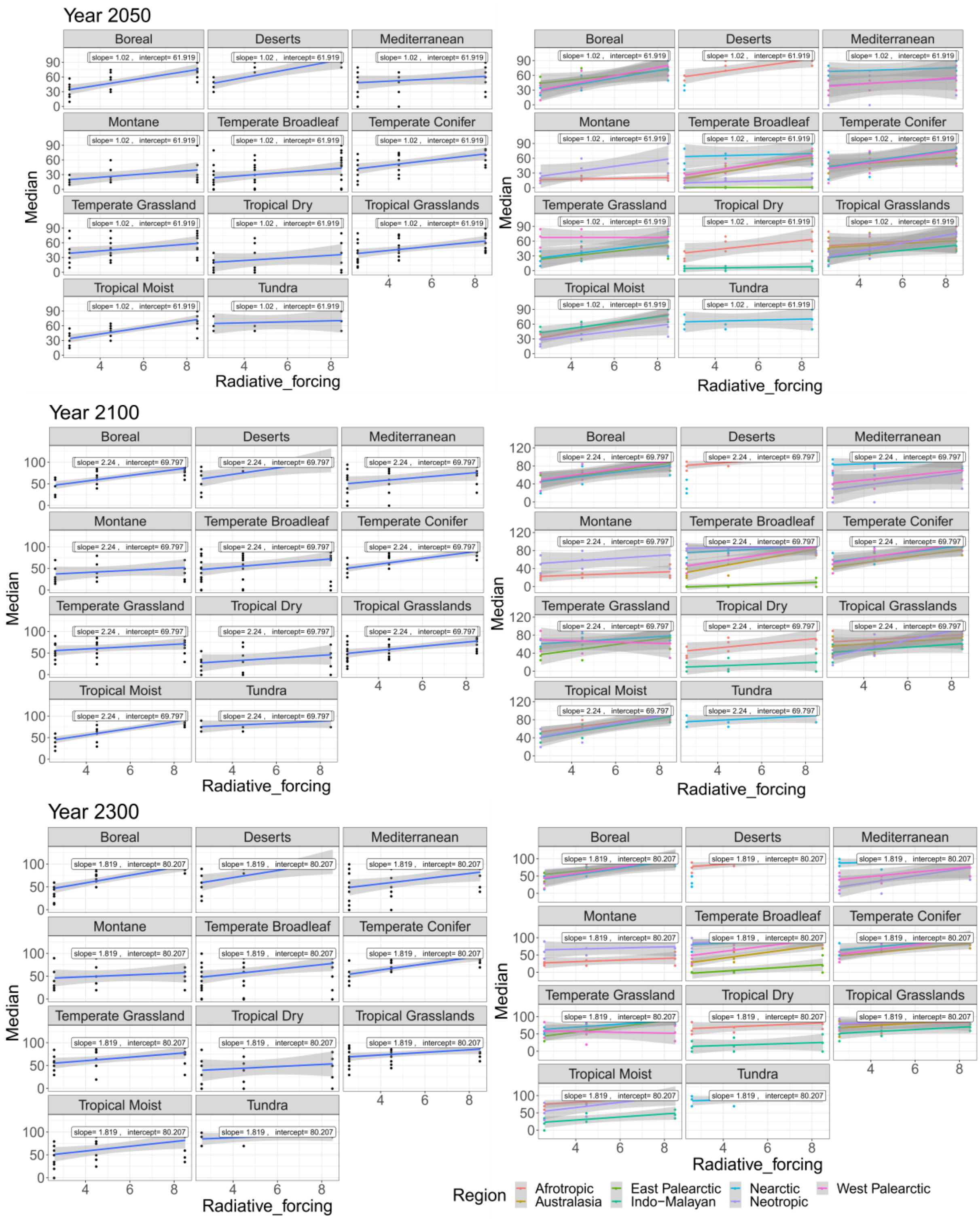


Fig. S11 Climate sensitivity of the likelihood of fire regime change, calculated based on the slope between the median of estimated likelihood of a fire regime change (%) by respondents across all quantiles and the magnitude of radiative forcing for the three RCP scenarios (W m^{-2}). The dots represent individual estimates.

2050

2100

2300

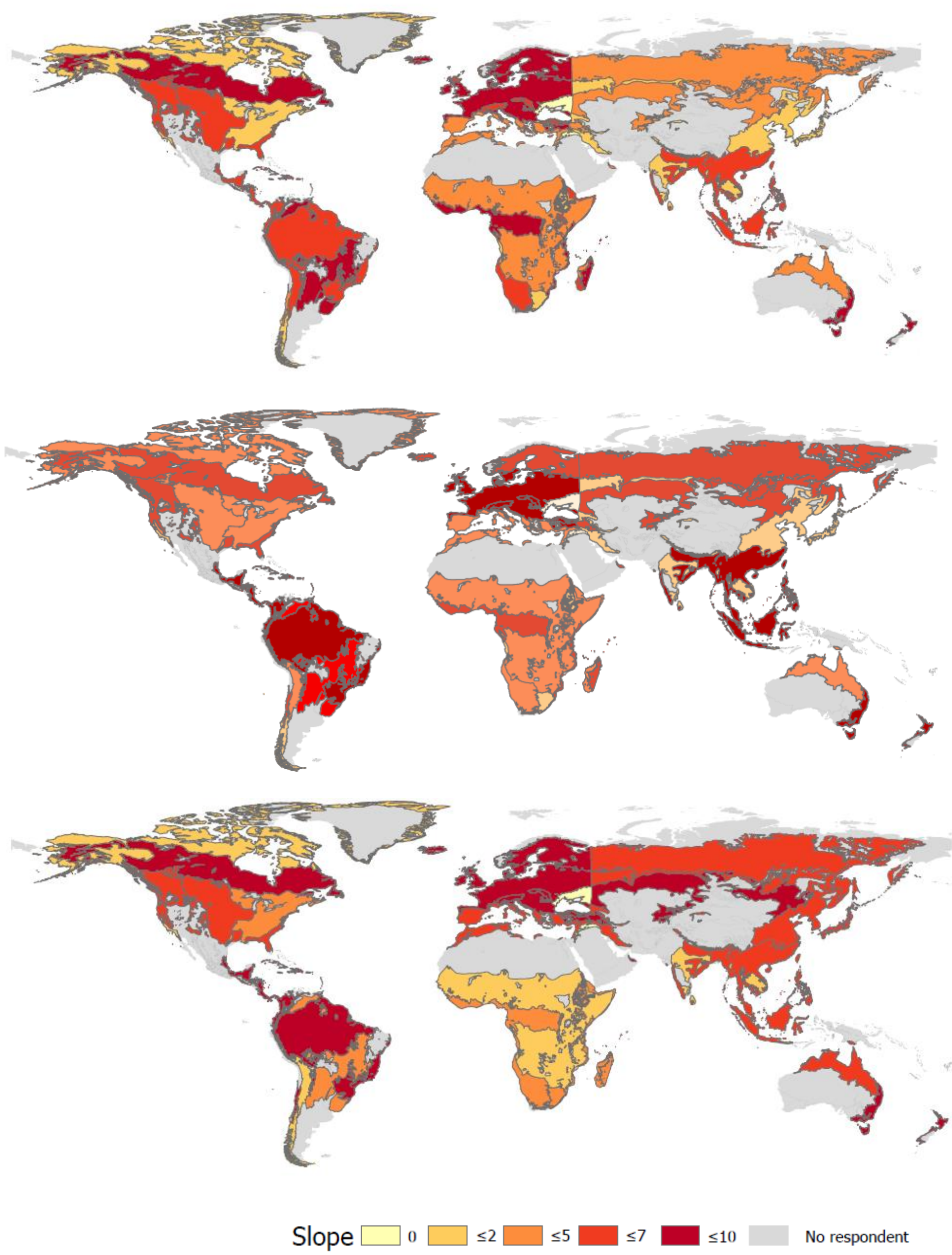
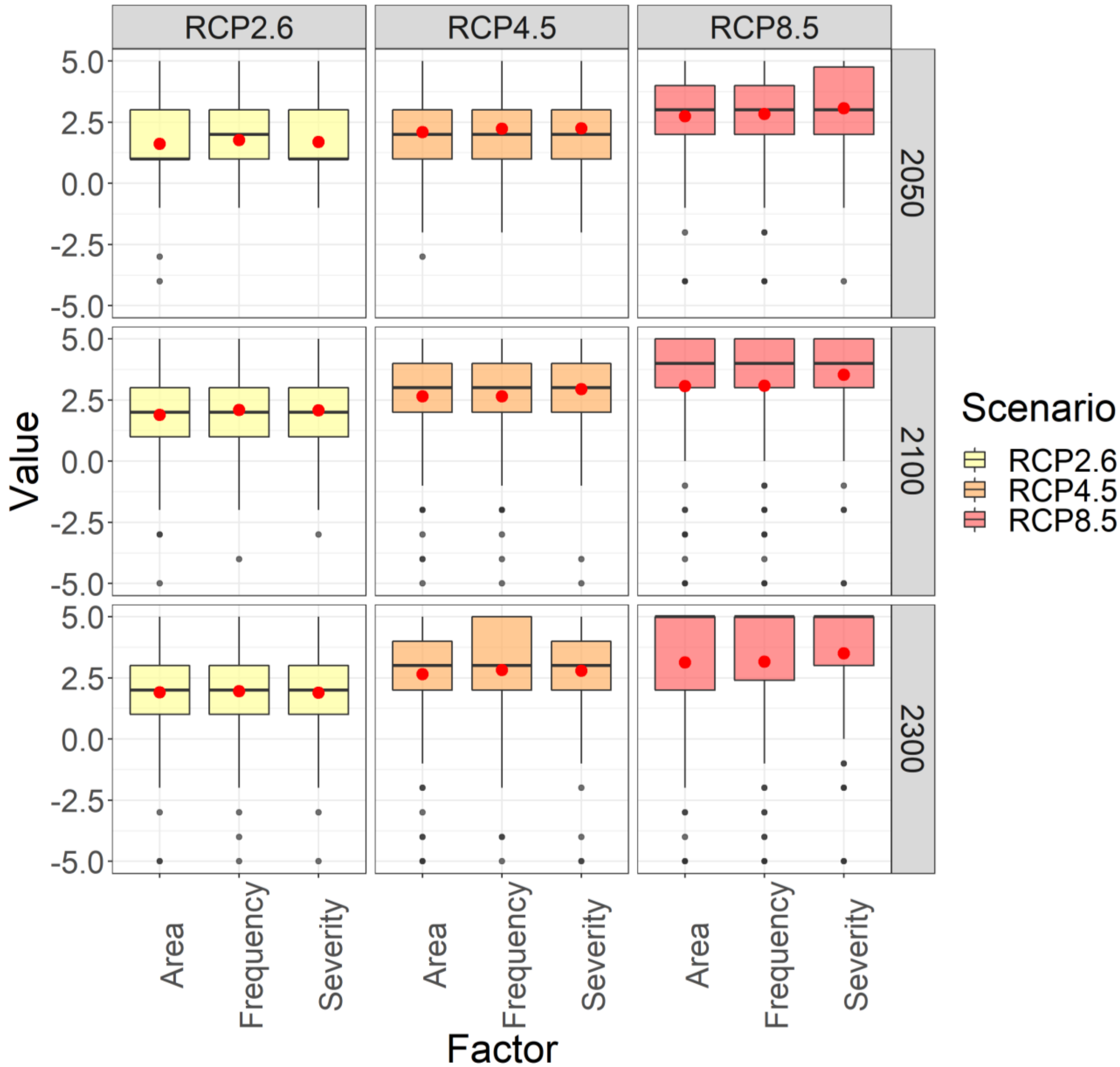


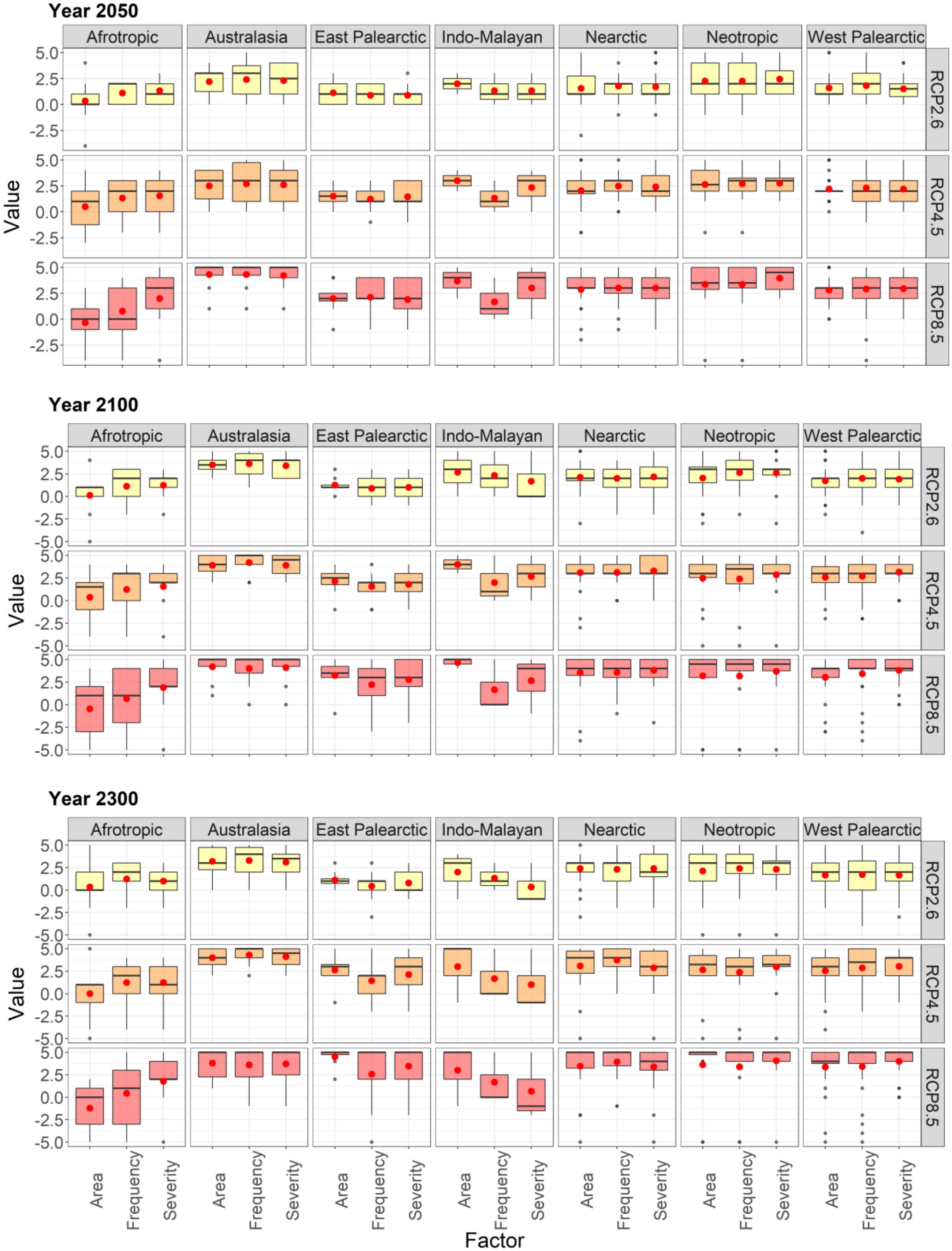
Fig. S12 Climate sensitivity of the likelihood of fire regime change among RCP2.6, RCP4.5, and RCP8.5. The slope value is derived from the median likelihood of a fire regime change (%) and the magnitude of radiative forcing.

a) Global

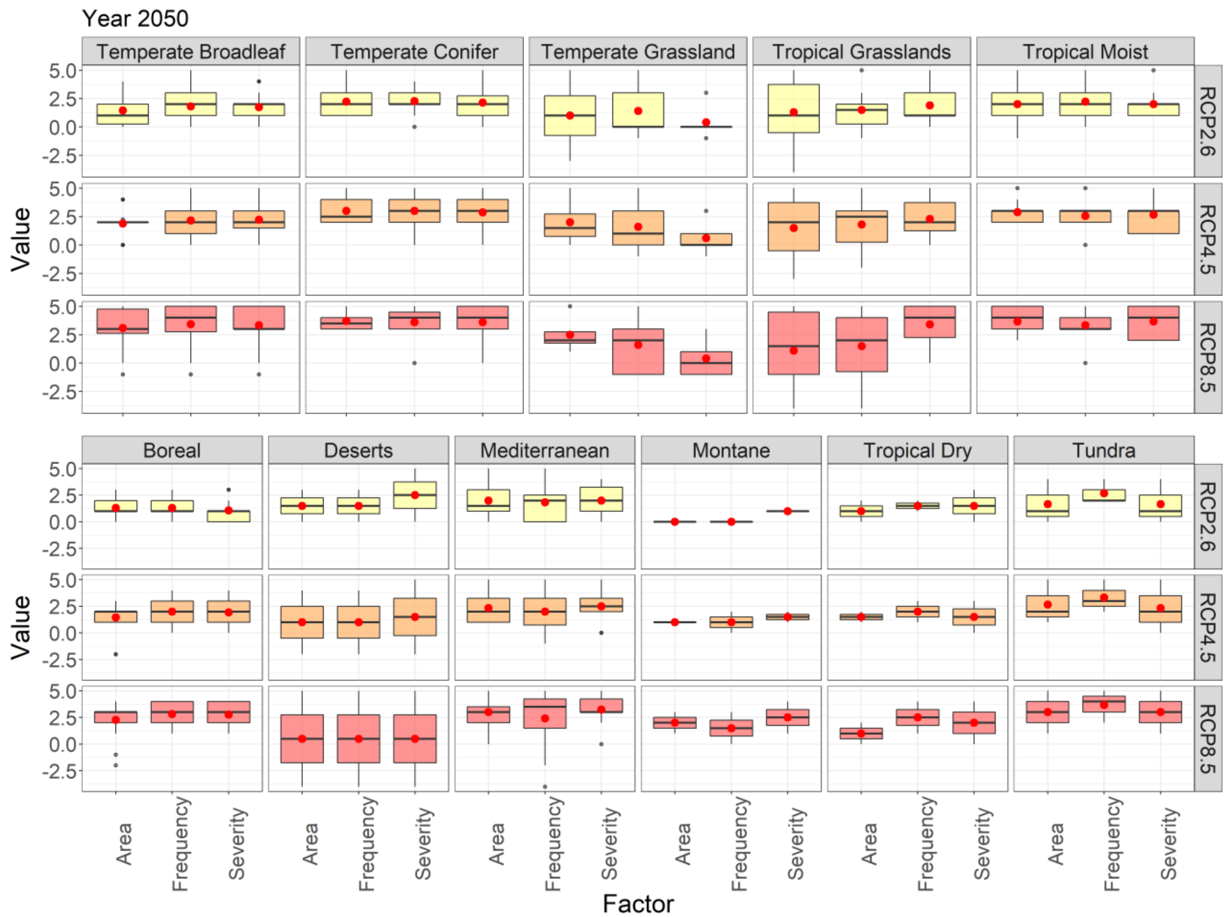


RCP2.6
RCP4.5
RCP8.5
5.0
2.5
0.0
-2.5
-5.0
2050
2100
2300
Value
Scenario
RCP2.6
RCP4.5
RCP8.5
Area
Frequency
Severity
Factor

b) Biogeographic realm

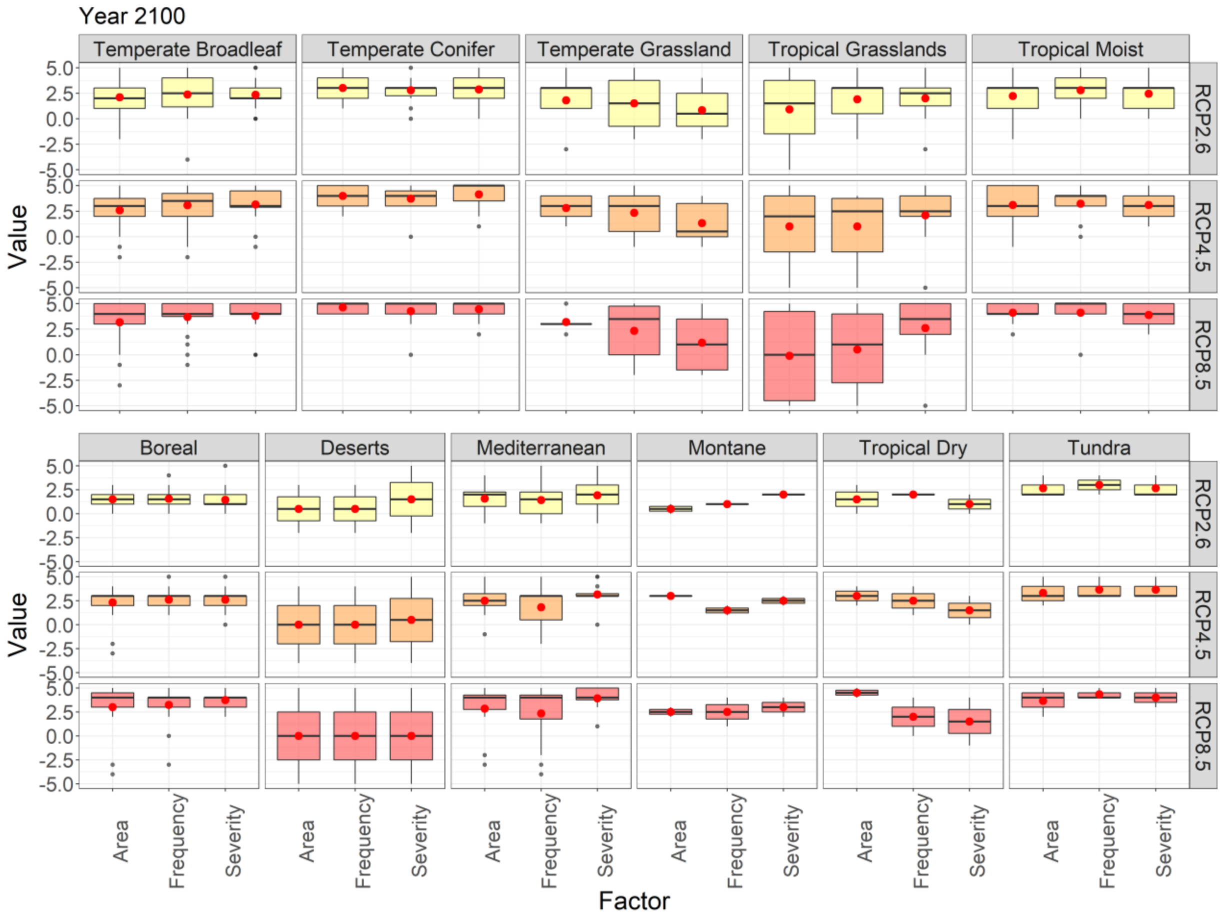


c) Biome



Year 2050
Temperate Broadleaf
Temperate Conifer
Temperate Grassland
Tropical Grasslands
Tropical Moist
Boreal
Deserts
Mediterranean
Montane
Tropical Dry
Tundra
RCP2.6
RCP4.5
RCP8.5
Value
5.0
2.5
0.0
-2.5
Area
Frequency
Severity
Factor

Biome


Year 2100
Temperate Broadleaf
Temperate Conifer
Temperate Grassland
Tropical Grasslands
Tropical Moist
RCP2.6
RCP4.5
RCP8.5
Value
5.0
2.5
0.0
-2.5
-5.0
Boreal
Deserts
Mediterranean
Montane
Tropical Dry
Tundra
Area
Frequency
Severity
Factor

Biome

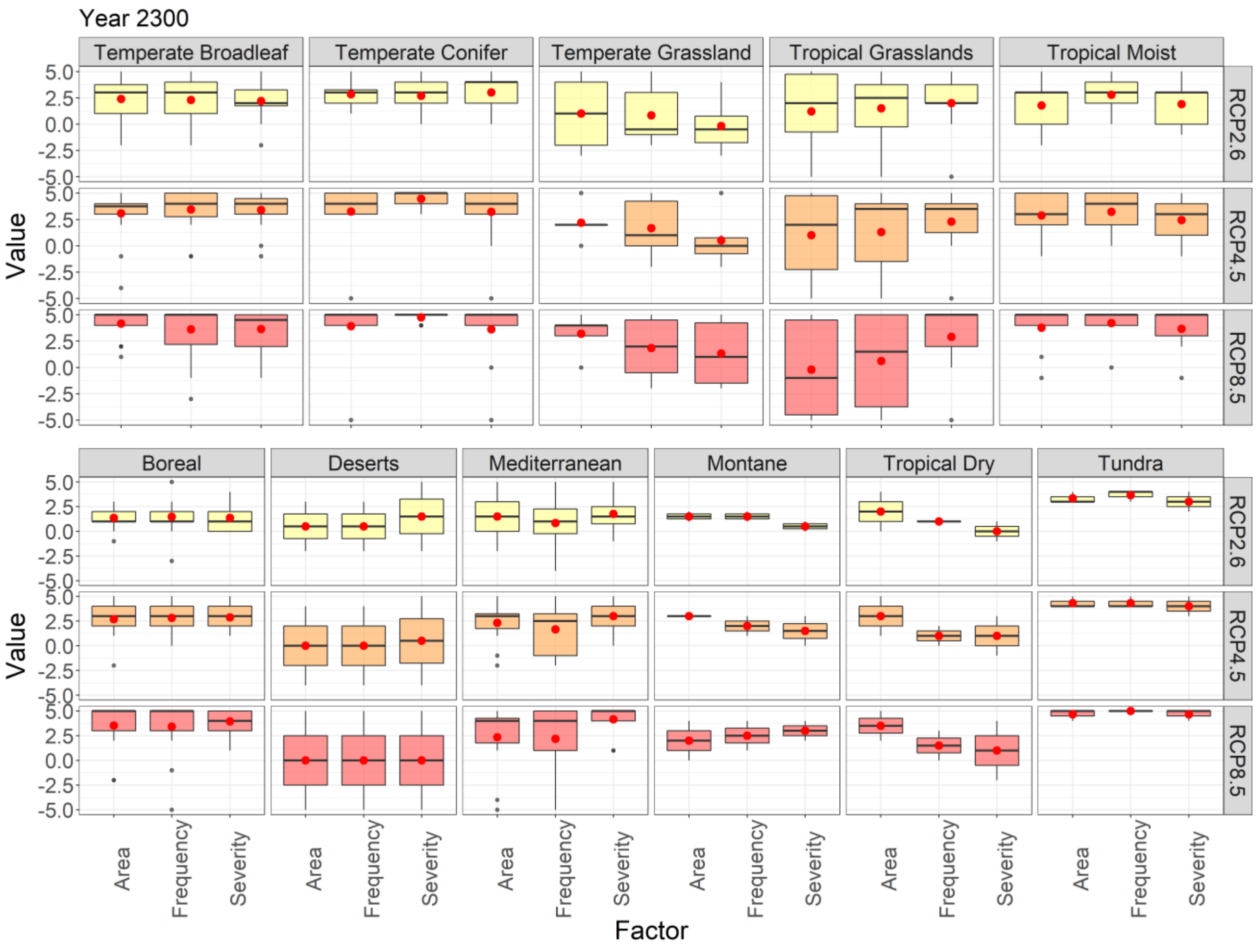


Fig. S13 Direction and magnitude of change of fire regime characteristics as estimated by respondents. The boxplots depict the median (black line) and average (red dots). Values range from -5 (significant decrease) to 0 (no change) to 5 (significant increase).

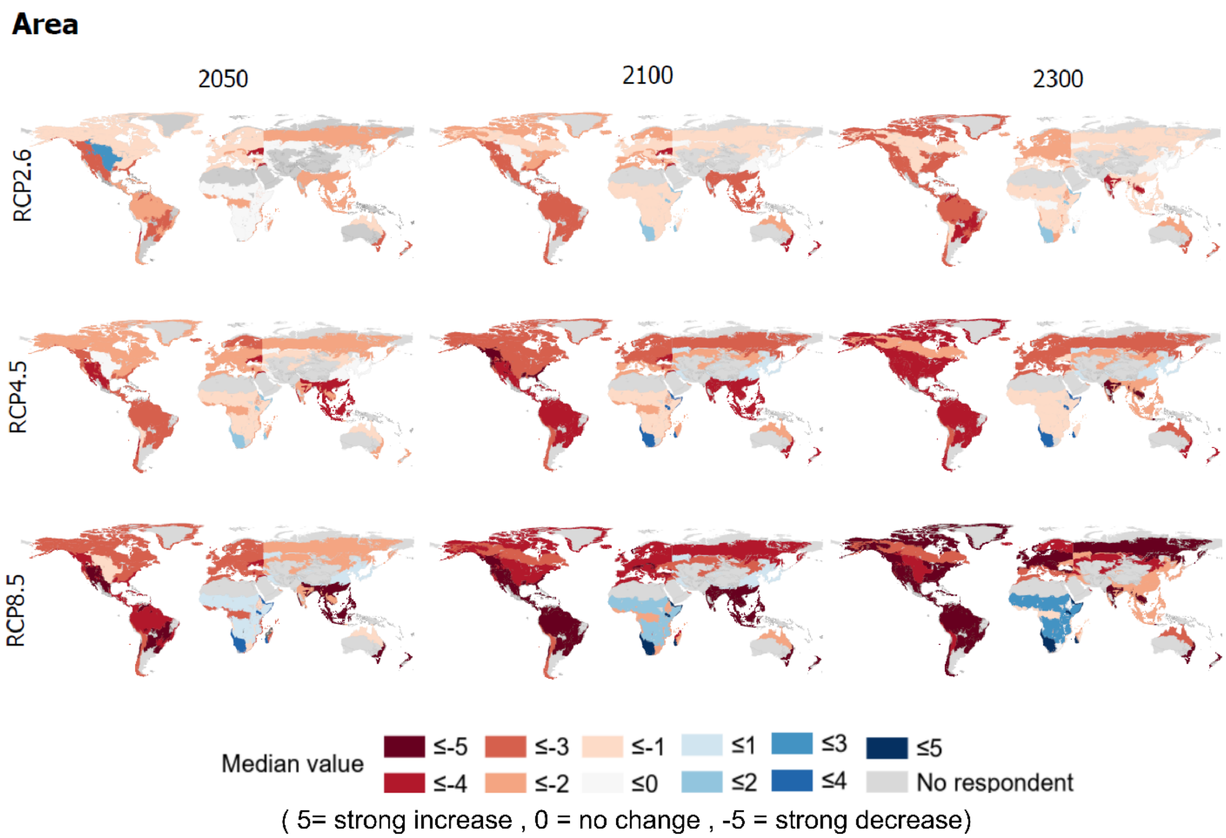


Fig. S14 Burned area change until 2050-2300 and three RCP scenarios. Map illustrates median values of estimates by respondents.

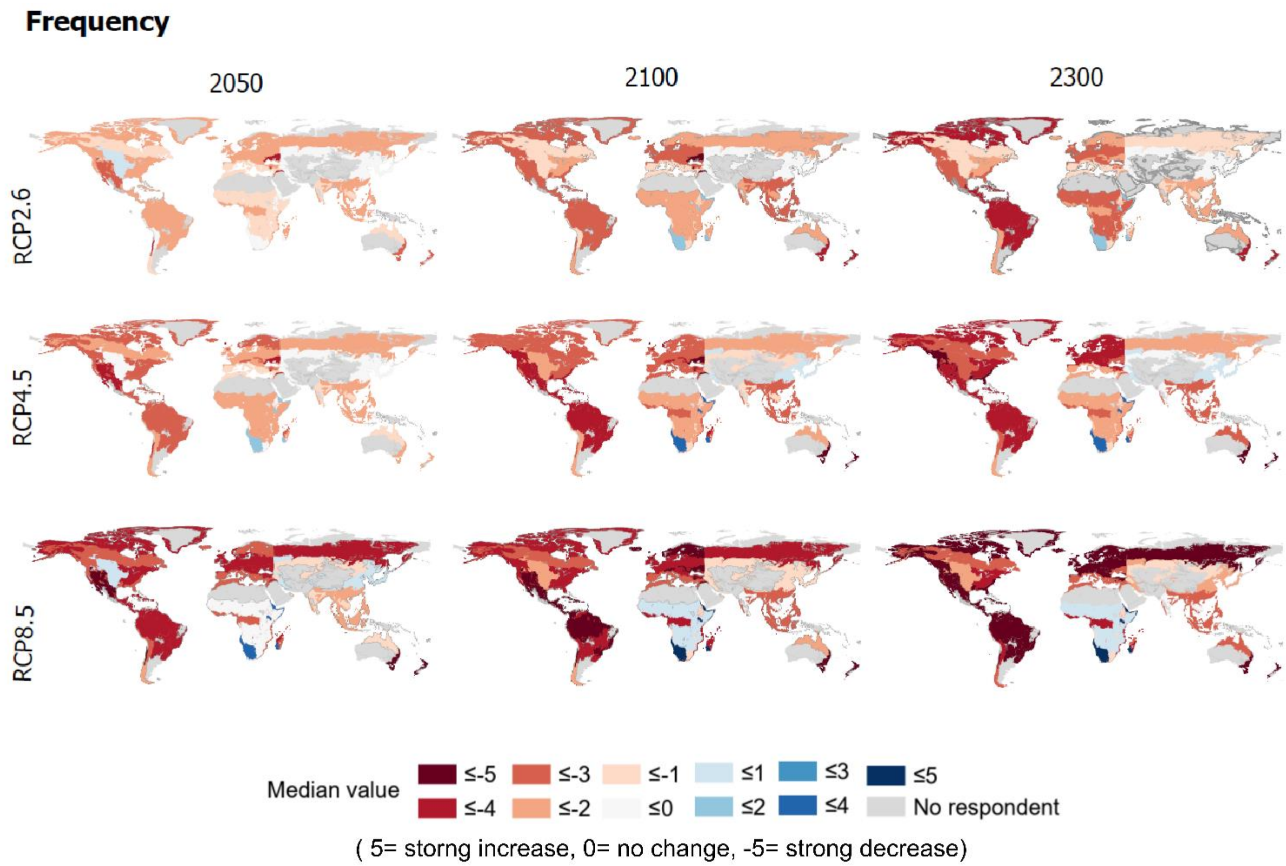


Fig. S15 Fire frequency change until 2050-2300 and three RCP scenarios. Map illustrates median values of estimates by respondents.

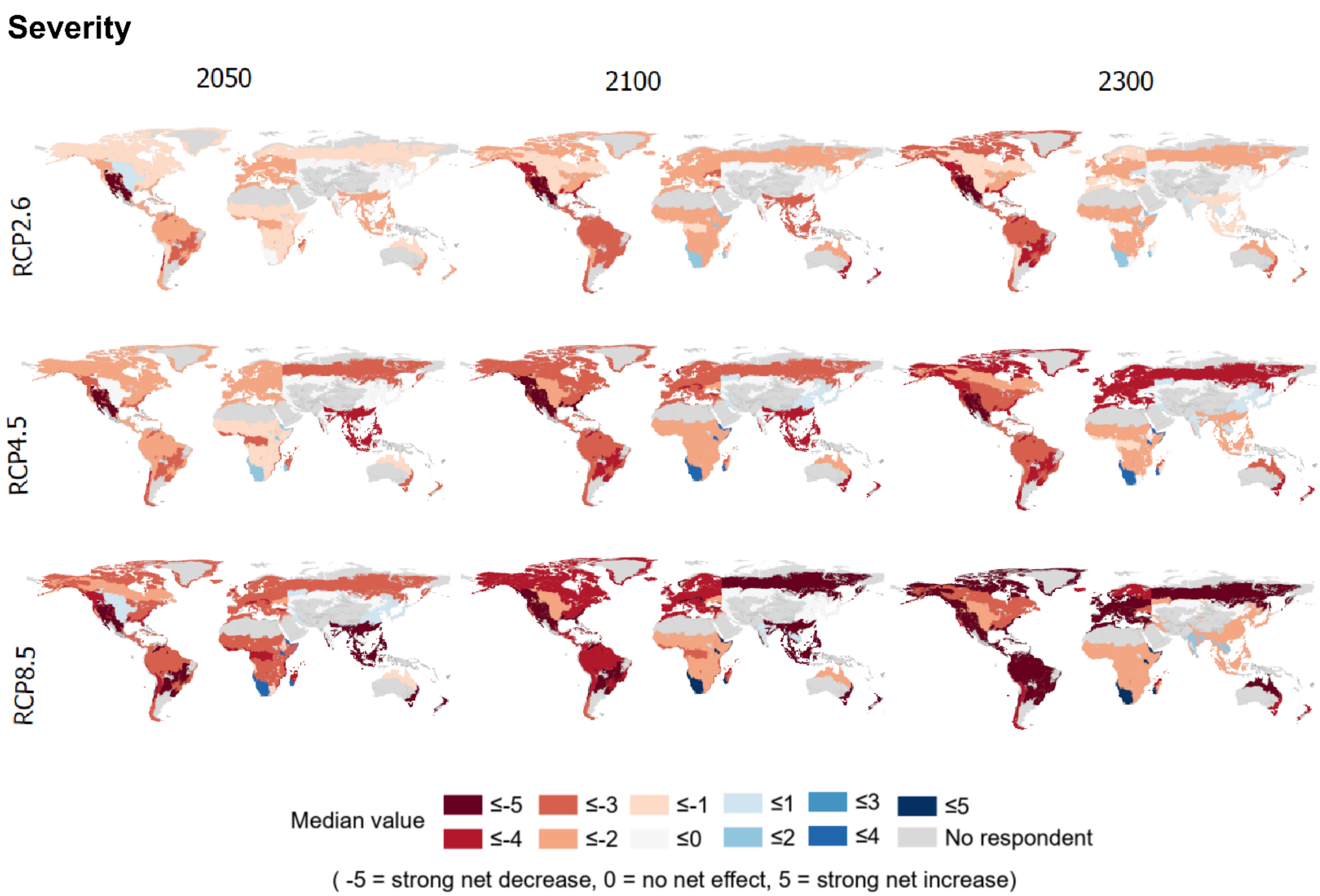
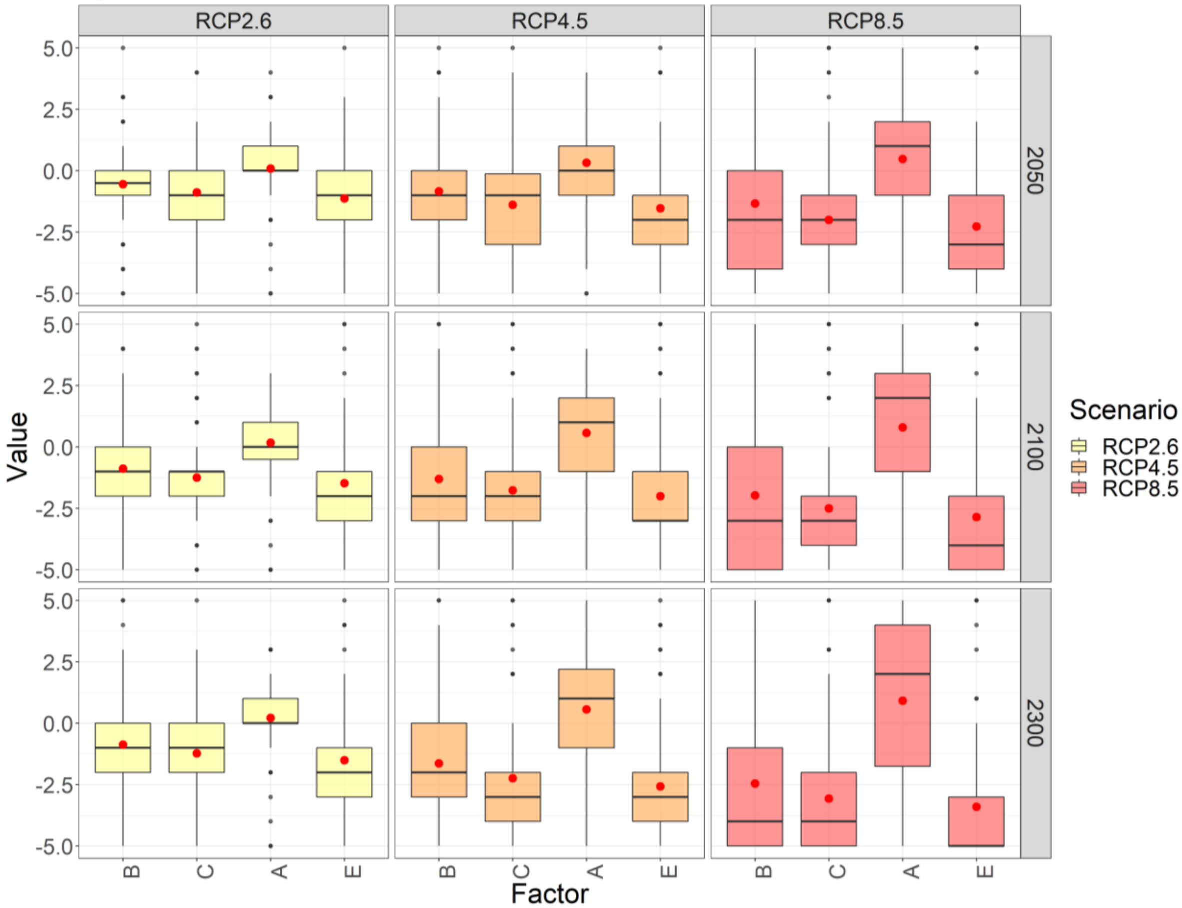


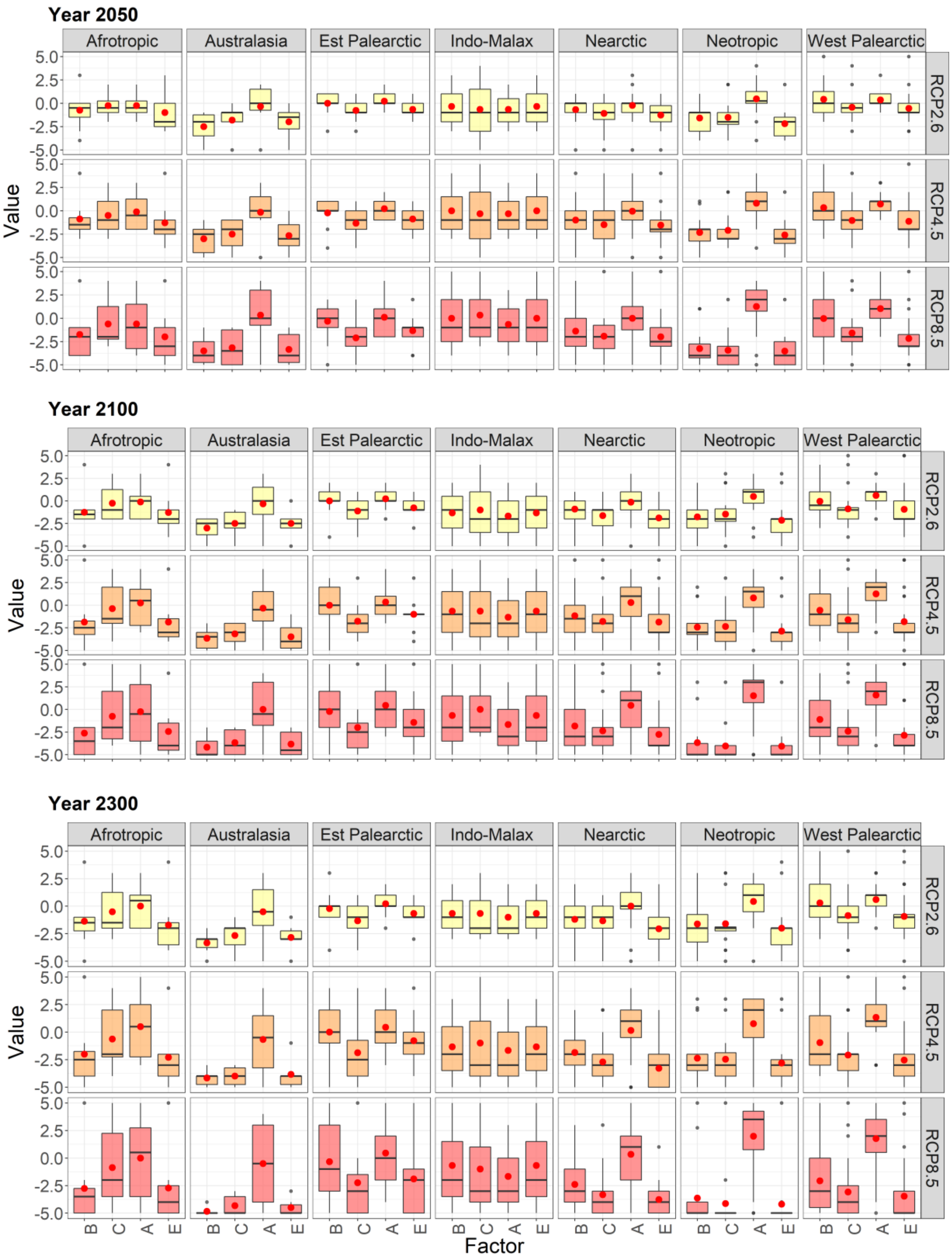
Fig. S16 Fire severity change until 2050-2300 and three RCP scenarios. Map illustrates median values of estimates by respondents.

a) Global

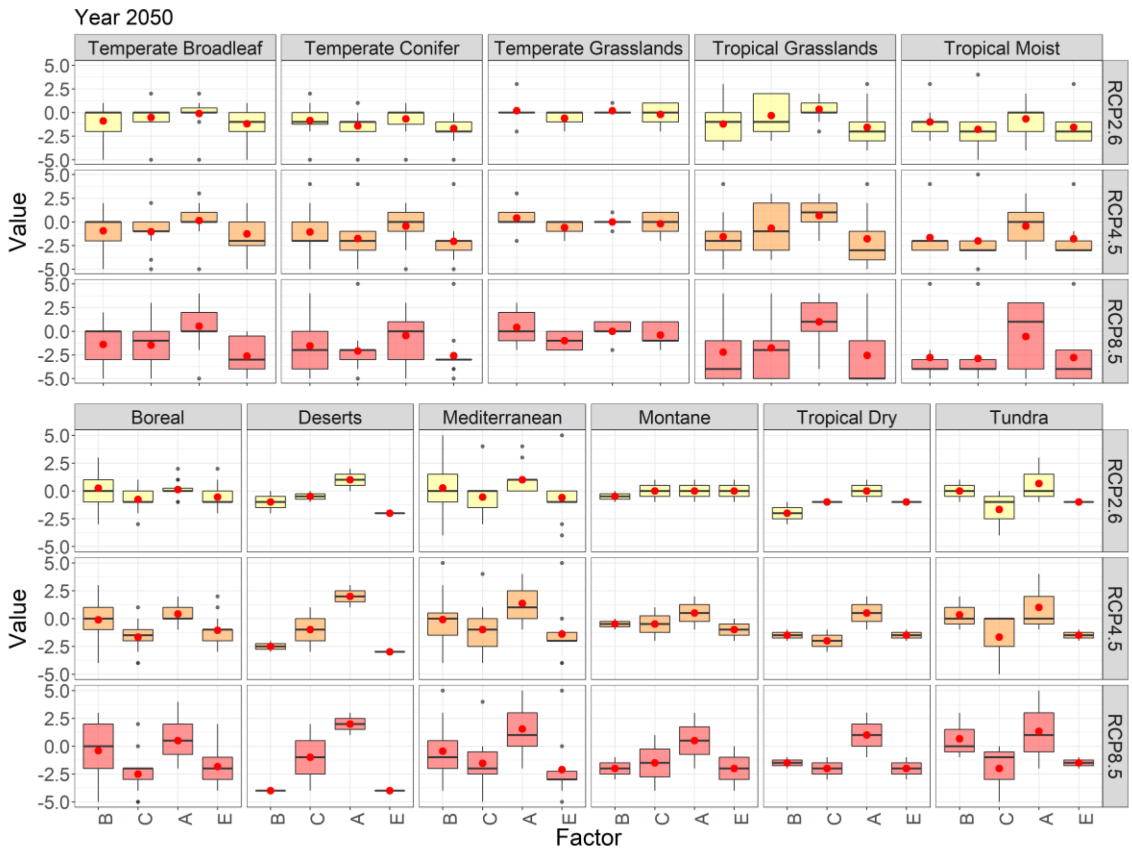


RCP2.6
RCP4.5
RCP8.5
5.0
2.5
0.0
-2.5
-5.0
2050
2100
2300
Value
Scenario
RCP2.6
RCP4.5
RCP8.5
B
C
A
E
Factor

b) Biogeographic realm

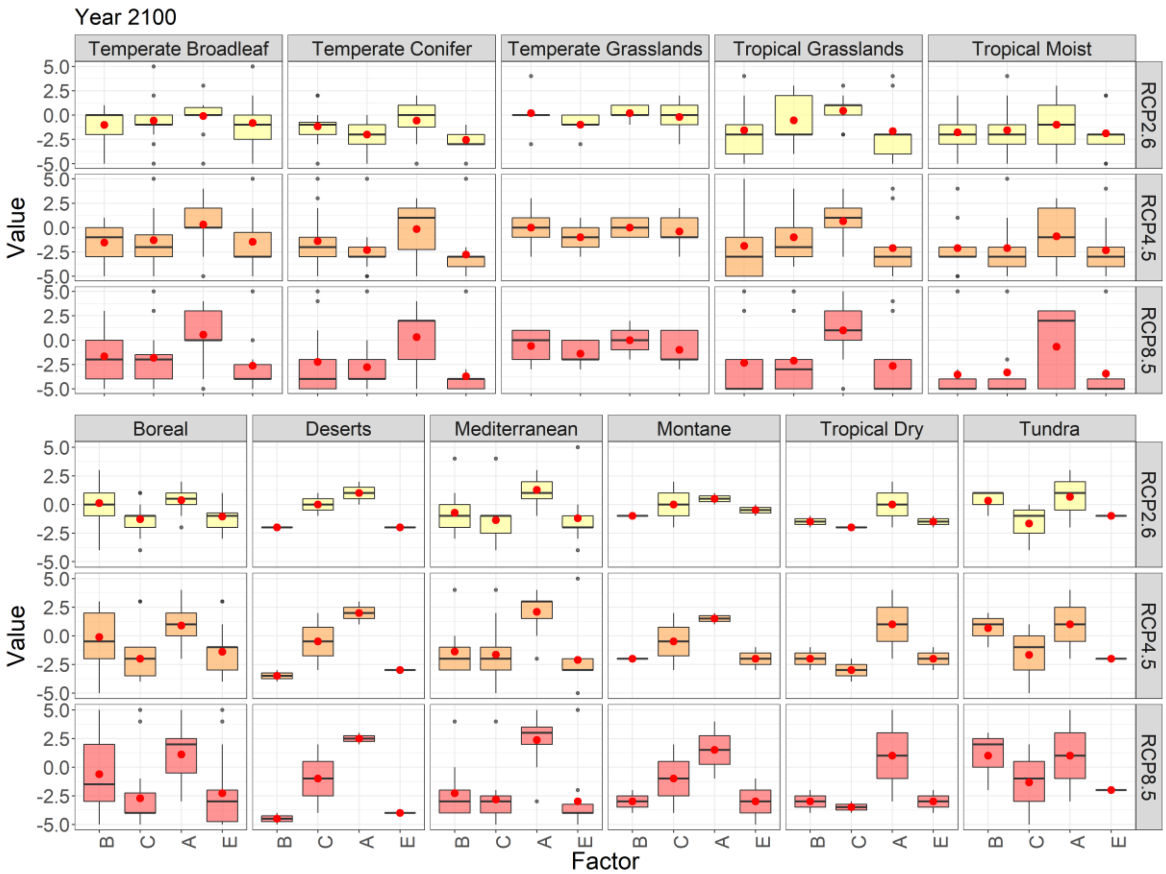


c) Biome



Year 2050
Temperate Broadleaf
Temperate Conifer
Temperate Grasslands
Tropical Grasslands
Tropical Moist
Boreal
Deserts
Mediterranean
Montane
Tropical Dry
Tundra
RCP2.6
RCP4.5
RCP8.5
Value
Factor
B
C
A
E
5.0
2.5
0.0
-2.5
-5.0

Biome


Year 2100
Temperate Broadleaf
Temperate Conifer
Temperate Grasslands
Tropical Grasslands
Tropical Moist
Boreal
Deserts
Mediterranean
Montane
Tropical Dry
Tundra
RCP2.6
RCP4.5
RCP8.5
Value
Factor
B
C
A
E
5.0
2.5
0.0
-2.5
-5.0

Biome

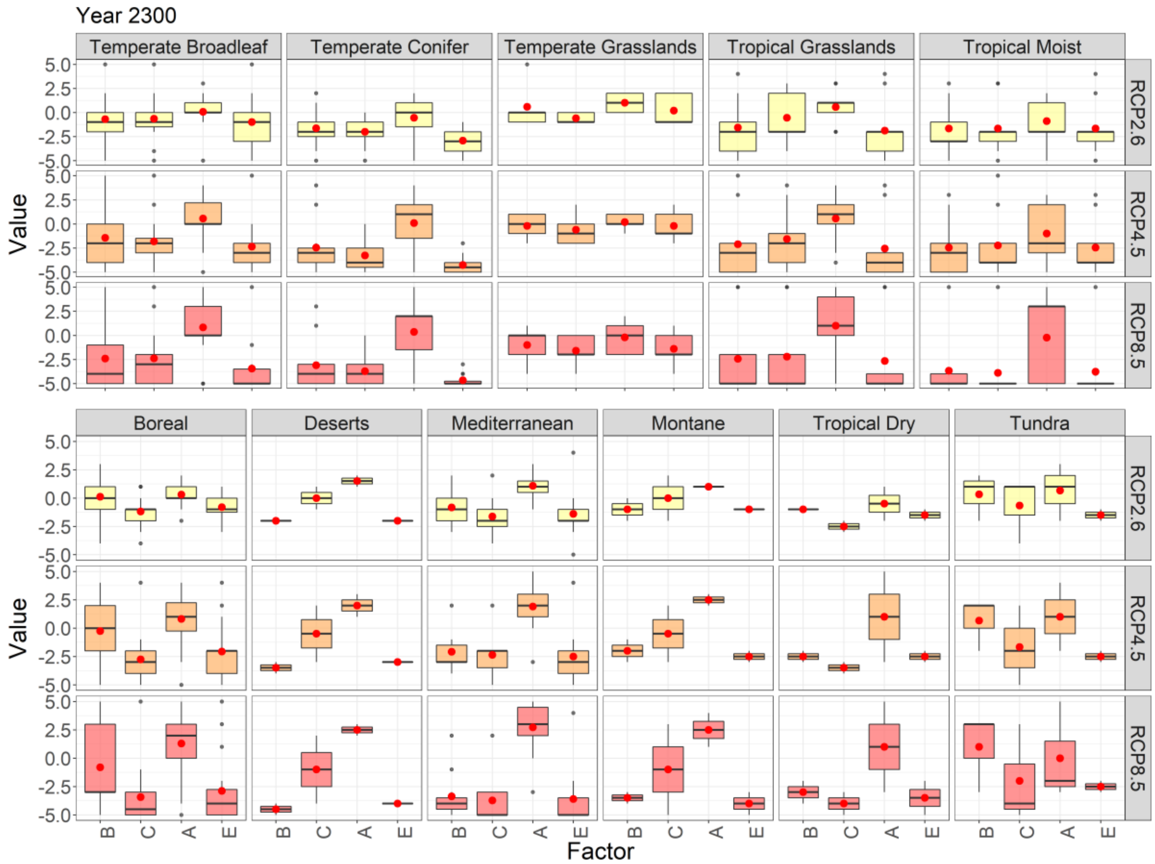


Fig. S17 Net change in biodiversity (B), carbon stocks (C), albedo (A), and ecosystem services (E) resulting from fire regime changes for the years 2050-2300 under RCP 2.6, RCP 4.5, and RCP 8.5. The boxplots illustrate the median (black line) and average (red dots) expert estimates of net change in various ecosystem values for the year 2100 across the three RCP scenarios. Values range from -5 (significant net decrease) to 0 (no net effect) to 5 (significant net increase).

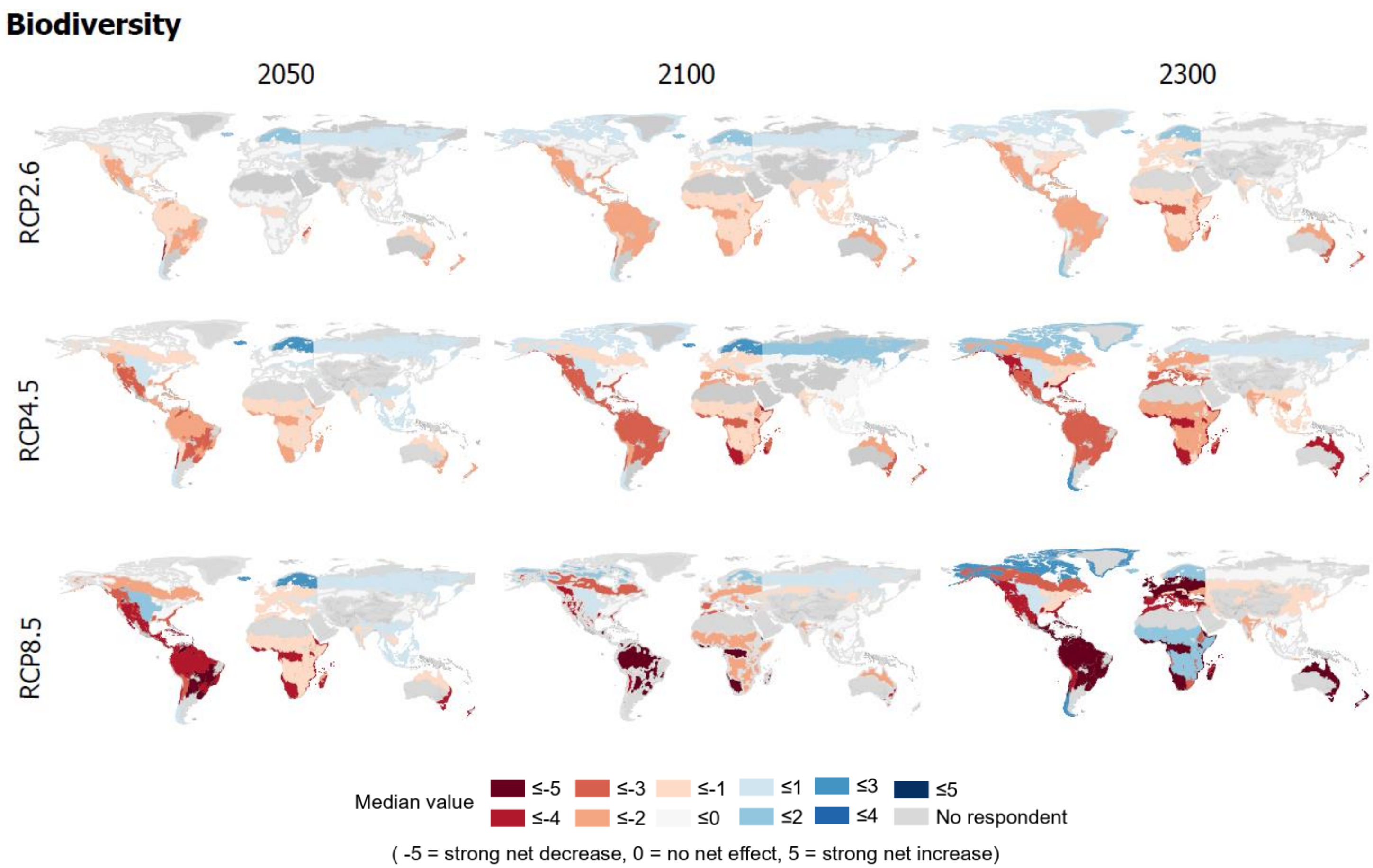


Fig. S18 Biodiversity change as a consequence of fire regime change until 2050-2300 and three RCP scenarios. Map illustrates median values of estimates by respondents.

Carbon Stocks

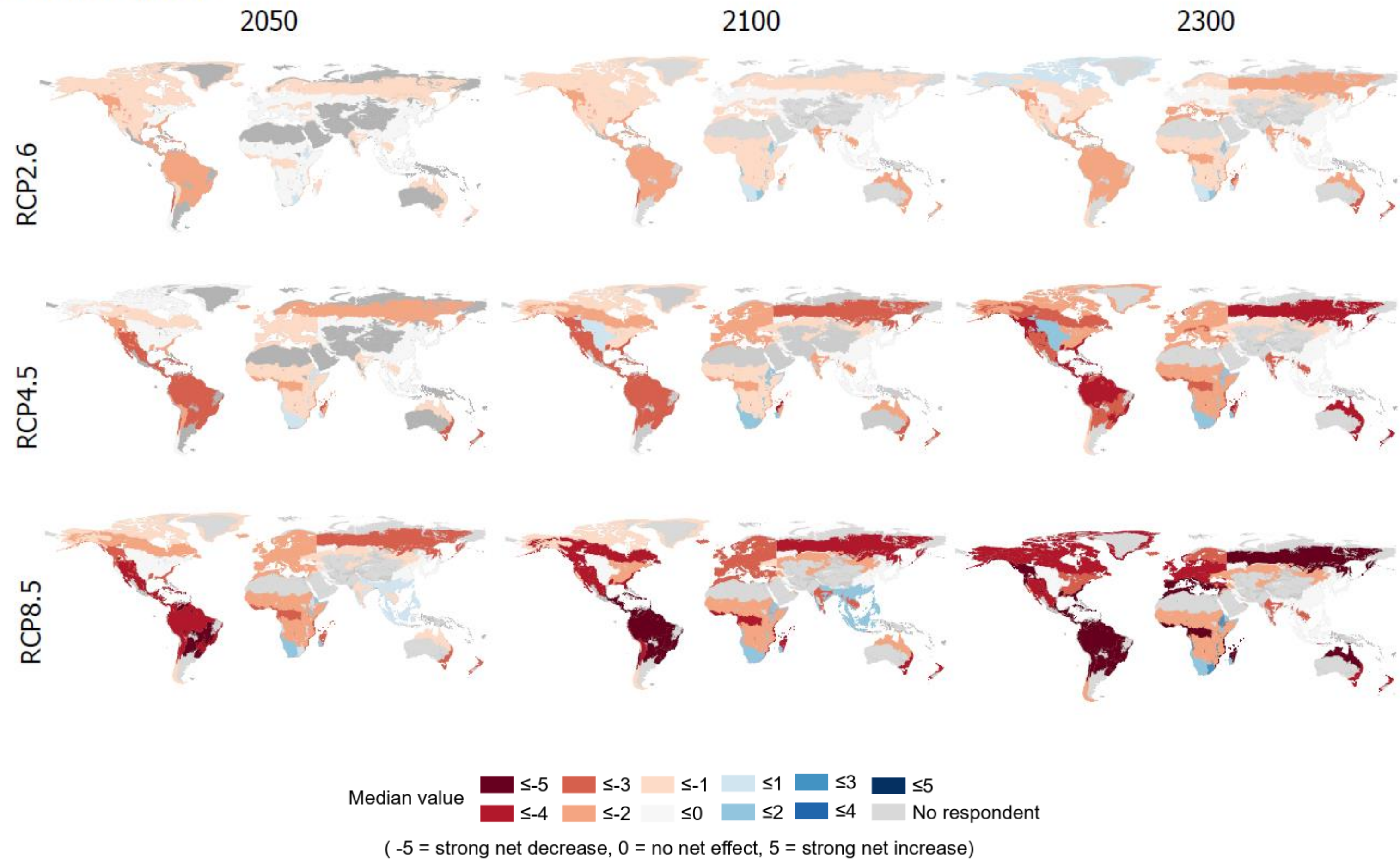


Fig. S19 Carbon stocks change as a consequence of fire regime change until 2050-2300 and three RCP scenarios. Map illustrates median values of estimates by respondents.

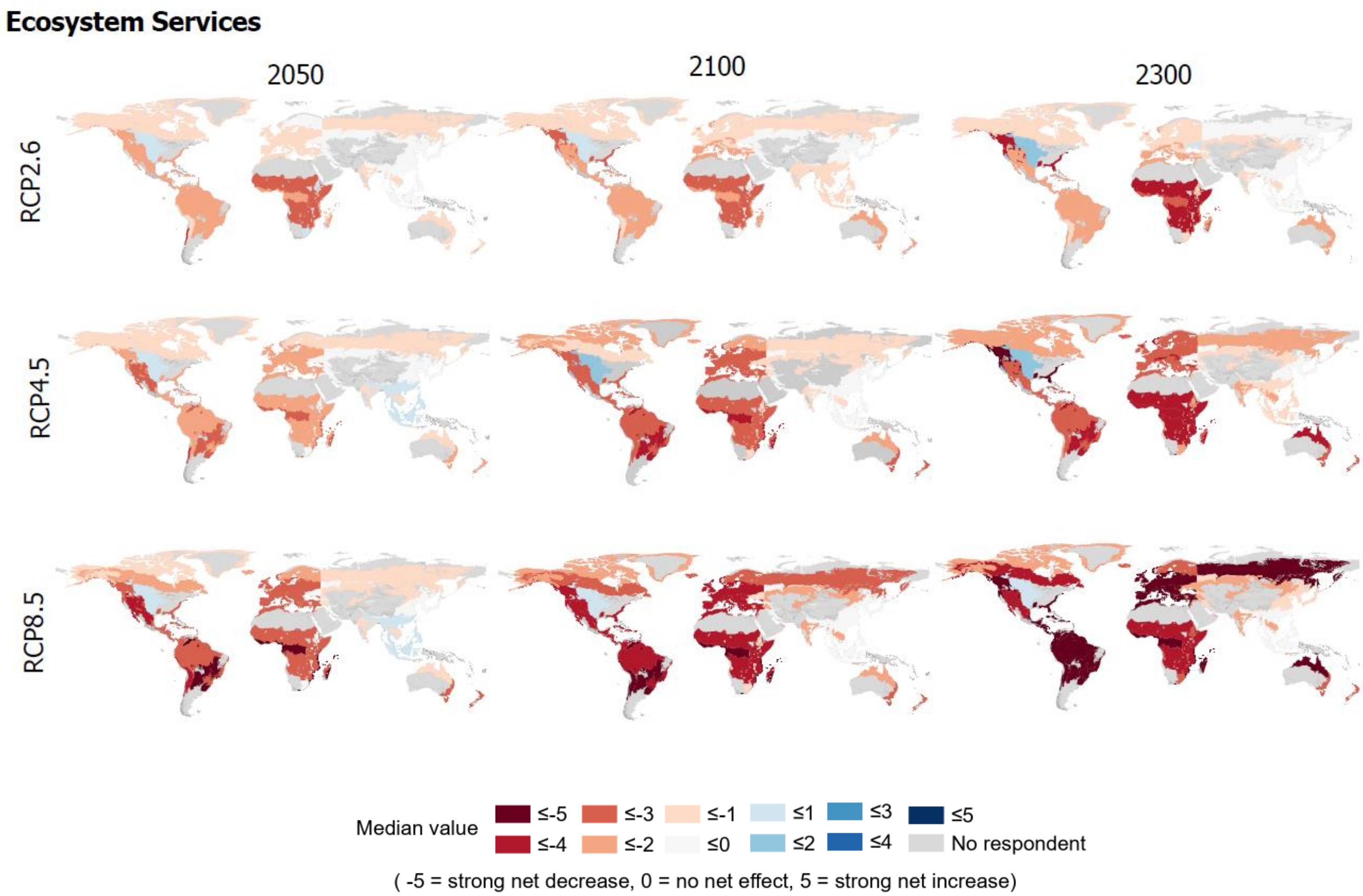


Fig. S20 Ecosystem services change as a consequence of fire regime change until 2050-2300 and three RCP scenarios. Map illustrates median values of estimates by respondents.

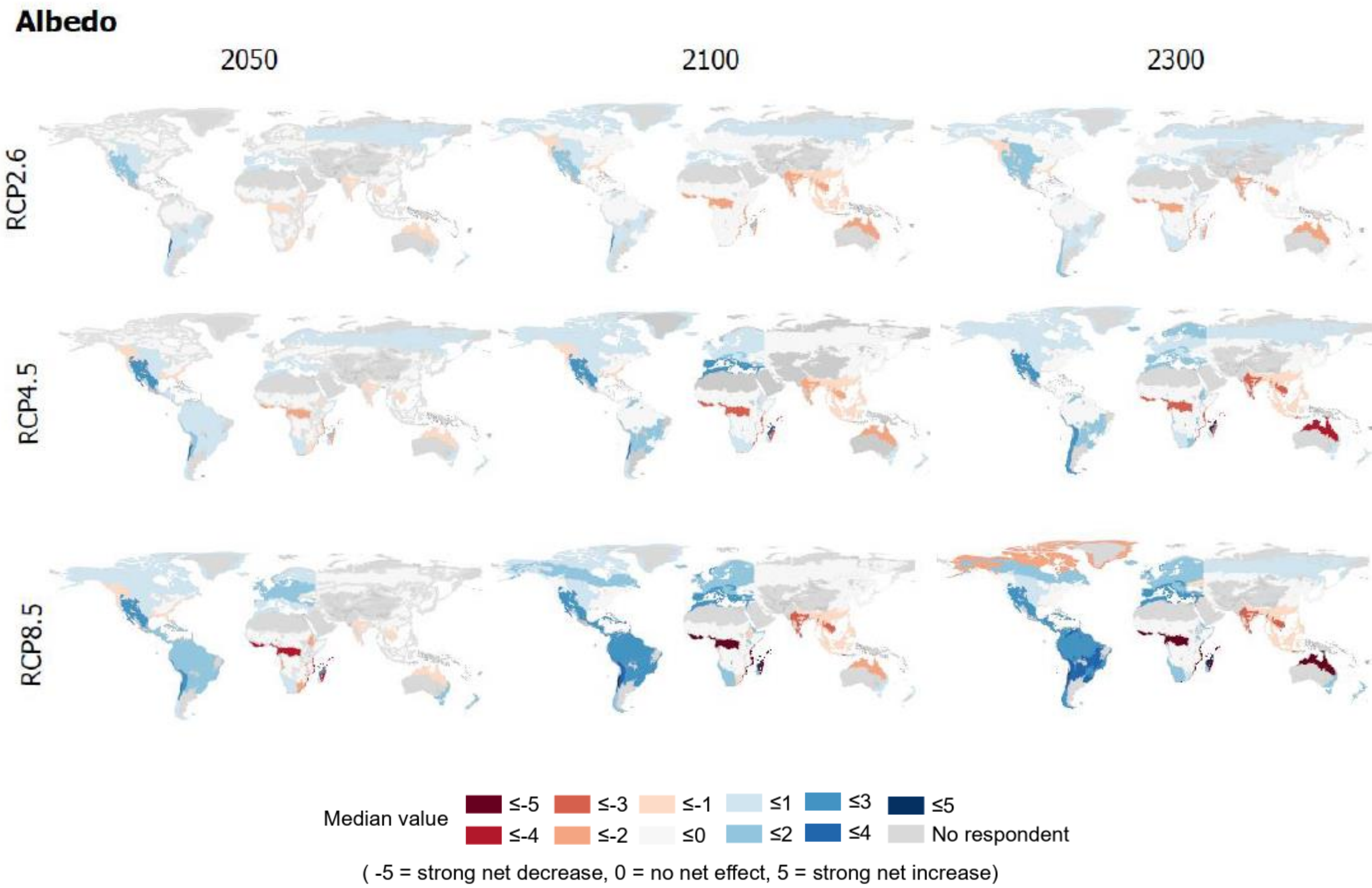


Fig. S21 Albedo change as a consequence of fire regime change until 2050-2300 and three RCP scenarios. Map illustrates median values of estimates by respondents.

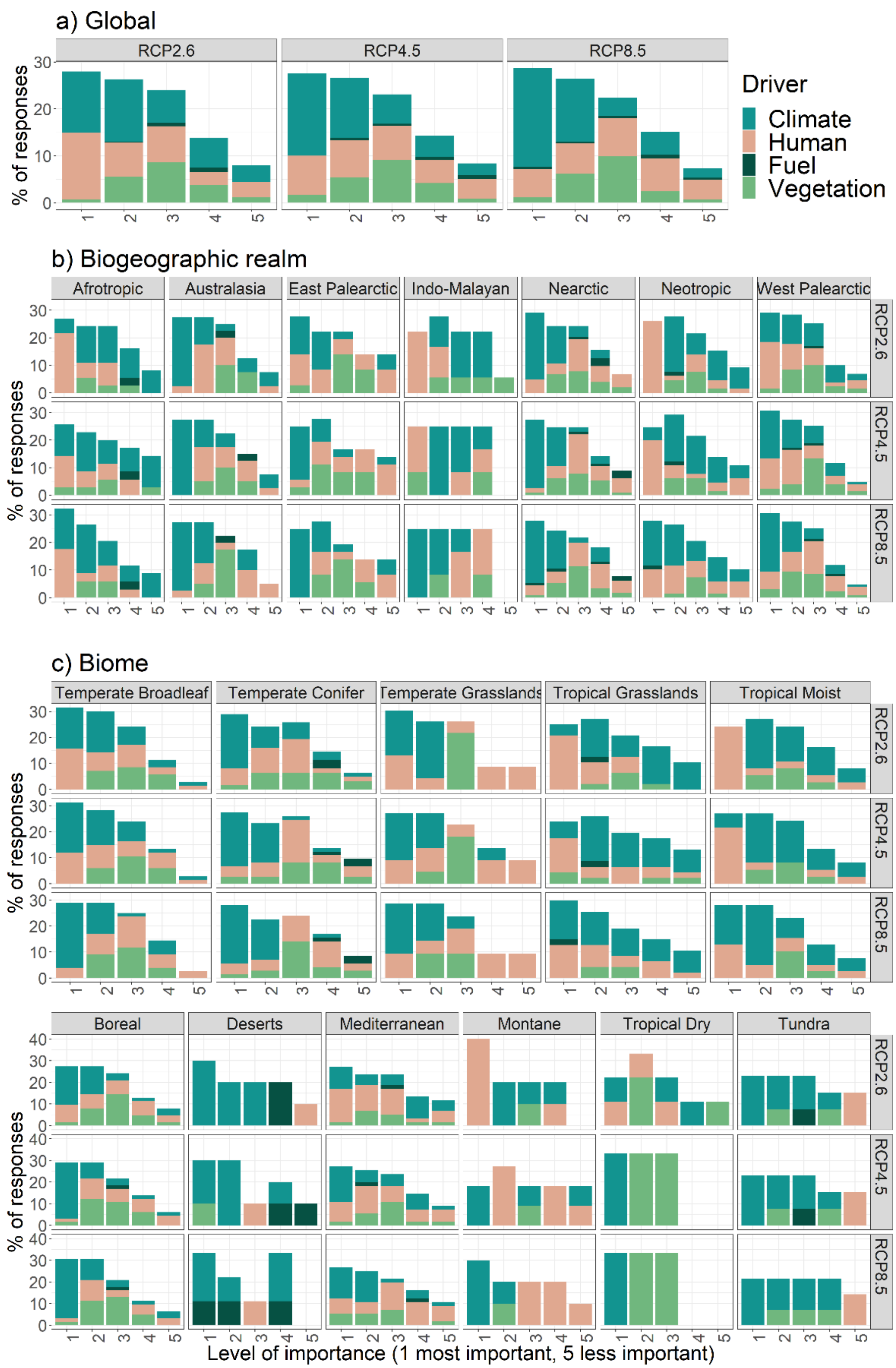


Fig. S22 Drivers of fire regime changes identified by respondents under three RCP scenarios by the year 2100 (ranked in order of importance).

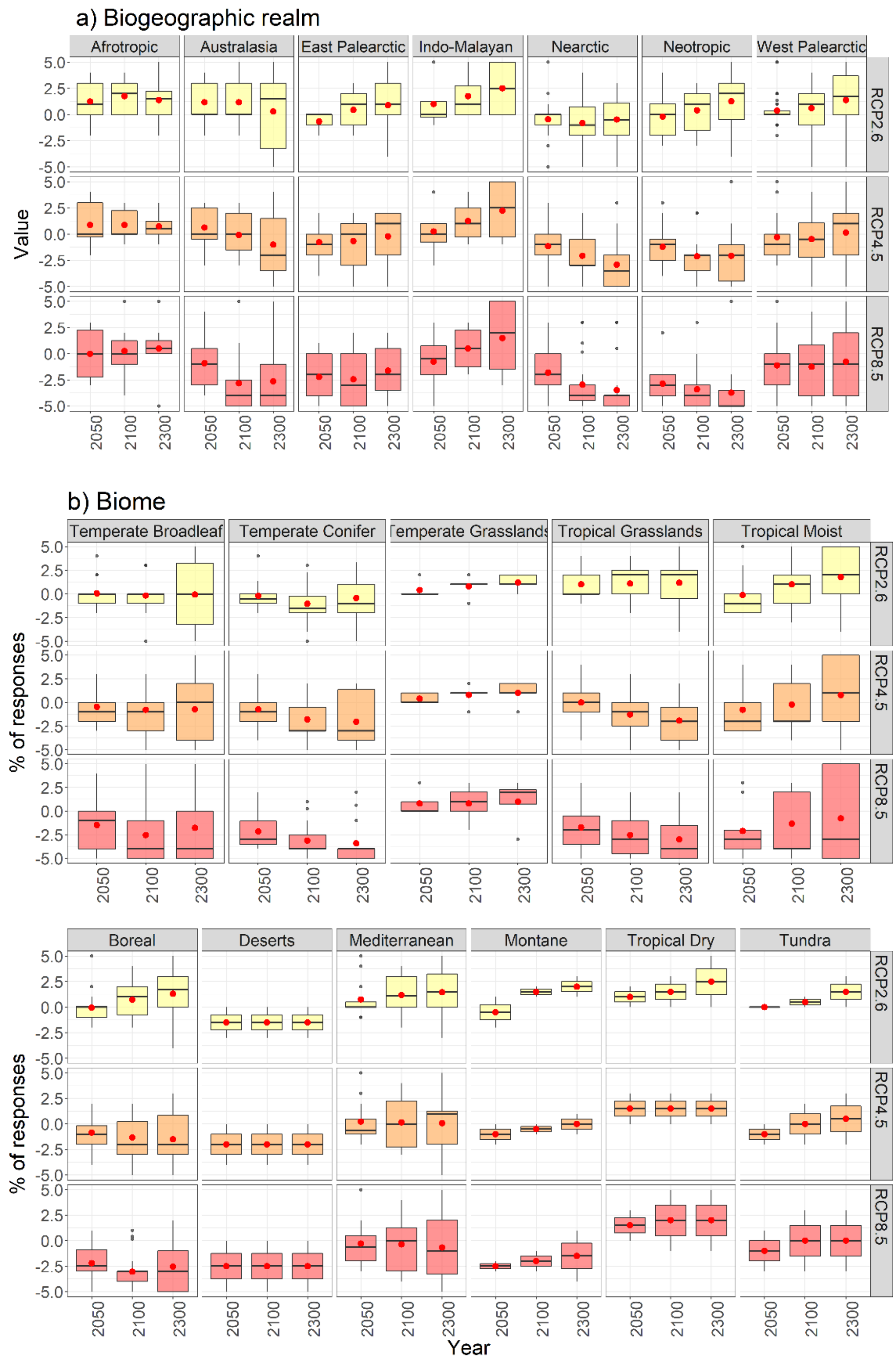


Fig. S23 Estimated effectiveness of human interventions (as identified in table S1) in mitigating potential damage to societies and ecosystems across the three RCP scenarios for the period 2050-2300, by respondents. Values range from -5 (significantly reduced capacity to control fire regime for this scenario and period), through 0 (same capacity as today), to 5 (much stronger capacity).

Table S1. Suggested management and intervention actions and their effects on different ecosystem services

Action	Description and examples	Biodiversity	Carbon St	Albedo	Eco Service
Fuel treatment (14%)	• Prescribed burning: Indigenous burning-controlled burning (10.2% of the responses)	3	2	0	3
	• Fuel management: Fuel removal by harvesting /cleansing; Fuel breaks and assisted migration/planting (3.2%)	2	1	0	2
Vegetation (23%)	• Forest-native vegetation restoration –Reducing exotic invasive Species-Reforestation/ Stop deforestation, etc. (17.5%)	3	3	3	3
	• Selecting nonflammable species – Plant more resilient trees, etc. (4.3%)	-2	1	0	1
Landscape (7%)	• E.g. Enhancing heterogeneous landscapes- Creating fire-resilient landscapes by reducing the spatial extent and continuity of forests and tall shrublands (5%)	3	2	2	3
	• Limiting wildland urban interface (2%)	3	1.5	0	2
Improved Agriculture and sustainability (5%)	• E.g. Reduction in area of cropland in marginal areas-stop using fire in agriculture practices– Better prevention of agricultural fire expanding into the forested area, Promoting agroforestry systems, etc. (5%)	3	3	2	3
Direct fire response (17%)	• Fire suppression (11%)	-1	1	0	1
	• Fire management: E.g. Increased firefighting capability and deployment for forest fires (5%)	2	1	0	2

	● Climate change mitigation (5%)	4	5	3	4.5
Social - infrastructure intervention (23%)	● Policy: E.g. Promoting conservation policy-Incorporate indigenous knowledge and practices– Regulating economic activities – Preventing human ignition – Monitoring Long-term and real-time (early detection) – water and waste management (13%)	3	3	1	3
	● Education (4%)	2	2	0	4
Non - Intervention (11%)	● Non Intervention (11%)	0	-1	0	-2

The percentages in the parenthesis indicate the proportion of responses identifying a management action (responses were categorized based on similarities).
The numbers beneath different ecosystem factors (e.g. biodiversity) represent the median values of estimates provided by respondents for each subcategory.

Table S2. Composition and characteristics of expert respondents

Survey Section	Paleo perspective	Current fire regime state	Future fire projection	Intervention and management
Response per Biogeographic realm				
Afrotropic	9	9	8	8
Australasia	15	11	10	11
East Palearctic	9	10	8	9
Indo-Malyan	4	3	4	3
Nearctic	31	24	24	22
Neotropic	16	16	16	16
West Palearctic	37	31	30	28
Average modeling/field self-rating[a]	2.36	2.36	2.38	2.32
Combined years of experience	1230	1176	1124	1003
Average years of experience	10	11	11	10
Ratio male: female	47:43	44:41	43:36	41:32

[a]1 was defined as exclusively field research and 5 as exclusively modeling research.

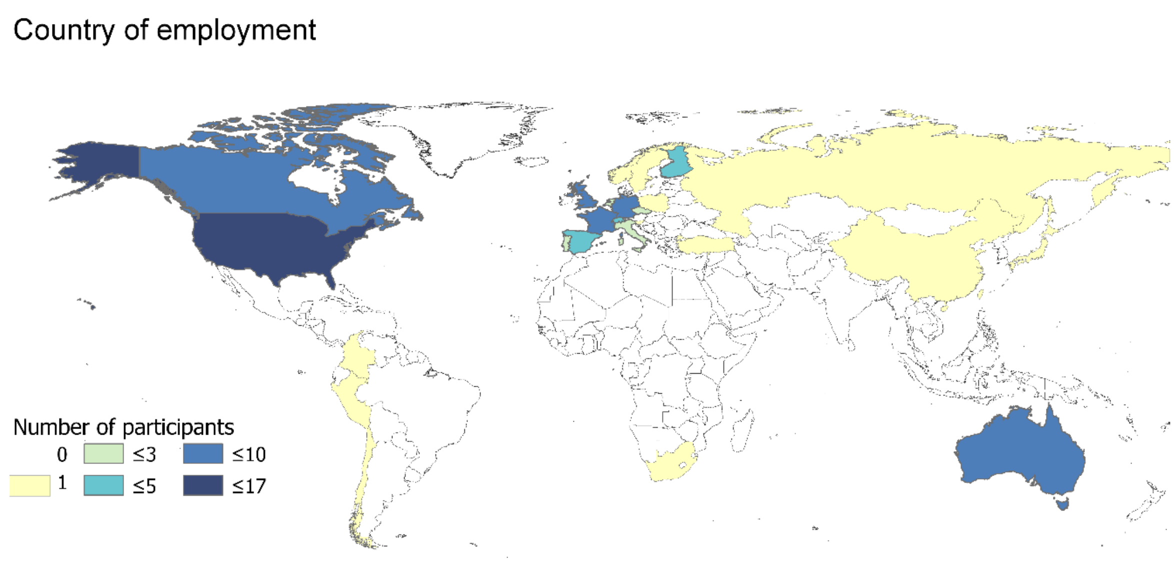


Fig. S24 Respondent's country of employment

Table S3. Mean self-reported confidence and expertise level for each section

Section	Mean expertise level	Mean confidence level	Estimates generate base
Paleo perspective	3.7	3.5	Published empirical data: 101 Published model estimates:31 Unpublished data:51 Professional opinion:68
Current fire regimes	2.8	2.7	Published empirical data:84 Published model estimates:32 Unpublished data:16 Professional opinion:69
Future projections	2.5	2.3	Published empirical data:50 Published model estimates:52 Unpublished data:18 Professional opinion:83
Management and intervention	2.4	2.3	Published empirical data:37 Published model estimates:22 Unpublished data:14 Professional opinion:71

The five-point "**Confidence level**" scale is defined as follows:

1 = My answer is my best guess, but I am not confident in it; it could easily be far off the mark.
2 = My answer is an educated guess; it could be far off the mark, but I have some confidence in it.
3 = I am moderately confident in my answer; it is not precise, but it may be near the true value.
4 = I am confident in my answer; the true value is likely to be somewhat different from my answer, but it is unlikely to be dramatically different.
5 = Given current understanding, I would be surprised if my answer were far off from the true value.

The five-point "**Expertise level**" scale is defined as follows:

1 = I have little familiarity with the literature, and I do not actively work on this area.
2 = I have some familiarity with the literature, and I've worked on related questions but haven't contributed to the literature on this issue; it is not an area of central expertise for me.
3 = I have worked on related issues and have contributed to the relevant literature but do not consider myself an expert on this issue.
4 = I am very familiar with relevant literature and have worked on related questions. This is an area of central expertise for me.
5 = I contribute actively to the literature directly concerned with this issue, and I consider myself one of the foremost experts on it.

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[4]Institute of Plant Sciences and Oeschger Centre for Climate Change Research, University of Bern, Bern, Switzerland
[5]Aix Marseille Univ, Avignon Univ, CNRS, IRD, IMBE, Aix-en-Provence, France
[6]Centre for Quaternary Research (CQR), Department of Geography, Royal Holloway University of London (RHUL), Egham, Surrey, UK
[7]Deptartment of Ecology, Philipps-Marburg University, Marburg, Germany
[8]Department of Past Landscape Dynamics Laboratory, Institute of Geography and Spatial Organization, Polish Academy of Sciences, Warsaw, Poland
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Questionnaire

Global assessment of abrupt change in fire regimes

A project from the International Paleofire Network (previously the Global Paleofire Working Group of Future Earth's Past Global Changes—PAGES—project)

Contents

1. Introduction

You have been identified as a fire expert by our analysis of the literature, and we invite you to participate in this expert assessment project. Our goal is to document scientific opinion on changes in fire regimes and their effects on ecosystems, climate, and societies. We are focusing on centennial to millennial changes in past, present, and future fire regimes by region and biome. Because responding to the 15 questions below will likely take between 5 to 10 hours, all participants will have an opportunity to be co-authors on the resulting manuscript, which we will submit to Nature Geoscience in the fall of 2020. Previous expert assessments have been highly successful at combining available information and identifying knowledge gaps (Abbott et al. 2016; Schuur et al. 2011, 2013). Additionally, these efforts have repeatedly led to longer-term collaborations and new research activities (Bamber and Aspinall 2013; Morgan 2014).

We recognize that climate- and human-caused fire feedbacks in complex Earth systems are not, and cannot be, precisely and definitively modeled. As such, we are only asking for your informed opinion, realizing that some of the included parameters are not well understood. Possible thresholds and tipping points in the relationship between climate, land cover, land use changes, ecosystem structure, and fire regime are of particular interest, because such nonlinearity is difficult to predict with models. Combining assessments from multiple scientists with applicable and diverse expertise will allow an integrative evaluation of the range of possible futures, providing a valuable complement to projections from numerical models. We hope sincerely that you will participate if you are able.

2. Definitions of fire regime & state change

Fire regime

While the term "fire regime" has multiple meanings in different fields, for the purposes of this survey we define fire regime in terms of spatial and temporal fire behavior (e.g. Hély et al. 2019; Keeley 2009; Whelan 1995). Spatial components of fire regime include the type of fire (e.g. heat and height) and its extent. Temporal components of fire regime include fire frequency, cycle, and seasonal timing. These variables interact to determine the effect of fire on ecosystem functioning and structure. For reference, we provide a short definition of common **aspects of fire regime** as described in the literature:

Frequency: Number of fires per unit of time in a defined area.
Interval: Time between two fire events in a defined area. In paleofire reconstructions, the interval is the time between two detectable fire episodes, given limitations in temporal resolution and sensitivity of fire proxies.
Seasonality: Timing of fire in relation to seasonal cycles (e.g. growing, dry, and rainy).
Extent: Spatial size of burned area.
Cycle: Time in years for cumulated fire area to equal 100% of the area of interest.
Type: Vegetation layer most impacted by flames and heat (e.g. ground, surface, understory, crown).
Intensity: Amount of heat released over time per area.
Severity: Degree of alteration of vegetation and soil (e.g. mortality %, organic matter combustion %, depth burned).

State Change

For the purposes of this survey, we define "state change" broadly as a large and sustained departure from a system behavior. State changes can be triggered by smooth or abrupt external or internal drivers (e.g. climate change, disturbances), and can be reversible or permanent. A state change in fire regime can be a shift in central tendency (e.g. significant decrease in mean annual area burned), overall variance (e.g. significant increase in interannual variability of area burned), or frequency of events that exceed some ecologically-relevant threshold (e.g. significant change in the return interval of crown fires). The defining characteristic of **a state change is not the abruptness of the shift, but the magnitude of change in regard to functioning of the system** (Biggs et al. 2009; Scheffer et al. 2001, 2009). Some examples of state changes related to fire:

- In the same climatic conditions, either tropical forest or savanna may develop, depending on feedbacks between vegetation and fire (Staver et al. 2011). A state change in the fire regime can trigger transition from savanna to forest in the case of fire suppression, or forest to savanna in the case of more frequent or severe fire.

- Broadleaf and coniferous trees in the boreal forest are associated with different fire regimes, due to differences in inherent and seasonal flammability. Long-term changes in vegetation have caused multiple state changes in fire due to the interaction of climatological and ecological factors (e.g. Girardin et al. 2013; Higuera et al. 2009; Jasinski and Payette, 2005).
- The transition from temperate woodlands to grasslands is driven by fire regime (Pausas 2015) , which has experienced multiple state changes due to intentional and unintentional human management (Valkó et al. 2016).

Visual examples of state change in fire regimes:

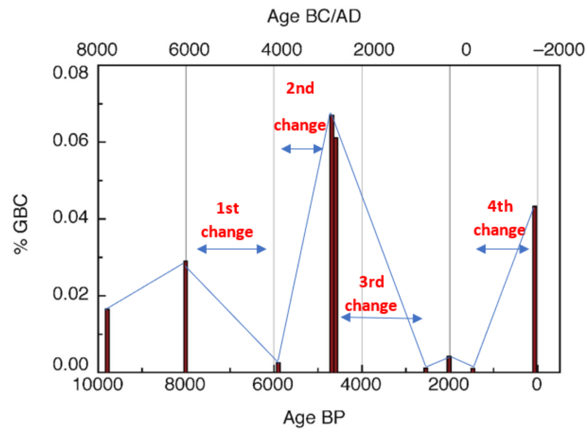

Figure 1| Adapted from (Anderson and Wahl, 2016). Graphite Black Carbon (GBC) percent vs. time at Lago Paixban, Guatemala.

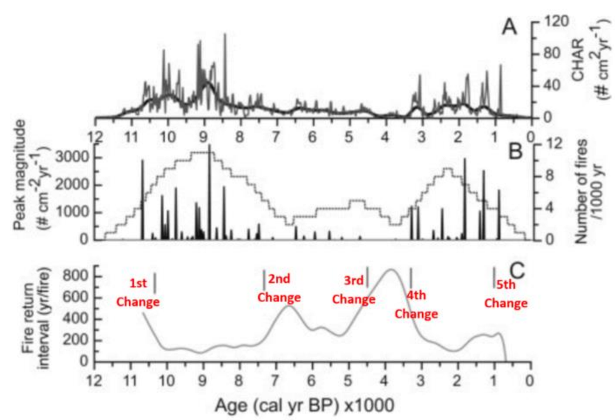

Figure 2| Changes in charcoal and fire frequency and magnitude from (Feurdean et al., 2013). "**A)** Interpolated macroscopic charcoal accumulation rate (CHAR; grey curve) and background CHAR (black curve); **B)** inferred number of fires/1000 years (grey dashed curve) and peak magnitude (vertical lines), and **C)** inferred fire return interval/1000 years. Vertical grey lines denote statistically significant zones."

3- Questionnaire instructions

You will be asked to provide estimates about past and current fire regime, possible response of fire regime to different climate scenarios, and then conclude with your opinion about fire management. For the purposes of this expert assessment, we are asking for regional estimates, and have partitioned the globe into nine continental regions and 14 eco-regions or biomes (Olson et al. 2001) that reflect bioclimatic, socioeconomic, and fire regime characteristics **(Figure 7)**. We recognize that this partitioning is imperfect and may group multiple conflicting fire regimes. Given the large spatial and temporal scales of interest, please consider the overall response of the region and biome.

For the fire projection section of the questionnaire (section 5.3), we ask for estimates for three warming scenarios (RCP2.6, RCP4.5 and RCP8.5) from the IPCC *AR5 Synthesis Report*, **Figures 3 - 6**). We will ask for estimates over short (Present-2050), medium (Present-2100), and long (Present-2300) time frames. Climate projections and estimates of system response become increasingly uncertain for distant time frames. However, because fire regime can take many decades or centuries to fully respond to disturbance, we have included the 2300-timestep to account for lags in this response. You may think of this third timestep conceptually, e.g. the eventual fire regime/ecosystem state if the described climate conditions persisted.

For each fire region you choose, you will have a chance to indicate your level of confidence and expertise concerning your answer, make comments on how you selected your estimates, and identify key sources of uncertainty concerning the future response of the system (e.g. what data or processes missing from current understanding would most improve our ability to predict system behavior). If there is not yet clear supporting evidence in the literature, but you have some basis for an estimate based on professional judgment, please make a note of that. These supporting questions allow us to compare responses from multiple experts and are just as valuable as your quantitative estimates.

Confidence level

The five-point "**Confidence level**" scale is defined as follows:

- **1 =** My answer is my best guess, but I am not confident in it; it could easily be far off the mark.
- **2 =** My answer is an educated guess; it could be far off the mark, but I have some confidence in it.
- **3 =** I am moderately confident in my answer; it is not precise, but it may be near the true value.
- **4 =** I am confident in my answer; the true value is likely to be somewhat different from my answer, but it is unlikely to be dramatically different.
- **5 =** Given current understanding, I would be surprised if my answer were far off from the true value.

Expertise level

The five-point "**Expertise level**" scale is defined as follows:

- **1 =** I have little familiarity with the literature, and I do not actively work on this area.
- **2 =** I have some familiarity with the literature, and I've worked on related questions but haven't contributed to the literature on this issue; it is not an area of central expertise for me.
- **3 =** I have worked on related issues and have contributed to the relevant literature but do not consider myself an expert on this issue.
- **4 =** I am very familiar with relevant literature and have worked on related questions. This is an area of central expertise for me.
- **5 =** I contribute actively to the literature directly concerned with this issue, and I consider myself one of the foremost experts on it.

4- Climate and disturbance scenarios

This section provides background information on the climate change scenarios and land use changes referenced in the "Fire projections" section of the questionnaire. There is a large body of literature on the scenarios (e.g. *IPCC*), which you are encouraged to draw on as needed for your region. Though the scenarios are largely defined by changes in temperature and precipitation, we encourage you to consider all climatic, ecological, and societal changes for the scenarios that could influence fire regime.

Table.1 RCP scenarios. From (Moss et al. 2010)

Scenario	Radiative forcing	CO_2-equiv (ppm) concentration	Pathway
RCP8.5	>8.5Wm^{-2} in 2100	>1370 in 2100	Rising
RCP4.5	~4.5Wm^{-2} at stabilization after 2100	~650 at stabilization after 2100	Stabilization without overshoot
RCP2.6	Peak at ~3Wm^{-2} before 2100 and then declines	490 before 2100 and then declines	Peak and decline

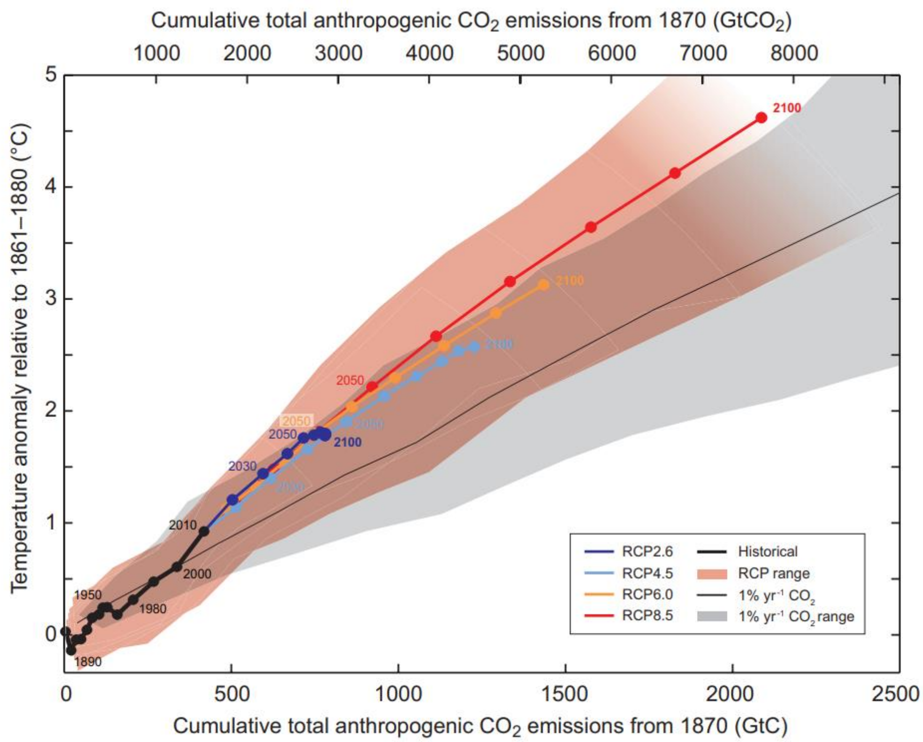

Fig. 3 Global mean surface temperature change compare to pre-industrial time (1861-1880) using different RCP scenarios. Each scenario is showed with a colored line and decadal mean(dots). From IPCC WG1AR5_Summary for policy makers, figure SPM10, page 28.

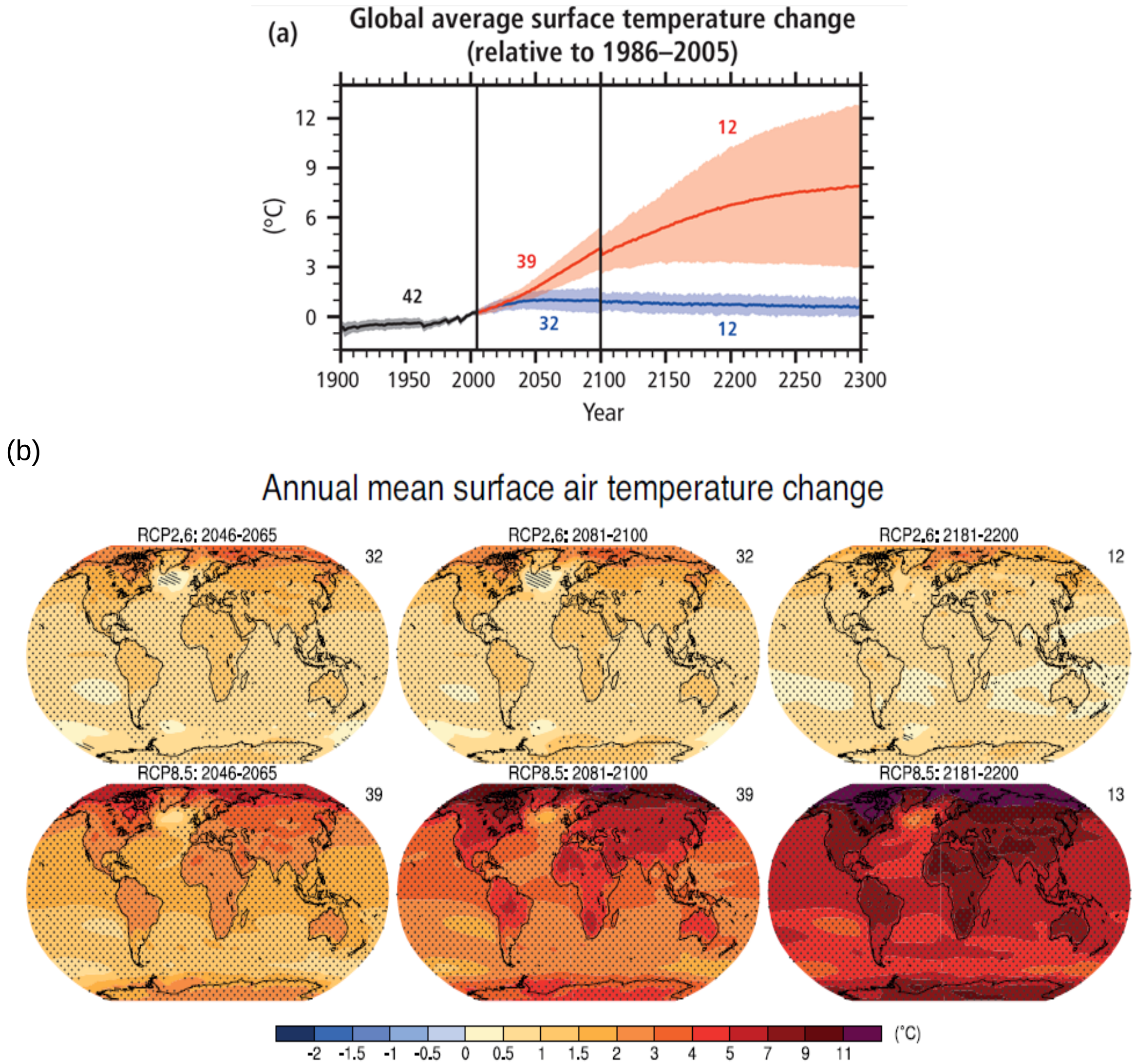

Fig. 4 Time series of global annual change in mean annual surface temperature for the 1900–2300 period (relative to 1986–2005) from Coupled Model Intercomparison Project Phase 5 (CMIP5). **(a)** Time series of projections and a measure of uncertainty (shading) are shown for scenarios RCP2.6 (blue) and RCP8.5 (red). The number of CMIP5 models used to calculate the multi-model mean is indicated. Projections are shown for the multi-model mean (solid lines) and the 5 to 95% range across the distribution of individual models (shading). Discontinuities at 2100 are due to different numbers of models performing the extension runs beyond the 21st century and have no physical meaning. Modified from IPCC AR5 Synthesis report, figure 2.1, page 59 **(b)** Projected change in average surface temperature for 2081–2100 and 2181-2200 relative to 1986-2005 under the RCP2.6 (top) and RCP8.5 (bottom) scenarios based on multi-model mean projections. Stippling (i.e. dots) shows regions where the projected change is large compared to natural internal variability, and where at least 90% of models agree on the sign of change. Hatching (i.e. diagonal lines) shows regions where the projected change is less than one standard deviation of the natural internal variability. Figures modified from IPCC WG1AR5 chapter 12 ,figure 12.11, page 1063. For detail on the scenarios and additional visualizations, visit: https://ar5-syr.ipcc.ch/topic_futurechanges.php

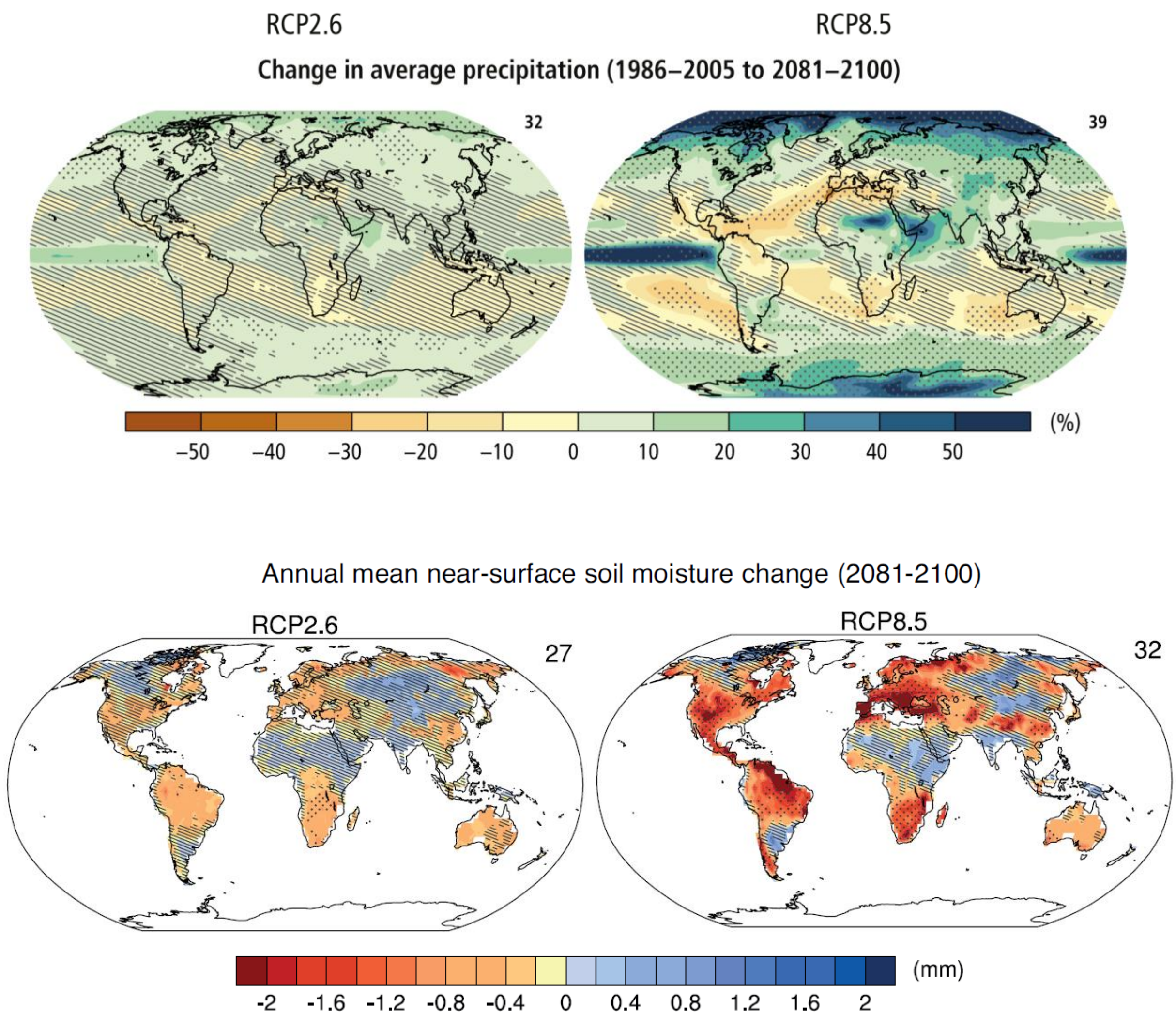

Fig. 5 Projected change in **(a)** annual mean precipitation Modified from IPCC AR5 Synthesis report, figure 2.2, page 61 and **(b)** annual mean soil moisture in the top 10 cm for 2081-2100 (relative to 1986–2005) for RCP2.6 and RCP8.5. Modified from the IPCC WG1AR5 chapter 12 ,figure 12.23, page 1080. For detailed projections, including seasonal temperature and precipitation trends, relative humidity, temperature return intervals, and more visit: http://www.climatechange2013.org/images/report/WG1AR5_Chapter12_FINAL.pdf

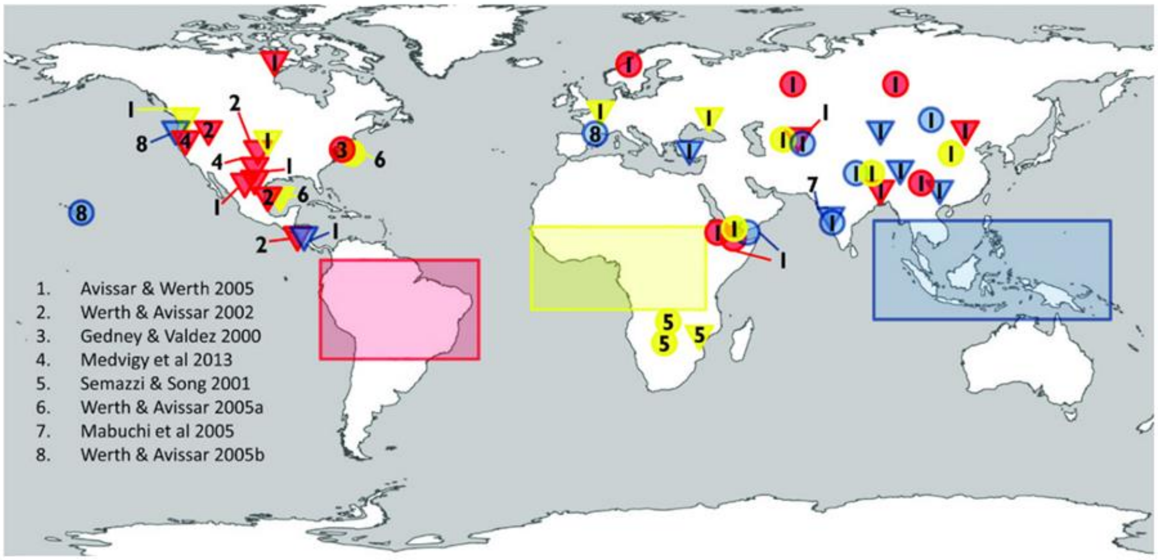

Fig. 6 An example of links between land-use/direct human disturbance and ecological conditions that could influence fire regime. Extra-tropical effects on precipitation due to deforestation in each of the three major tropical regions. The circles indicate increasing and the triangles indicate decreasing of precipitation as a result of deforestation of the three areas shown with boxes in the figure, including: Red(Amazonia); Yellow(Africa); Blue (Southeast Asia) reviewed by (Lawrence & Vandecar, 2015). From IPCC Climate change and Land_Chapter 2, figure 2.23, page 185.

5- Questionnaire

Respondent background information	
First and Last Name	
Gender	
Primary research discipline	
Secondary research discipline	
Rate yourself on a scale of 1 to 5 where 1 is exclusively field research and 5 is exclusively modeling research.	
Country of origin	
Country of employment	
Years of experience in fire research	

5.1 Selecting region

Please fill out the questionnaire for each region and biome combination (hereafter "fire region") for which you are qualified. If you are qualified to answer for multiple fire regions, please copy the questionnaire from this point on and paste it at the bottom of the document as many times as needed.

Region name (9 options listed in Fig. 7, e.g. Afrotropic, Australasia, Est Palearctic, Neotropic, etc.)	
Biome name (15 options listed in Fig. 7, e.g. Tundra, Mangroves, Temperate conifer forests, etc.)	
Number of years' experience in this area	
Regional expertise rating (on a scale of 1 to 5, see *Expertise level*)	

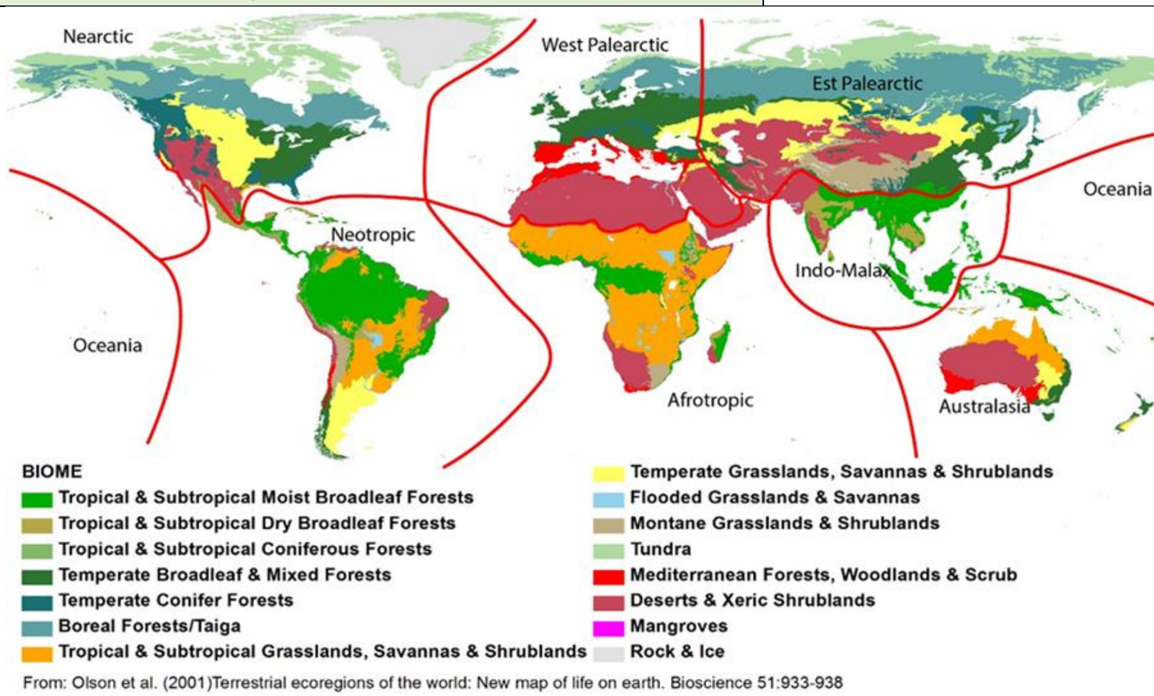

Fig. 7 Regional partition of the globe by continents and biomes from Olson et al. (2001), "Terrestrial ecoregions of the world: New map of life on earth."

5.2 Paleo perspective

1. How many fire regime state changes have occurred in your selected fire region over the last 12,000 years (e.g. during the Holocene)? (See ***State Change*** for background)

Number of fire regime state changes	

2. When did the three largest of these state changes occur?

Fire regime state	Year before present	Name or description of the event
Change 1		
Change 2		
Change 3		

3. What were the primary drivers of these state changes?
Note: List up to three drivers in order of relative importance.

Fire regime state	State change 1	State change 2	State change 3
Driver 1			
Driver 2			
Driver 3			

4. Which aspects of the fire regime in this region did post-industrial society influence most strongly?
Note: Please identify up to three aspects (see introduction) and how they were influenced (provide as much detail as you wish).

Aspect 1	
Aspect 2	
Aspect 3	

5. How influential is past fire behavior on current fire regimes?

Percentage (0% = no skill or utility at predicting future behavior, 100% equals deterministic relationship)	

Please indicate your expertise and confidence related to section 5.2 Paleo perspective

Average Expertise level (1lowest-5 highest)		**Average Confidence level (1lowest-5 highest)**	
How did you generate these estimates (mark with "x" all that apply)?		**What are the largest sources of uncertainty in these estimates?**	
a) published empirical data: b) published model estimates: c) unpublished data: d) professional opinion: other (please specify):			
Additional comments:			

5.3 Current fire regime state

Note: These questions seek to characterize recent fire behavior in your region. They establish a baseline for the next section. For many of the questions that follow, you will be asked to provide "Lower," "Central," and "Upper" estimates, constituting a qualitative 90% confidence interval (see diagram below).

There is a 90% probability the real value is within this range.

Lower =
There is a 95% chance that the real value will be greater than this estimate

Central =
This is my best estimate

Upper =
There is a 95% chance that the real value will be lower than this estimate

6. How long has the current fire regime persisted in your selected region?

Note: For this question, if there had been a state change in fire regime for your region in the 1950s or 60s, you might answer , "60", "70", and "85" in the 3 columns.

Duration of current fire regime state (years)	Lower	Central	Upper

7. What is the mean area burned yearly in your region for the period identified in Question 6?

Extent burned (% of region burned per year)	Lower	Central	Upper

8. What is the mean fire return interval in your region for the period identified in Question 6?

Fire Interval (years)	Lower	Central	Upper

9. What is the current mean fire severity in your region?

Note: While there are multiple definitions of fire severity, please respond with the mean percentage of surface organic matter combusted. If you only know the qualitative severity, you can convert to percentage combustion using the scale below (Miesel et al., 2015).

Lightly burned = surface organic matter combustion less than 15%
Moderately burned = surface organic matter combustion between 15% to 60%
Severely burned = surface organic matter combustion more than 60%

Surface organic matter combustion (%)	Lower	Central	Upper

Please indicate your expertise and confidence related to section 5.3 Current fire state

Average Expertise level (1lowest-5 highest)		**Average Confidence level (1lowest-5 highest)**	
How did you generate these estimates (mark with "x" all that apply)?		**What are the largest sources of uncertainty in these estimates?**	
a) published empirical data: b) published model estimates: c) unpublished data: d) professional opinion: other (please specify):			
Additional comments:			

5.4 Fire projections

10. What is the likelihood of a state change in fire regime for the following global warming scenarios and time steps?
Note: Please provide a lower, central, and upper estimate in percent (0 = no possibility of state change, 100 = assured state change) for each time step. Estimates for all three time-steps should be compared with the current fire regime you defined in the last section. In addition to climatic factors, please consider all possible changes for each scenario and time step, including human actions, ecosystem responses, etc.

Your estimate in %									
Scenario	**RCP2.6**			**RCP4.5**			**RCP8.5**		
Year / CI	**2050**	**2100**	**2300**	**2050**	**2100**	**2300**	**2050**	**2100**	**2300**
Lower									
Central									
Upper									

11. If a change occurs in the fire regime, in what direction would fire extent (area), frequency, and severity likely trend/change for the following global warming scenarios and time steps?
Note: Indicate the direction and magnitude for each fire regime dimension by selecting a value between -5 and 5, where -5 = strong decrease, 0 = no change, and 5= strong increase.

Your estimate between -5 to 5									
Scenario	**RCP2.6**			**RCP4.5**			**RCP8.5**		
Year	**2050**	**2100**	**2300**	**2050**	**2100**	**2300**	**2050**	**2100**	**2300**
Area									
Frequency									
Severity									

12. What would be the net effect of the fire regime changes you estimated in questions 10 and 11 on biodiversity, carbon stocks, albedo, and ecosystem services (-5 = strong net decrease, 0 = no net effect, 5= strong net increase)?
Note: This question focuses on the possible ecological and societal consequences of changes in fire regime. We are interested if the fire regime change will make things better or worse regarding biodiversity (habitat extent, diversity, and quality), climate feedbacks (soil and vegetation carbon stocks and surface albedo), and ecosystem services (other benefits for societies living in this region).

Your estimate between -5 to 5									
Scenario	**RCP2.6**			**RCP4.5**			**RCP8.5**		
Year	**2050**	**2100**	**2300**	**2050**	**2100**	**2300**	**2050**	**2100**	**2300**
Biodiversity									
Carbon stocks									
Albedo									
Ecosystem services									

13. What are the most important drivers of fire regime for the climate scenarios?
Note: This question aims to identify how medium and long-term drivers (e.g. climate, vegetation, human activity) interact to determine fire regime over different timescales. For the purposes of this question, we ask you to consider change by the year 2100. List up to 5 fire regime drivers in order of relative importance.

Fire regime drivers in order of relative importance			
Scenario	RCP2.6	RCP4.5	RCP8.5
(Most important) 1-			
2-			
3-			
4-			
(Less important) 5-			

Please indicate your expertise and confidence related to section 5.4 Fire Projections

Average Expertise level (1lowest-5 highest)		Average Confidence level (1lowest-5 highest)	
How did you generate these estimates (mark with "x" all that apply)?		**What are the largest sources of uncertainty in these estimates?**	
a) published empirical data: b) published model estimates: c) unpublished data: d) professional opinion: other (please specify):			
Additional comments:			

5.5 Intervention and management

14. What human actions regarding fire would be most effective in preserving or enhancing the following values over the next 20-50 years?
Note: Please note that "Non-intervention" is also an action. Indicate up to 5 actions. For each action indicate the degree of effect on a scale of -5 to 5, where -5 = most damaging or counterproductive, 0 = no effect, and 5 = most preserving or enhancing. (**Ecosystem services** here refer to all provisioning, regulating, social and cultural services that forests provide for humans.)

Human actions regarding fire	Your estimate between -5 to 5			
Human action	Biodiversity	Carbon Stocks	Albedo	Other ecosystem services

15. How effective could human interventions be in mitigating potential damage to societies and ecosystems for the following scenarios and time periods?
Note: This question seeks to assess humans' ability to manage fire under increasing climatological and ecological forcing of fire regime. For example, in the future will environmental changes systematically surpass human's technical and social abilities to control fire regime, or does human capacity grow as fast or faster as environmental drivers? Indicate your response on a scale of -5 to 5 compared to current conditions, where -5 = much less capacity to control fire regime for this scenario and period, 0 = same capacity as today, and 5 = much stronger capacity.

Your estimate between -5 to 5									
Scenario	**RCP2.6**			**RCP4.5**			**RCP8.5**		
Year	**2050**	**2100**	**2300**	**2050**	**2100**	**2300**	**2050**	**2100**	**2300**

Please indicate your expertise and confidence related to section 5.5 Intervention and management

Average Expertise level (1lowest-5 highest)		**Average Confidence level (1lowest-5 highest)**	
How did you generate these estimates (mark with "x" all that apply)?		**What are the largest sources of uncertainty in these estimates?**	
a) published empirical data: b) published model estimates: c) unpublished data: d) professional opinion: other (please specify):			
Additional comments:			

What are the three most important scientific citations/studies about fire in your selected region.	
Reference 1	
Reference 2	
Reference 3	

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