



Supplementary Information for

**Conservation of Earth's biodiversity is embedded in Indigenous fire stewardship**

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**This PDF file includes:**

Supplementary text

Figures S1-S2

Tables S1-S3

SI references

**Other supplementary materials for this manuscript include the following:**

Dataset S1

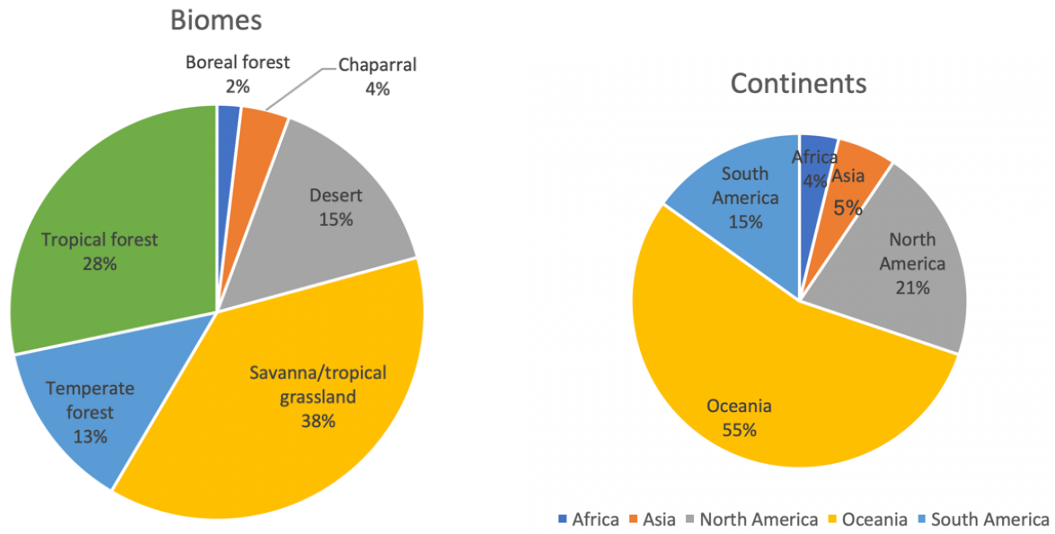
## **Supplementary Information Text**

### **Detailed Web of Science methods:**

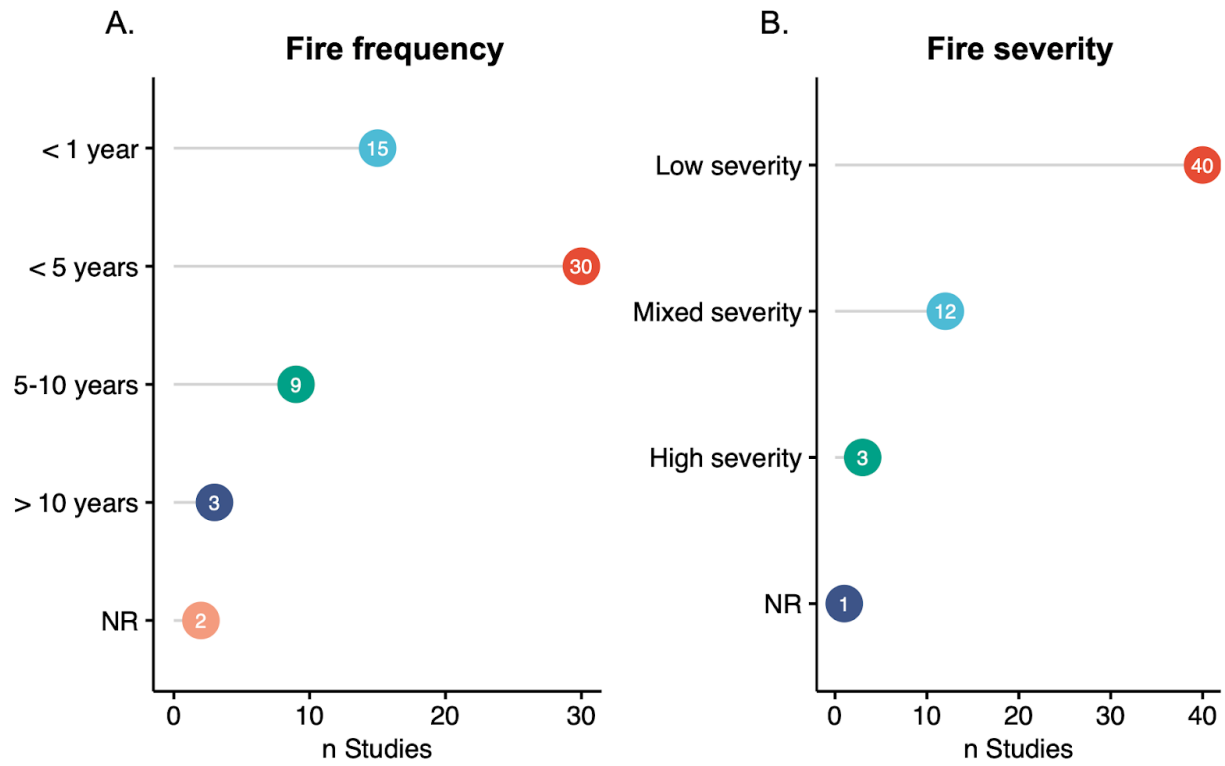
Our final web of science search list comprised of 840 papers and were randomly assigned to 10 reviewers (84 per person). Some reviewers were unable to review all assigned papers due to other obligations; those papers were reassigned to other group members. Group members had two months to read the papers and decide if they were applicable to the research question. Readers classified papers as 'yes', 'no', or 'maybe' in terms of their applicability, and recorded various data about the paper (see Table S2 below). Papers that were opportunistically encountered (reference lists, etc.) but not included in the original search results were added to the reading list and assigned to reviewers (n = 21). Once all papers were reviewed, a group discussion was held to clarify the requirements of a paper being considered applicable, and each reviewer was asked to reread the papers they had been uncertain about in the first round ("maybes") and decide if they were applicable or not. This resulted in 67 papers deemed by the group to be applicable to the research question. For this list of papers, reviewers were assigned a series of data columns to verify for each of the papers (e.g., fire intensity; fire frequency; etc) to ensure papers were classified consistently. The papers in this list were then reread by a single reviewer to ensure that all papers considered to be applicable to the research question were classified consistently across all categories and that they were relevant to the research question. In this final review of the papers, some categories from the initial review were further subdivided (e.g., changes in species composition were separated from changes in biodiversity) and refined. This review resulted in a final 53 papers being included. Some data were recategorized from the author's statements into more general groups for analysis and presentation of the data (e.g., species studied, ecosystem, use of fire, study approach, etc.).

### **Criteria for inclusion to final list**

Papers were required to include primary data relevant to the research question. The paper could also be a review, but it had to include new, primary information. Data had to concern one or all of the following: changes in biodiversity, species composition, or habitat heterogeneity. If authors did not measure these factors directly but concluded that they were altered in some way by the use of fire, we noted that these conclusions were inferred by the authors and not directly measured. The inferred responses were included in the final review. The paper had to have a comparative element - for example, impacts of use of fire by Indigenous groups compared to non-burned areas, lightning fires, areas impacted by colonization. The comparison could be either direct or implied.



**Fig. S1.** Biomes were defined following the World Wildlife Federation’s descriptions of the 14 terrestrial ecoregions (left). Some classifications were grouped together to reflect overlapping or similar definitions. Note that the tundra and mangrove biomes were not included in this review. Data from five continents (right) were reported in this study. The proportion of studies from each continent is presented.



**Fig. S2.** A) The number of studies with reported fires frequencies of less than 1 year, less than 5 years, every 5-10 years, and greater than 10 years. Two studies did not report (NR) fire frequencies. B) The number of studies that reported low-, mixed-, and high-severity fires within their respective study areas. Note that one study did not report (NR) severity nor could it be inferred from supporting data. Several studies reported more than one fire frequency and more than one type of fire severity which is reflected in the number of studies (n) reported on the x-axis (in both Figure A and B).

**Table S1.** Web of Science search criteria, search history, and search strings. Associated results are displayed on the left.

**Search History:**

Set	Results	Save History / Create Alert	Open Saved History	Edit Sets	Combine Sets AND OR Combine	Delete Sets Select All Delete
# 4	840	#3 AND #2 AND #1 <i>Indexes=SCI-EXPANDED, SSCI, A&amp;HCI, CPCI-S, CPCI-SSH, ESCI Timespan=All years</i>		Edit	<input type="checkbox"/> AND <input type="checkbox"/> OR	<input type="checkbox"/> Select All <input type="checkbox"/> Delete
# 3	324,132	TS = ((Indigenous) OR (Aboriginal) OR ("First Nation**") OR ("Natives") OR ("Native people**") OR (Indian) OR (tribal)) <i>Indexes=SCI-EXPANDED, SSCI, A&amp;HCI, CPCI-S, CPCI-SSH, ESCI Timespan=All years</i>		Edit	<input type="checkbox"/> AND <input type="checkbox"/> OR	<input type="checkbox"/> Select All <input type="checkbox"/> Delete
# 2	3,687,887	TS = ((Biodivers* OR divers*) OR (abundance) OR (richness) OR (pyrodivers*) OR (heterogen*) OR (patch*) OR (matri*)) <i>Indexes=SCI-EXPANDED, SSCI, A&amp;HCI, CPCI-S, CPCI-SSH, ESCI Timespan=All years</i>		Edit	<input type="checkbox"/> AND <input type="checkbox"/> OR	<input type="checkbox"/> Select All <input type="checkbox"/> Delete
# 1	436,214	TS = ((fire) OR (burn*) OR (bio*char) OR (terra*pre*ta)) <i>Indexes=SCI-EXPANDED, SSCI, A&amp;HCI, CPCI-S, CPCI-SSH, ESCI Timespan=All years</i>		Edit	<input type="checkbox"/> AND <input type="checkbox"/> OR	<input type="checkbox"/> Select All <input type="checkbox"/> Delete

**Table S2.** Description of recorded and reclassified variables.

<b>Information Collected by Reviewers</b>	<b>Considerations</b>
Primary data paper	Marked as 'yes' if paper contained new analysis; this was a requirement for a paper to be included in the final list
Synthesis/review/meta-analysis paper	Marked as 'yes' if there was a formal literature review component to the paper
More than one study site	Marked as 'yes' if more than one study site was analyzed
Continent	Name of the continent on which the research took place
Country	Name of the country in which the research took place
Study region	The detailed location in which the research took place
Latitude (N, -S)	Latitude (decimal degrees) of study location; centered on larger study area if more than one site (inferred by review team if not reported)
Longitude (E, -W)	Longitude (decimal degrees) of study location; centered on larger study area if more than one site (inferred by review team if not reported)
Author described ecosystem	Type of study ecosystem, as described by the authors
Biome	Biome in which the study took place as classified by the review team
Time frame	Time frame over which the conclusions are drawn (Short: 0-10 years; Medium: 0-50 years; Long: 0-150 years; Historic: 0-150+ years)
Indigenous group/territory involved	Name of the Indigenous group or territory being considered in the research as described by the authors
Reason for fire by Indigenous group	A list of the reasons that fire was used by the Indigenous group as described in the paper
Reason for fire by Indigenous group, general	Reclassified reasons for use of fire as classified by review team
Fire used for slash-burn, swidden, intensive agriculture, terra preta, etc.	Yes or no response based on descriptions provided by study authors
Type of agricultural use of fire	Specific type of agricultural fire use reported by authors

Contemporary or historical burning	Time period in which fires occurred; marked as 'historical' if the burning was framed as occurring in the past, and as 'contemporary' if the burning was occurring at time of publication
Frequency of fire (years)	How often fires were set. In some cases it is difficult to differentiate whether it is the same area being burnt.
Frequency of fire (reclassified)	Fire frequency inferred by reviewers based on information contained within the article.
Severity or intensity of fire	A comment about the severity or intensity of the fires set by Indigenous groups, based on author descriptions.
Severity of fire (reclassified)	Fire severity (low, mixed, or high) as inferred by reviewers.
Timing (seasonality) of fire	The part of the year in which burning by Indigenous groups generally took place. Reported by season (i.e., dry season) when possible.
Scale of research (local/regional/global)	The spatial scale of the research according to the review team (Local: plot area totaling 0 to 2 km <sup>2</sup> or single field site; Regional: plot area greater than 2 km <sup>2</sup> to whatever or has multiple field sites; Global: no restrictions to spatial extent).
Approach used	A list of the main research approach used by the authors.
Approach used (reclassified)	A reclassified list of the research approach used by the authors, defined by the review team.
Species studied	The species/genera/lifeforms studied, reported by authors.
Lifeform studied (reclassified)	A reclassified list of lifeforms studied based on species information presented by authors.
Biodiversity change	Marked as 'yes' if there were data to support the conclusion that biodiversity had changed as a result of Indigenous burning; marked as 'yes*' if authors drew that same conclusion from non-data sources.
Biodiversity increase or decrease	Marked as 'yes' if biodiversity was shown to increase with the use of Indigenous burning relative to a contrasting condition (i.e., European burning or land management, fire suppression, unburned areas, after burning stopped); marked as 'yes*' if authors inferred this conclusion based on non-data sources.
Compositional change	Marked as 'yes' if there were data to support the conclusion that species composition had changed as a result of Indigenous burning; marked as 'yes*' if authors drew that same conclusion from non-data sources.

Type of biodiversity/compositional change	The aspect of biodiversity or species composition that was altered (e.g., diversity, abundance, composition, etc.).
Biodiversity / Compositional rationale	Rationale for having listed biodiversity or species composition to have changed.
Diversity metric or approach used by authors	The metric or approach for quantifying diversity or demonstrating compositional change used by the authors.
Habitat heterogeneity change	Marked as 'yes' if habitat heterogeneity was concluded to have changed; marked as 'yes*' if the authors inferred heterogeneity to have changed based on non-data sources.
Habitat heterogeneity increase vs. decrease	Marked as 'yes' if habitat heterogeneity was concluded to have increased due to Indigenous burning; marked as 'yes*' if it was inferred by authors to have increased based on non-data sources.
Habitat heterogeneity language	Words used by authors in the text that suggested habitat heterogeneity had changed.



**Table S3.** Terms, definitions and their associated references acknowledged in this review paper.

Term	Definition
Indigenous fire stewardship	The use of fire by Indigenous peoples to: 1) modify fire regimes, adapting and responding to climate and local environmental conditions to promote desired landscapes, habitats, species, and 2) to increase the abundance of favored resources to sustain knowledge systems, ceremonial and subsistence practices, economies and livelihoods. Also referred to as cultural fire and controlled burning (1)
Indigenous Ecological Knowledge (IEK)	IEK relates to western concepts of ecology and the environment however it is grounded in spiritual worldviews and cultural values that have emerged from centuries of survival strategies and cultural systems that have sustained Indigenous communities (2–4)
Fire regime	The kind of fire activity or pattern of fires that generally characterize a given area over a given time period. Some important elements of the characteristic pattern include fire cycle or fire interval, fire season, and the number, type, and intensity of fires (5–7).
Biodiversity	Variety of living species on earth and can be measured by diversity metrics such as Shannon’s Index, Hill numbers and species richness.
Heterogeneity	<p>The difference or diversity in kind or arrangement of component elements or constituents (8)</p> <p><b>Related:</b>  <i>Patch:</i> relatively homogeneous area that differs from its surroundings</p> <p><i>Matrix:</i> <i>x</i> is the "background ecological system" of a landscape with a high degree of connectivity</p>
Species composition	Information related to the abundance and/or diversity of species within a community
Fire severity	The ecological impact of fire on vegetation and soil, through organic matter consumption from flaming and smouldering combustion.
Fire frequency	The average number of fires that occur per unit time at a given point.
Fire effects	Any ecosystem impacts attributable to a fire, whether immediate or long-term. May be detrimental, beneficial, or benign
Fire suppression	All activities concerned with controlling and extinguishing a fire following its detection.
Indigenous peoples	Inhabitants of geographical regions at the time when people of different regions or ethnic origins arrived and became dominant through conquest, occupation, settlement or other means. Indigenous people practice unique traditions, retain social, cultural, economic and political characteristics that are distinct from those of the dominant societies in which they live (9-10).

**Dataset S1 (separate file):** Citations of all papers included in the review.

## SI References

1. F. K. Lake, A. C. Christianson, Indigenous fire stewardship. *Encycl. Wildfires Wildland-Urban Interface WUI Fires* (2019).
2. R. C. Dudgeon, F. Berkes, “Local Understandings of the Land: Traditional Ecological Knowledge and Indigenous Knowledge” in *Nature Across Cultures: Views of Nature and the Environment in Non-Western Cultures*, Science Across Cultures: The History of Non-Western Science., H. Selin, Ed. (Springer Netherlands, 2003), pp. 75–96.
3. L. R. Simpson, Anticolonial Strategies for the Recovery and Maintenance of Indigenous Knowledge. *Am. Indian Q.* **28**, 373–384 (2004).
4. H. A. Smith, K. Sharp, Indigenous climate knowledges. *WIREs Clim. Change* **3**, 467–476 (2012).
5. R. A. Bradstock, J. E. Williams, M. A. Gill, *Flammable Australia: The Fire Regimes and Biodiversity of a Continent* (Cambridge University Press, 2002).
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7. J. E. Keeley, Fire intensity, fire severity and burn severity: a brief review and suggested usage. *Int. J. Wildland Fire* **18**, 116–126 (2009).
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9. United Nations Declaration on the Rights of Indigenous Peoples | United Nations For Indigenous Peoples (April 20, 2021).
10. United Nations Permanent Forum on Indigenous Issues. Accessed April 1<sup>st</sup>, (2021)