

Global mapping of human fire use and management from new databases and models

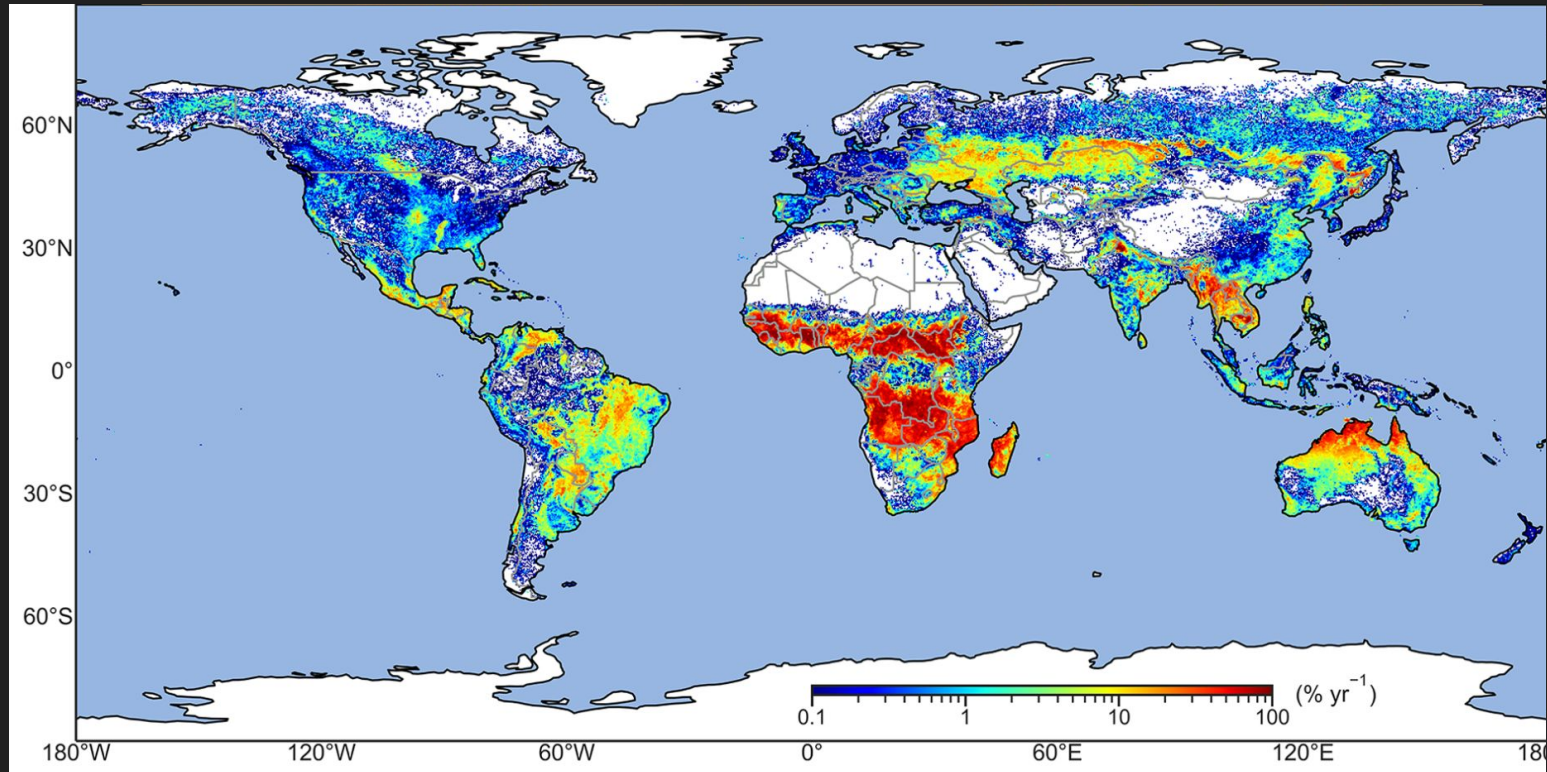
O. Perkins, J.D.A. Millington, C. Smith, J. Mistry

28 Aug 2024, Royal Geographical Society Annual Conference



LEVERHULME
Centre for Wildfires,
Environment and Society

Global Burned Area (from space)



GFED 0.25° (~25 km at equator)

Annual mean %/yr

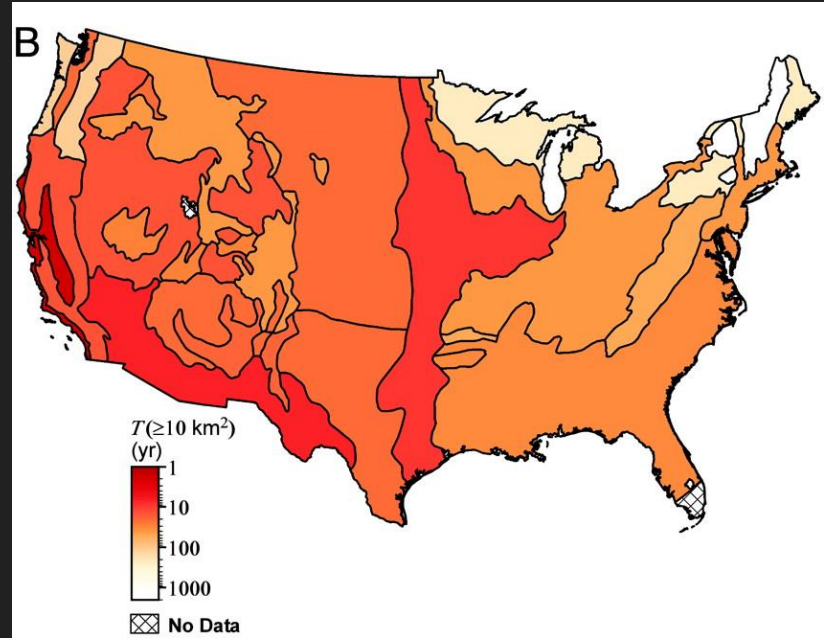
Paper: [Chen et al. 2024](#) | Data: [via Zenodo](#)

Burned Area (from government data)

USFS and US DOI recorded
657,949 wildland fires (1970-2000)

Malamud *et al.* (2005) used
88,916 USFS fires >1 acre to
map fire regimes by ecoregion

- 64% were classified as human caused: 'campfire', 'arson', 'miscellaneous' and 'smoking'



Recurrence intervals for fires $>10 \text{ km}^2$ per $1,000 \text{ km}^2$

Diverse Empirical Research

Burning the Seasonal Mosaic: Preventative Burning Strategies in the Wooded Savanna of Southern Mali

Paul Laris¹

Human Ecology, Vol. 30, No. 2, June 2002 (© 2002)

Data are presented indicating a seasonal mosaic pattern of burning in the savanna of southern Mali. A seasonal mosaic is a landscape that is annually



Journal of Environmental Management 82 (2007) 481–494

Cattle-rangeland management practices and perceptions of pastoralists towards rangeland degradation in the Borana zone of southern Ethiopia

T.B. Solomon, H.A. Snyman*, G.N. Smit

Department of Animal, Wildlife and Grassland Sciences, University of the Free State, P.O. Box 339, Bloemfontein 9300, Republic of South Africa
Received 7 March 2004; received in revised form 12 January 2006; accepted 13 January 2006
Available online 17 April 2006

Abstract

A survey was conducted in the Borana pastoral areas of southern Ethiopia to assess current livestock management practices and the perceptions of the pastoralists towards rangeland degradation and pastoral development.



ELSEVIER

Land Use Policy 47 (2015) 448–458

Contents lists available at ScienceDirect

Land Use Policy

journal homepage: www.elsevier.com/locate/landusepol

Why do farmers burn rice residue? Examining farmers' choices in Punjab, Pakistan

Tanvir Ahmed^{a,*}, Bashir Ahmad^b, Waseem Ahmad^c

^a Associate Professor, Department of Economics, Forman Christian College (A Chartered University) Lahore, Pakistan
^b Professor Emeritus, Institute of Agricultural and Resource Economics, University of Agriculture, Faisalabad, Pakistan
^c Assistant Professor, Institute of Business Management Sciences, University of Agriculture, Faisalabad, Pakistan

ARTICLE INFO

Article history:
Received 10 August 2014
Received in revised form 19 April 2015
Accepted 7 May 2015

ABSTRACT

Burning agriculture residues has a negative impact on carbon and climate change.

Wildlife Biology 2017; w.b.00318
doi: 10.2981/wlb.00318

© 2017 The Authors. This is an Open Access article

Subject Editor: Erlend Nilsen. Editor-in-Chief: Ilse Storch. Accepted 25 September 2017



Journal of
Environmental
Management

www.elsevier.com/locate/jenvman

Managing grassland for wildlife: the effects of rotational burning on tick presence and abundance in African savannah habitat

Anne E. Goodenough, Alison N. Harrell, Rachel L. Keating, Richard N. Rolfe, Hannah Stubbs, Lynne MacTavish and Adam G. Hart

A. E. Goodenough (aegoodenough@glos.ac.uk), A. N. Harrell, R. L. Keating, R. N. Rolfe, H. Stubbs and A. G. Hart, Natural and Social Sciences, Univ. of Gloucestershire, Francis Close Hall, Cheltenham, GL50 4AZ, UK. – L. MacTavish, Mankwe Wildlife Reserve, Northwest Province, South Africa.

New Databases and Models

DAFI

Database of Anthropogenic Fire

Millington *et al.* (2022)

LIFE

Livelihood Fire Database

Smith *et al.* (2022)

GFUS

Global Fire Use Survey

Smith *et al.* (in review) [[data online](#)]

WHAM!

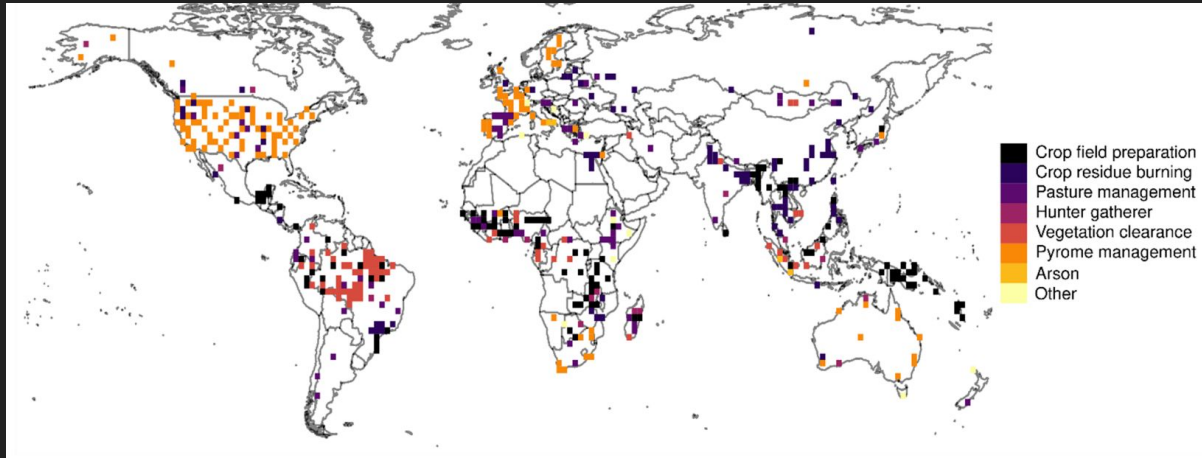
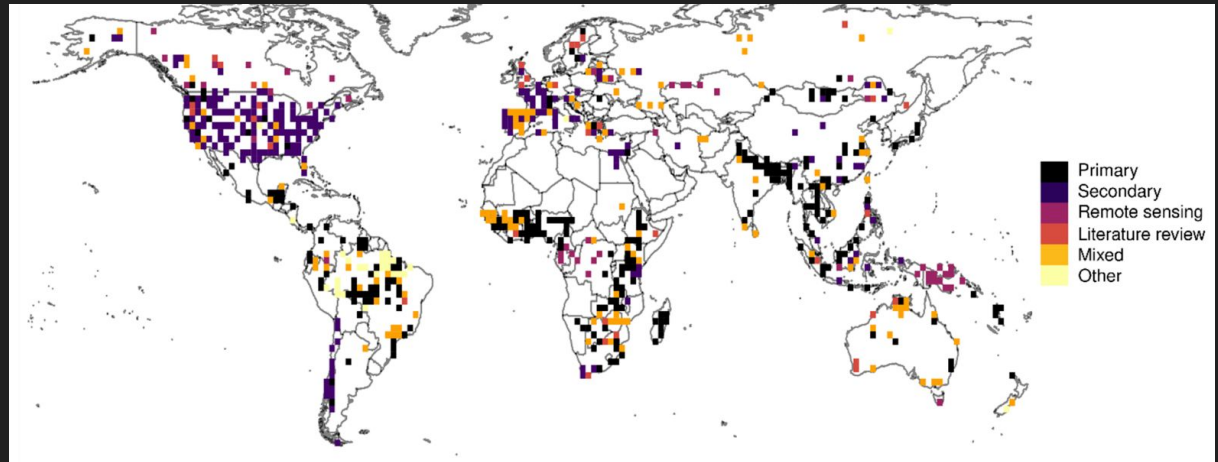
Wildfire Human Agency Model

Perkins *et al.* (2024)

	DAFI	LIFE	GFUS
Data Points	1809 cases 504 sources	1708 practices 592 sources	174 regions 311 responses
Data Source	Literature: Primary, Secondary, Remote Sensing, Reviews	Literature: Primary	Primary: Expert elicitation
Time Span	1990-2020	1990-2020	2018-2022
Fire Uses	<i>7 primary</i> [>20 total] Crop prep., Crop resid., Pasture, Hunt-Gather, Veg. clearing, Fuel mgmt, Arson	<i>8 primary</i> [29 total] Crops, Pasture, Hunt-Fish, Gather, Charcoal, Movement, Health, Social Signals	<i>25 total</i> Main type by user: Livelihood - agri/pasture State/NGO - fuel mgmt. Commercial - agri/pasture
Policy and Governance	<i>Intervention:</i> Incentivise, Restrict, Ban <i>Rationale:</i> Environ., Econ., Health	<i>Intervention:</i> Regulations, Incentives, Voluntary <i>Intention:</i> Reduce, Retain, Grow, Introduce <i>Actor:</i> state, NGO, community	<i>Intervention:</i> Reg., Incentives, Voluntary <i>Effectiveness:</i> Very, Somewhat, Not <i>Level:</i> High, Med, Low

DAFI

Spatial Distribution of Sources



DAFI

Spatial Distribution of Fire Uses

Poster: Perkins et al. 2021
Paper: Millington et al. (2022)
Data: via FigShare

Oliver Perkins^{1,3}, Cathy Smith^{2,3}, James D.A. Millington^{1,3}
¹King's College London, ²Royal Holloway, University of London, ³Leverhulme Centre for Wildfires, Environment and Society



Poster

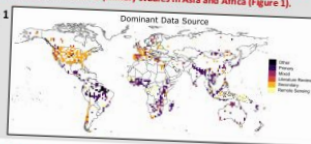
Part 1

Empirical studies of human use and management of fire in landscapes around the world have been conducted in many different academic fields, including geography, anthropology, land economics and ecology. Studies have varied in approach, from quantitative and broad-scale (e.g., remote sensing to qualitative fire use and suppression studies [e.g., anthropological]). No global synthesis of human–fire interactions has yet been attempted (though there are some attempts at regional syntheses). We present the most comprehensive meta-analysis of global fire use-to-date, spanning all key land systems and policy regimes from over 105 countries on which we call the DAI was developed between 1990–2000. Our study has produced a database comprising data on burning practices across more than 1800 case studies that we call the DAI was developed in an iterative manner but based on our knowledge of what works best for ‘stages’ (after Pyne 1976) in landscape analysis. Fire stages are pre-agricultural, agricultural, industrial & post-industrial while land systems are cropland, pasture, forest & non-extractive. The types of fires included in DAI vary according to space, with rural/agricultural secondary studies in Europe and North America versus dominance of primary studies in Asia and Africa.

Information	Data Format (case study)	Data Type (DAFI)	Example Variables (DAF)
Fire Use	Quantitative	Continuous	Intended or actual fire size
Suppression	Mixed	Ordinal	Activity type & effort level
Policies	Qualitative	Boolean	Existence of law or incentives
Land Use & Cover	Mixed	Continuous & Nominal	Land use intensity & type

Table 2

Figure 3



Analysis of DAI reveals that seven fire-use types (listed in Table 2) account for >90% of case studies. The seven fire-use types have distinctive quantitative signatures (Table 2) and spatial distributions (Figure 2). Shifting cultivation field preparation has a similar mean fire size to non-shifting crop residue burning. However, the relatively low fire-return period and high density of fields when compared to shifting cultivation combine to produce a much greater proportional mean burned area. Pyroline management activities dominate in North America and Europe, while vegetation clearance is a primary use across much of Africa and crop residue burning is dominant across parts of Asia.

Fire-use Type	DAFI Records (%)	Mean Size (ha)	Mean Burned Area (% LS)	Mean Return Period (yrs.)	Escape (%)
Field Prep.	19.8	0.8	14.2	10.2	0.05
Crop Residue Burning	16.7	3.9	36.3	2.0	0.01
Pasture Prep.	12.3	33.9	32.1	3.4	4.95
Hunt/Gather	6.4	2.1	14.3	5.0	2.90
Veget. Clearing	14.2	9.2	2.5	N/A	3.23
Pyroline Mgmt.	17.7	357.2	14.0	5.9	0.30
Arson	3.3	N/A	N/A	N/A	N/A

Table 2

Figure 2

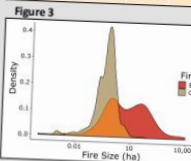
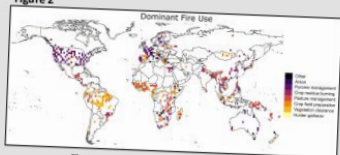


Figure 3

DAFI enables examination of fire regime characteristics as a function of broader fire use approaches and how fire uses vary between fire stages. For example, cropland fires tend to be smaller than fire broadcast across pasture and forest landscapes (Figure 3). We find distinct differences in fire suppression between fire stages (Figure 4). **Code for analysis of DAFI and plots is available** (Perkins 2021).

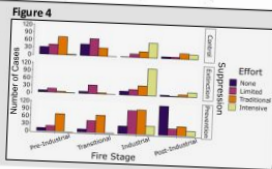


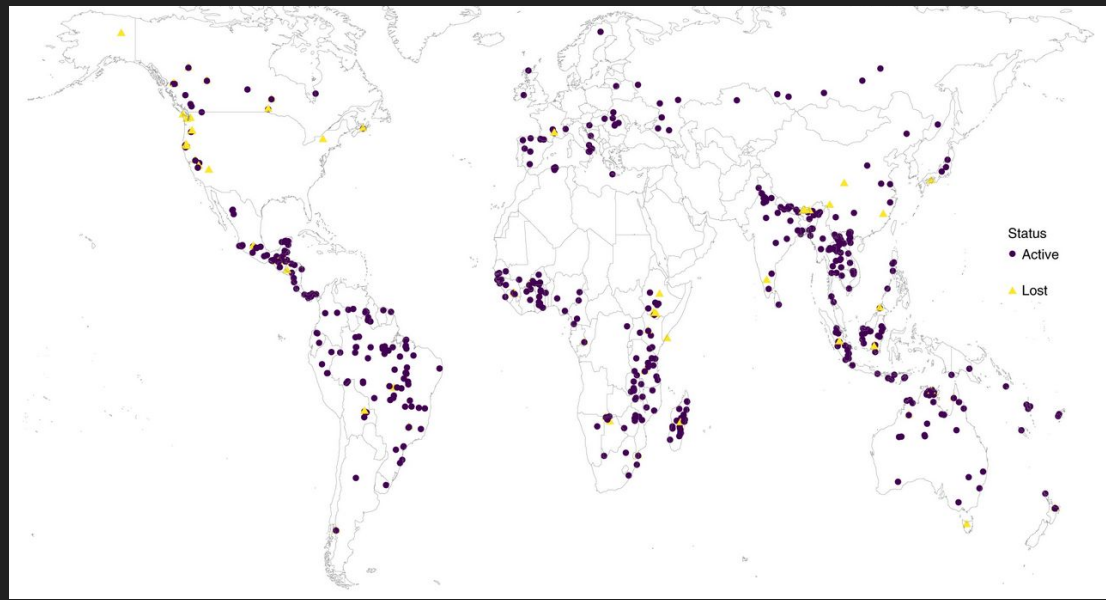
Figure 4

Attempts to systematize human-wildlife interactions have sought to configure human impacts as deviations from underlying ‘natural’ uses of vegetation and fire ecology (e.g. McWethy et al. 2011). Such approaches have not yet developed a coherent overall framework to capture human impacts on wildlife. A key finding of the Fire Model Intercomparison Project was that there is no systematic empirical basis for understanding human impacts on wildfire regimes and presents a challenge to incorporating anthropogenic fire risk into dynamic models (McWethy et al. 2016). The project’s findings are available online at <http://www.firemodelintercomparison.org/>. We plan to use DAFI to support development of a new, open-source, community-based approach to modeling human impacts on wildfire regimes. This work presented at anthropogenic fire in DGVMs still relies on few readily available data sources. To improve model accuracy and better represent human fire in DGVMs, representation of models using these variables in globally-uniform relationships may be due to the disregard for how people use and manage fire in the context of different functions of underlying land use objectives. Examples may include shifting cultivation farmer, large-scale industrial logging, and fire use and suppression as a means of managing land use objectives. Land use changes can also impact fire regimes through changes in fuel availability and fire frequency. We expect that by mapping these types globally using ancillary data, we will be able to improve simulation model representation of human fire, including feedbacks with vegetation and climate.

[illegible]

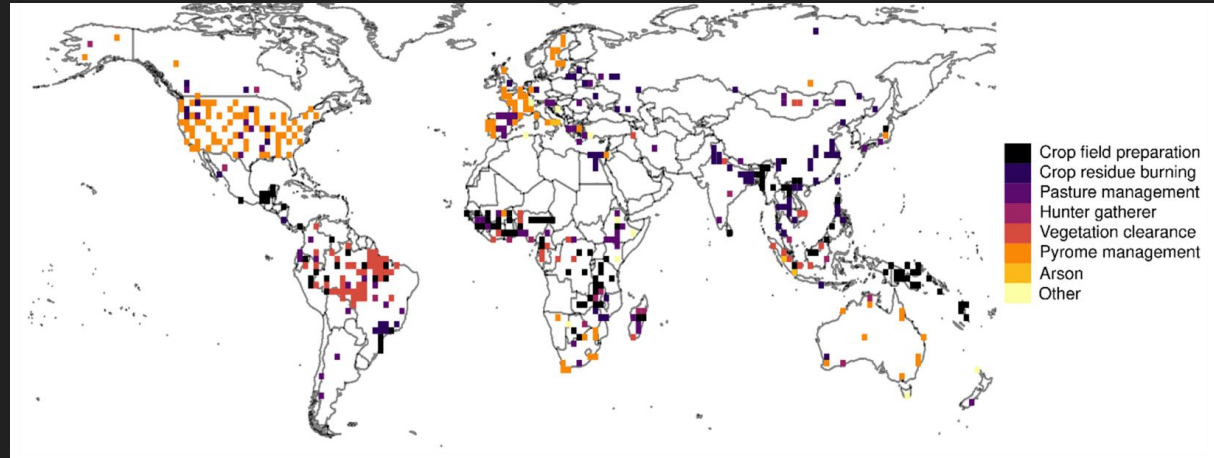
LIFE

Spatial Distribution of Case Studies (point location)



DAFI

Spatial Distribution of Fire Uses (gridded mode)

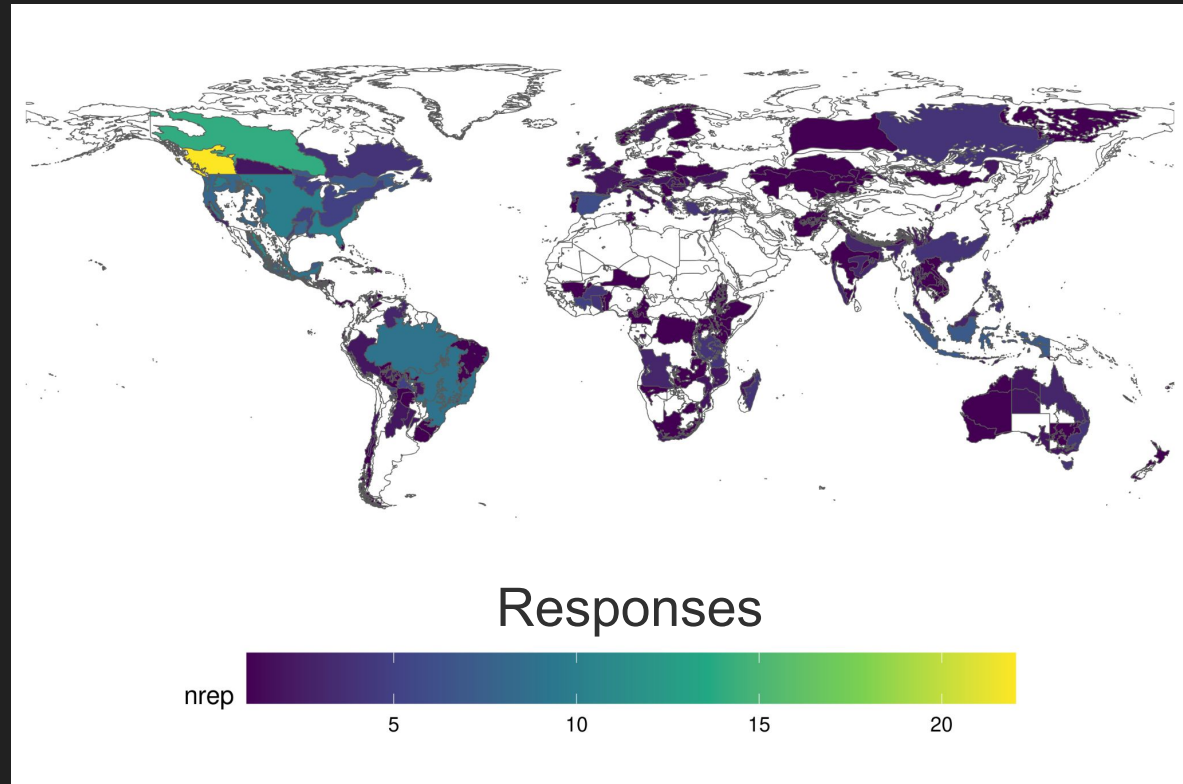


GFUS

Spatial Distribution of Responses

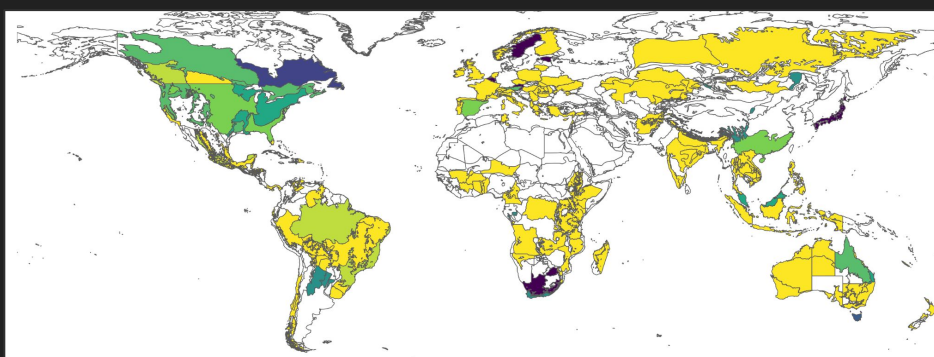
Data for Russia and
Kazakhstan

Over-representation in
Americas?

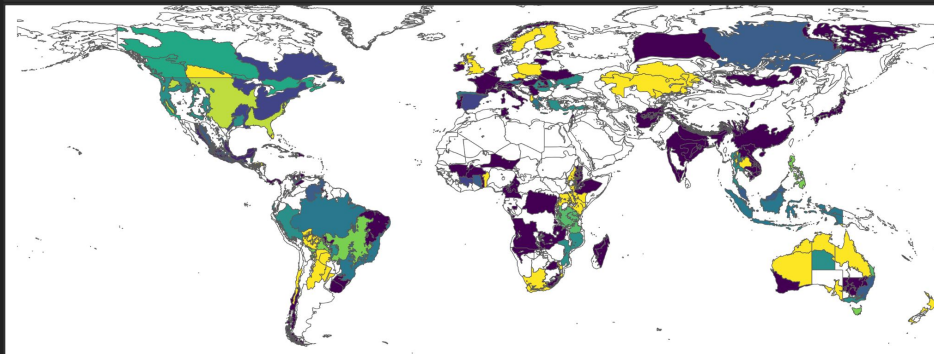


GFUS

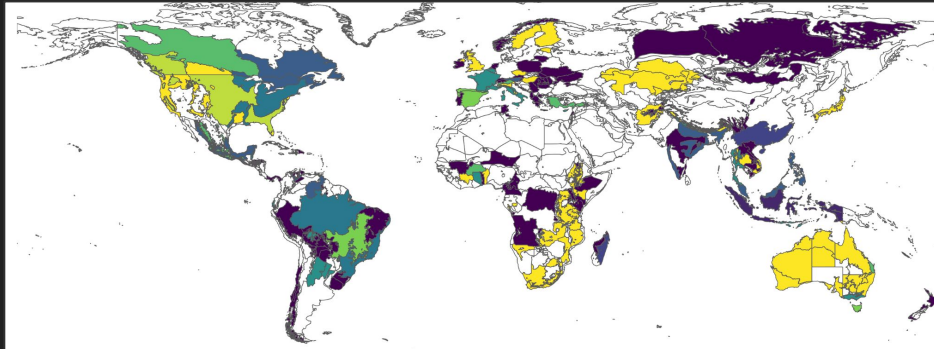
Prop. of responses
indicating actor is
present in a region



Livelihood



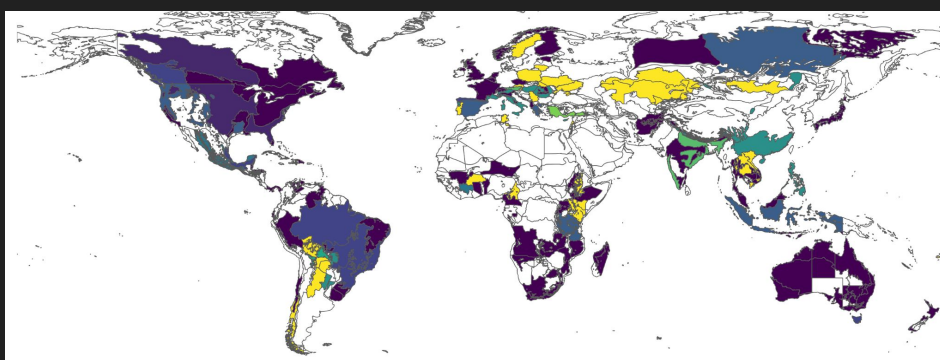
Commercial



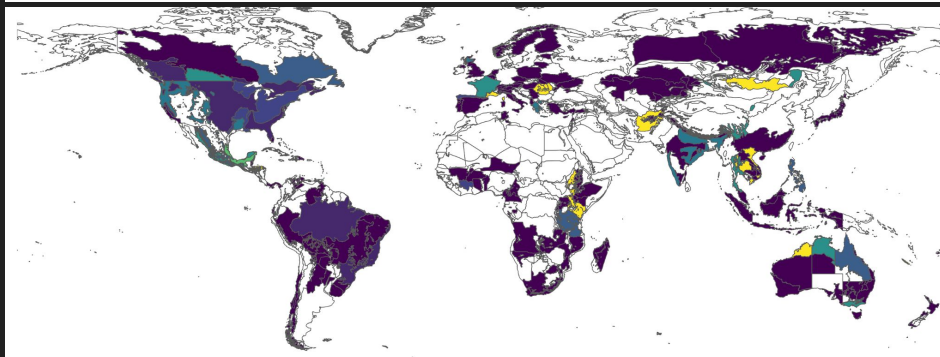
State/NGO

GFUS

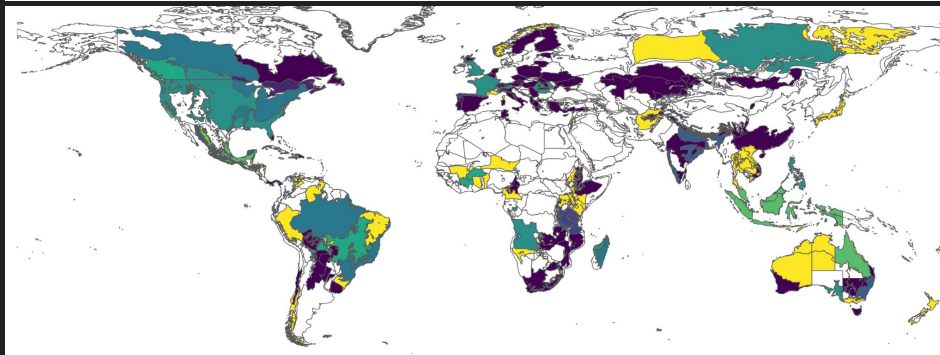
Prop. of responses
indicating action is
present in a region



Banned



Economic
Incentive



Community
Governance

1. Anthropogenic Fire Regimes

- ~~First Fire~~ — ~~pre-human~~
- Second Fire **pre-industrial**
- 2.5th Fire **transition**
- Third Fire **industrial**
- Pyrocene **post-industrial**

After Pyne's Fire 'stages', **AFRs** reflect available resources and management perspectives



[\[TED 15 min summary\]](#)

2. Land Use Systems

Non-Extractive



Forest

Pasture



Cropland



Combine land use intensity and land management practices

See Václavík *et al.* 2013 [[GEC](#)], Dou *et al.* 2021 [[Lsp Ecol](#)]

Land-Fire Systems [‘AGENT TYPES’]

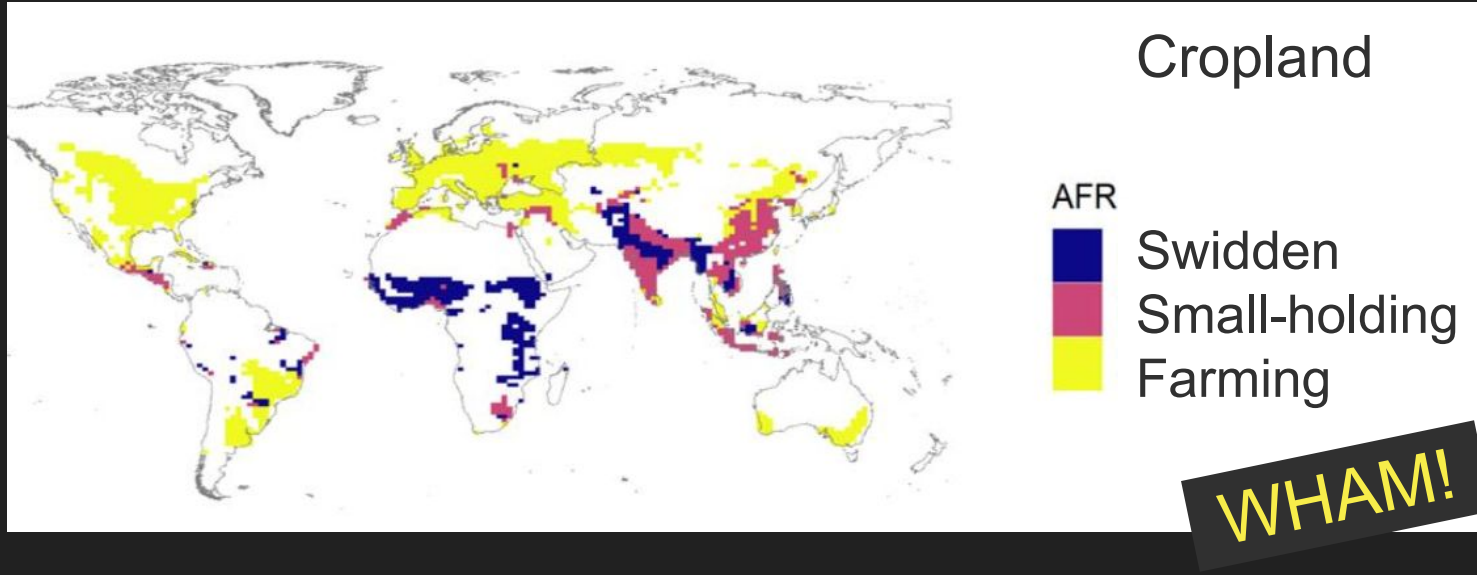
More here: [Perkins et al. \(2024\)](#)

From combination of Anthro. Fire Regimes and Land Use Systems

<div>WHAM!</div> <div>Anthro. Fire Regime</div>		Land Use System			
		<i>Non-Extractive</i>	<i>Livestock</i>	<i>Crops</i>	<i>Forestry</i>
<i>Pre-Industrial</i>		Unoccupied	Pastoralism (S)	Swidden (S)	Hunt & Gather (S)
<i>Transition</i>		Unmanaged	Ranching (Extensive, S M)	Small- holding (S M)	Logging (M) (Primary Forest)
<i>Industrial</i>		Pyro-exclusion (State Manager)	Ranching (Intensive, M)	Farming (Intensive, M)	Managed (M) (Plantation or Second Forest)
<i>Post-Industrial</i>		Pyro-diverse (Fuel Load Management)	Grazing (Subsidised, Fuel Mgmnt)	Abandoned	Abandoned

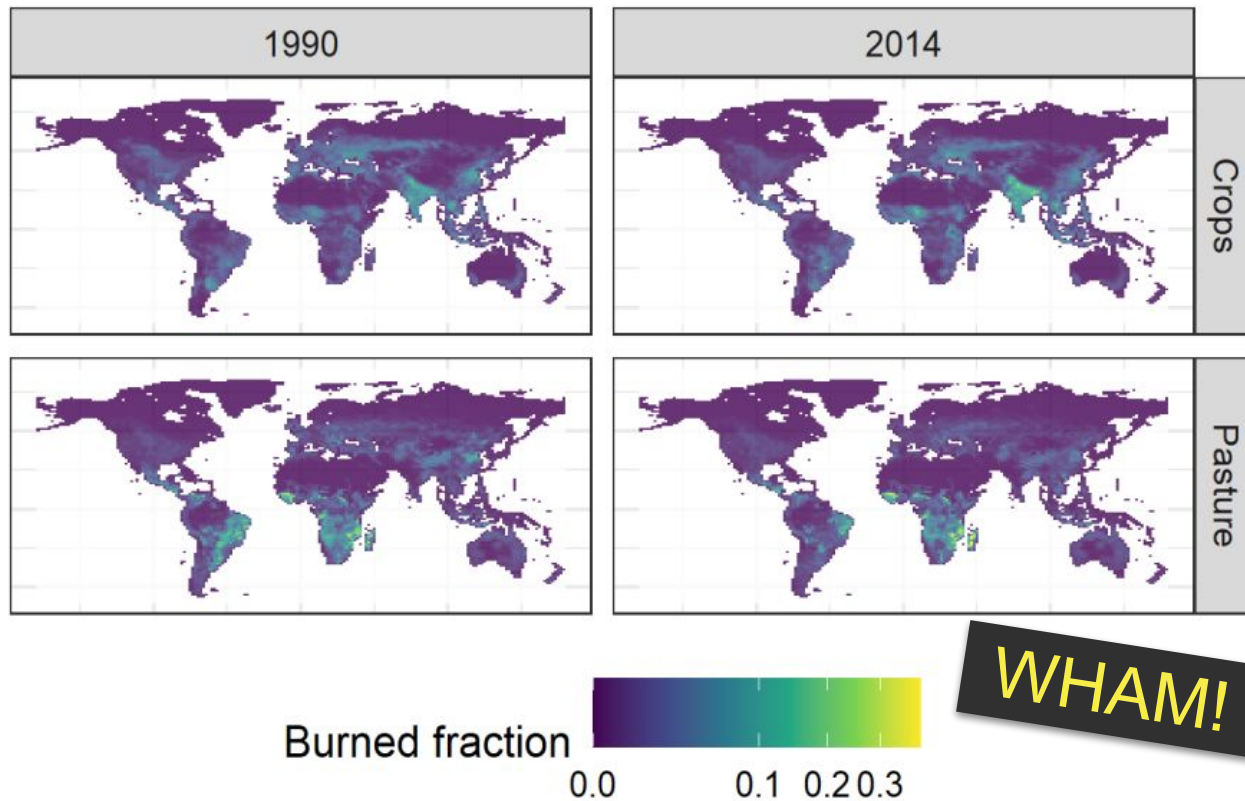
Non-Extractive = e.g. parks S = subsistence M = market

Modelled Spatial Distribution of LFS



Combine density of *LFS* with
data from DAHI to
estimate *human Burned Area*

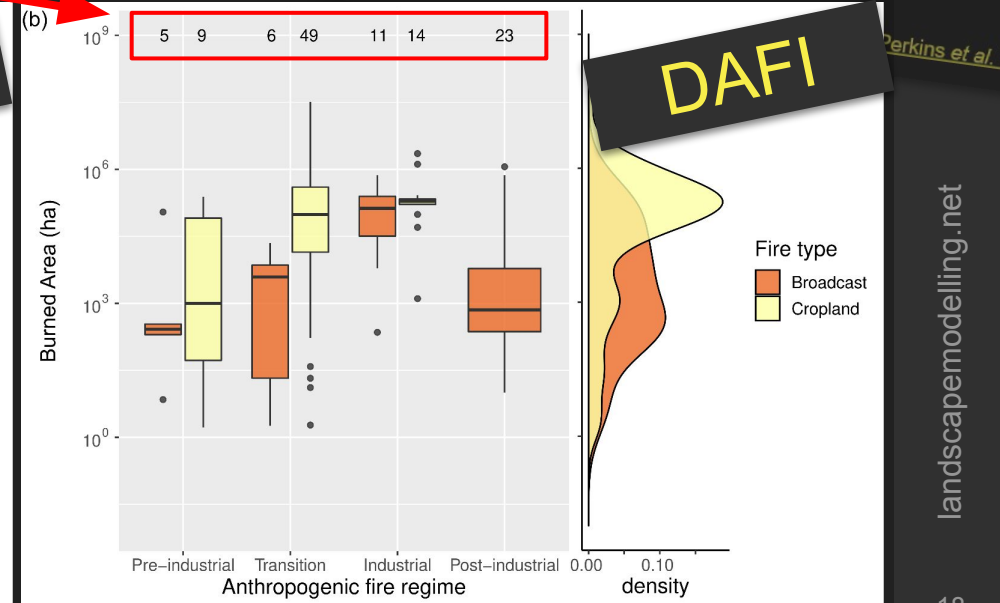
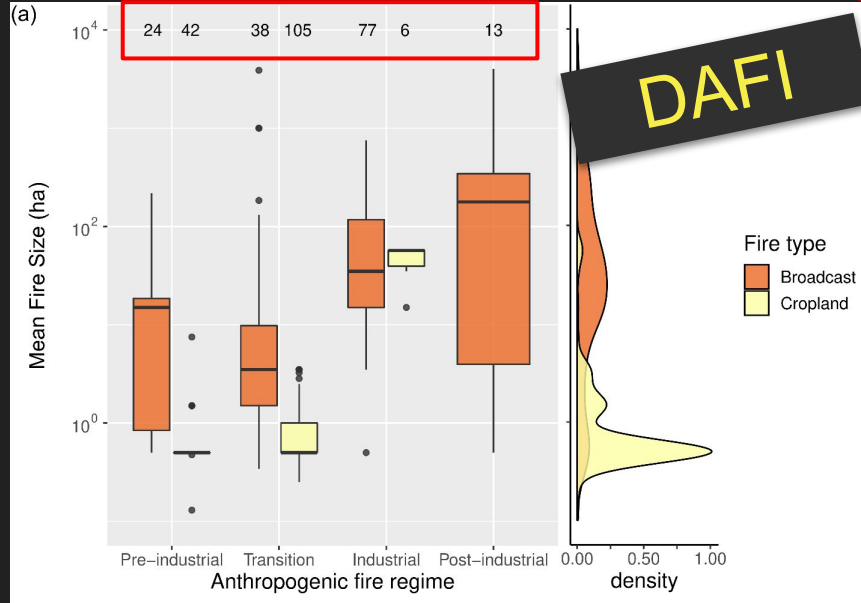
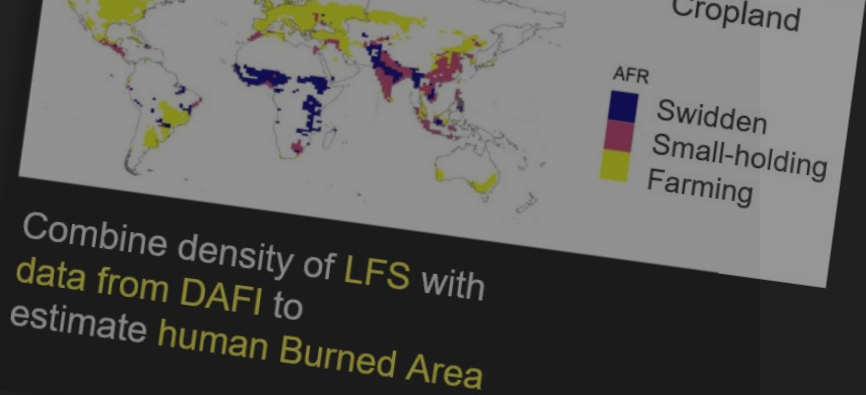
Modelled Agriculture Burned Area



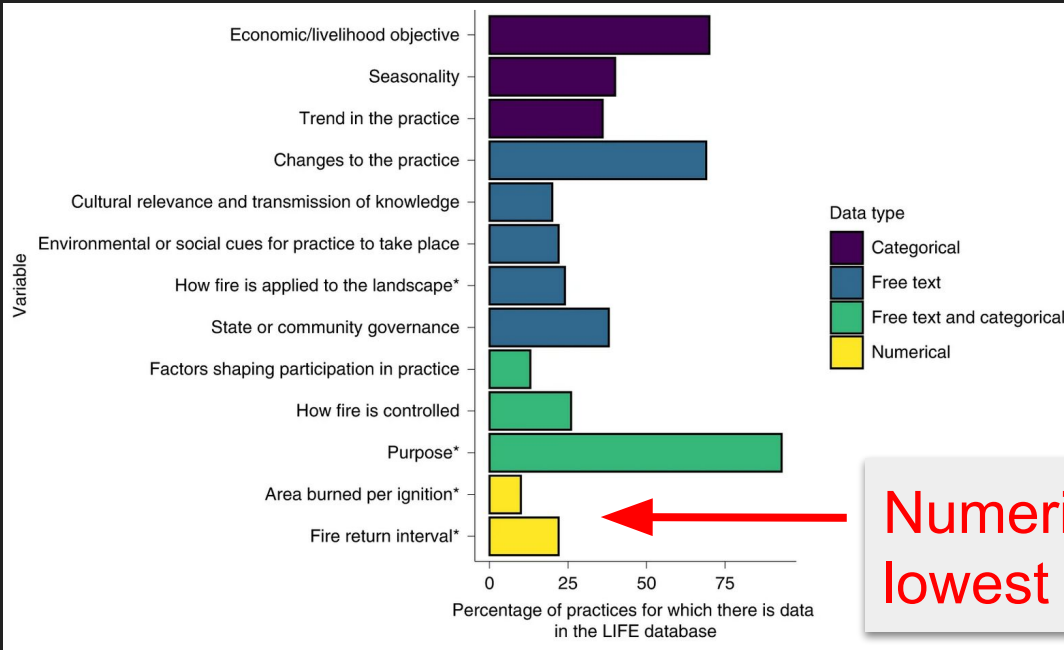
Paper:
Perkins et al. (2024)

Quantitative Estimates

Global BA by agent type based on relatively *low sample sizes*



LIFE Variable data completeness



DAFI

Only half of studies on Hunt-Gathering provided quantitative metrics

Numerical variables have lowest representation in LIFE

*Not all fire users use formal quantification ...
but statistical and many simulation models do*

Other Challenges

Clandestine Activity

- Difficult to study and therefore an area of uncertainty
- No studies (3.5% of all) had quantitative metrics for arson
- Several GFUS responses highlight importance of illegal activities

Studies of Fire Absence

- LIFE highlights the loss of traditional fire practices
- Studies of (wild)fire mitigation and suppression are limited
- More studies needed on where fire is not used where it could be
- Longer-term understanding of absence (e.g. land abandonment)

Summary

Good progress collating/analysing data globally, but challenges and gaps in data and understanding remain

- **Spatial Coverage:** language, areas of change
- **Fire Use in DGVMs:** model fires, not ignitions - but better data needed!
[see **Kasoar *et al.* (2024)**]
- **Clandestine Activity:** need more studies on effects of state bans, arson
- **Mitigation and Suppression:** far fewer studies than of fire use
- **Long-term change:** understanding pre-1990s fire use
- **Qualitative Emphasis:** mixed methods studies? e.g. with RS