Estimating historical elephant treefall rates across Africa: a quantitative analysis

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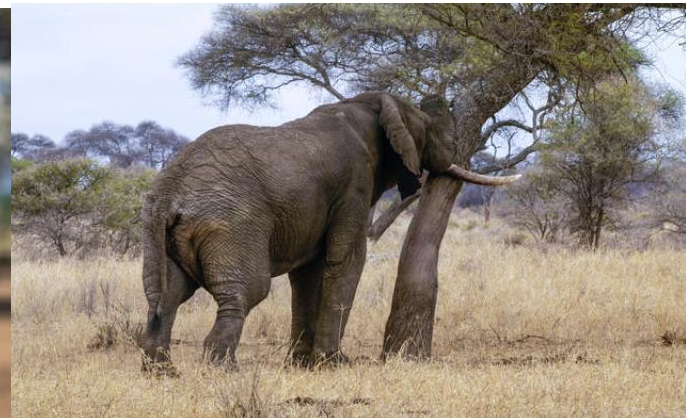





Co-authors

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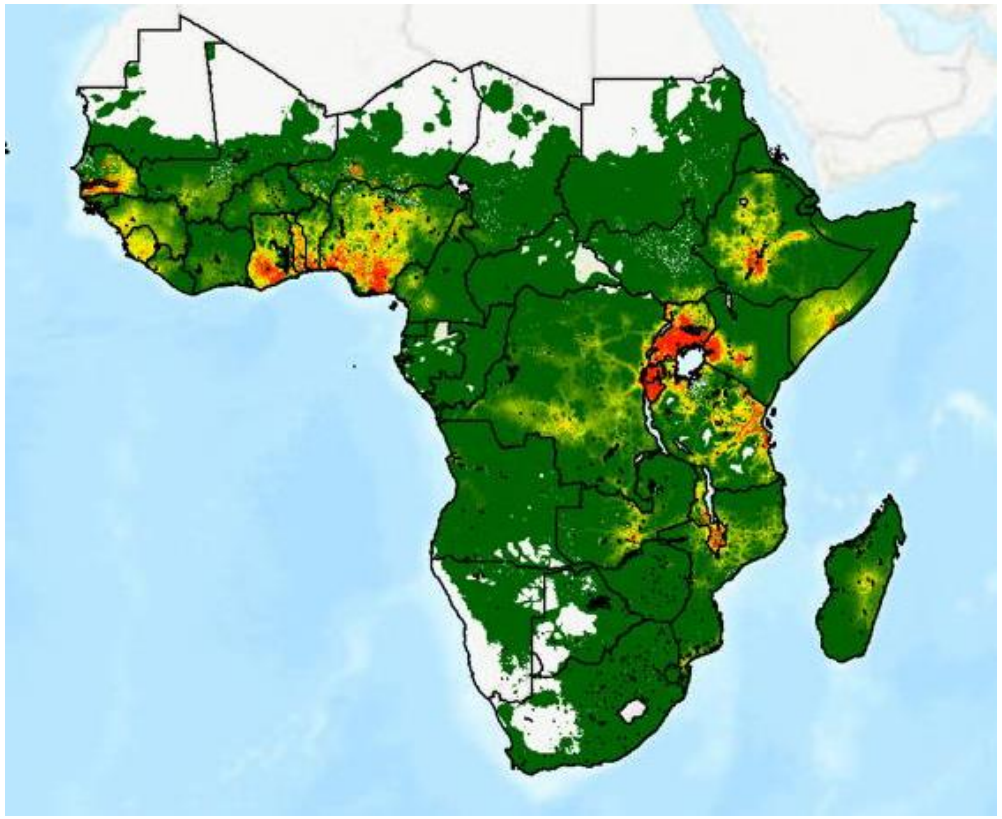
Sustainable use:

- Use that doesn’t degrade the resource (economic definition)
  - Difficult, but possible, to quantify
- Use that doesn’t degrade the ecosystem or biodiversity (ecological definition)
  - Very difficult (?impossible?) to quantify
  - Often what people want to achieve

Current approaches to estimating sustainable fuelwood use:



Fuelwood harvesting rates

Fraction non-renewable biomass (fNRB):

What proportion of harvested biomass does not grow back?

Table ES1: Regional fNRB values

Region	fNRB	Std deviation
Asia	17%	22%
Latin America	33%	14%
Sub-Saharan Africa	39%	17%
Global	32%	18%

MoFuSS: Modelling Fuelwood Saving Scenarios, Adrian Ghilardi and Rob Bailis 2024

MoFuSS harvesting example:

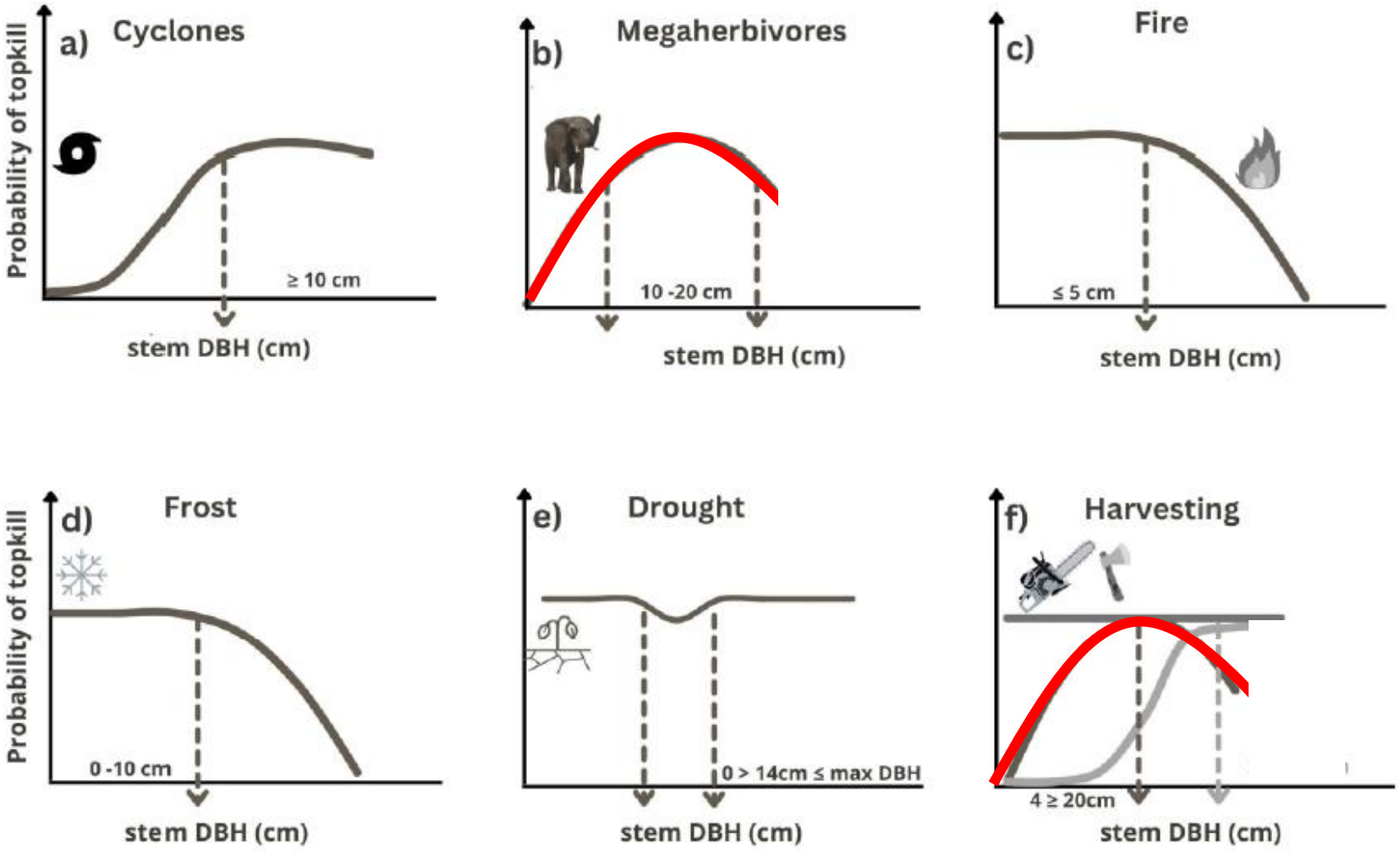
- Doesn’t grow back == not sustainable.
- Useful from a resource management perspective (maintaining resource for people into the future).
- Not really meaningful ecologically in systems that are dynamic:
  - Ignores decades of non-equilibrium thinking that has provided good insights and appropriate management tools.

A different approach:

- What level of tree top-kill did different African ecosystems evolve with?
- Can we use this to identify “ecologically appropriate” human resource use of woody plants.

Elephants used to knock over a lot of trees in Africa. Now, in most landscapes, they don’t.

- Shouldn’t we still be knocking over these trees?



Mtsetfwa and Archibald in review Current Biology:

Human preferences are similar to elephant preferences: same size classes targeted

(but often different species)

Goals

1. Quantifiable insights about the scale and magnitude of elephants in the past.
2. Reframe discussions around degradation, restoration and sustainable use
3. Motivate to advance thinking about measuring and modelling elephant disturbances

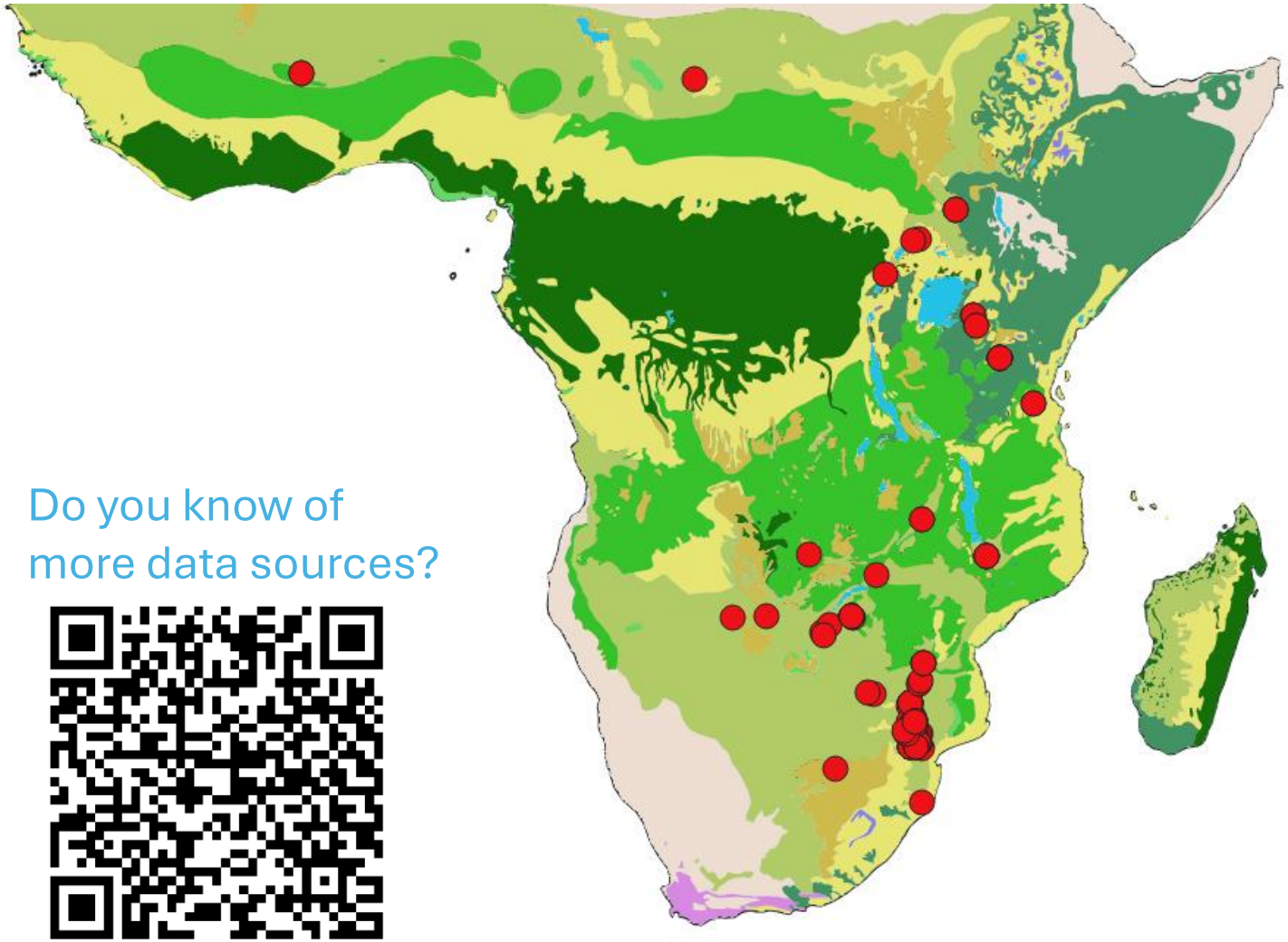
Methods: Quantitative data on tree toppling rates

- Literature review: studies that quantify elephant impacts by:
  - # trees knocked down per ha year OR
  - % trees knocked down per year OR
  - Trees knocked down per elephant per day
- These forms of data allow us to quantify a “tree toppling rate” that can be converted to biomass
- Also recorded:
  - Scale of study (plot, landscape, region)
  - Size classes considered
  - Type of data collection (tagged trees, aerial photographs, lidar etc).

NB: The index used reveals author assumptions:

- **% trees toppled** assumes the number of topplings is proportional to the number of trees
  - for constant elephant density, double the tree density equals double the toppling rate.
- **# trees toppled/ha** assumes the number of topplings is independent of the number of trees.
  - for constant elephant density, double the tree density equals the same toppling rate
  - i.e. low tree cover systems are more affected by elephants.
- WHICH IS MORE REALISTIC?
  - No agreement in the literature (Tafangenyasha, Abrahams, Dunham…)
  - Models often try to incorporate both: eg Duffy 1999

Data sources

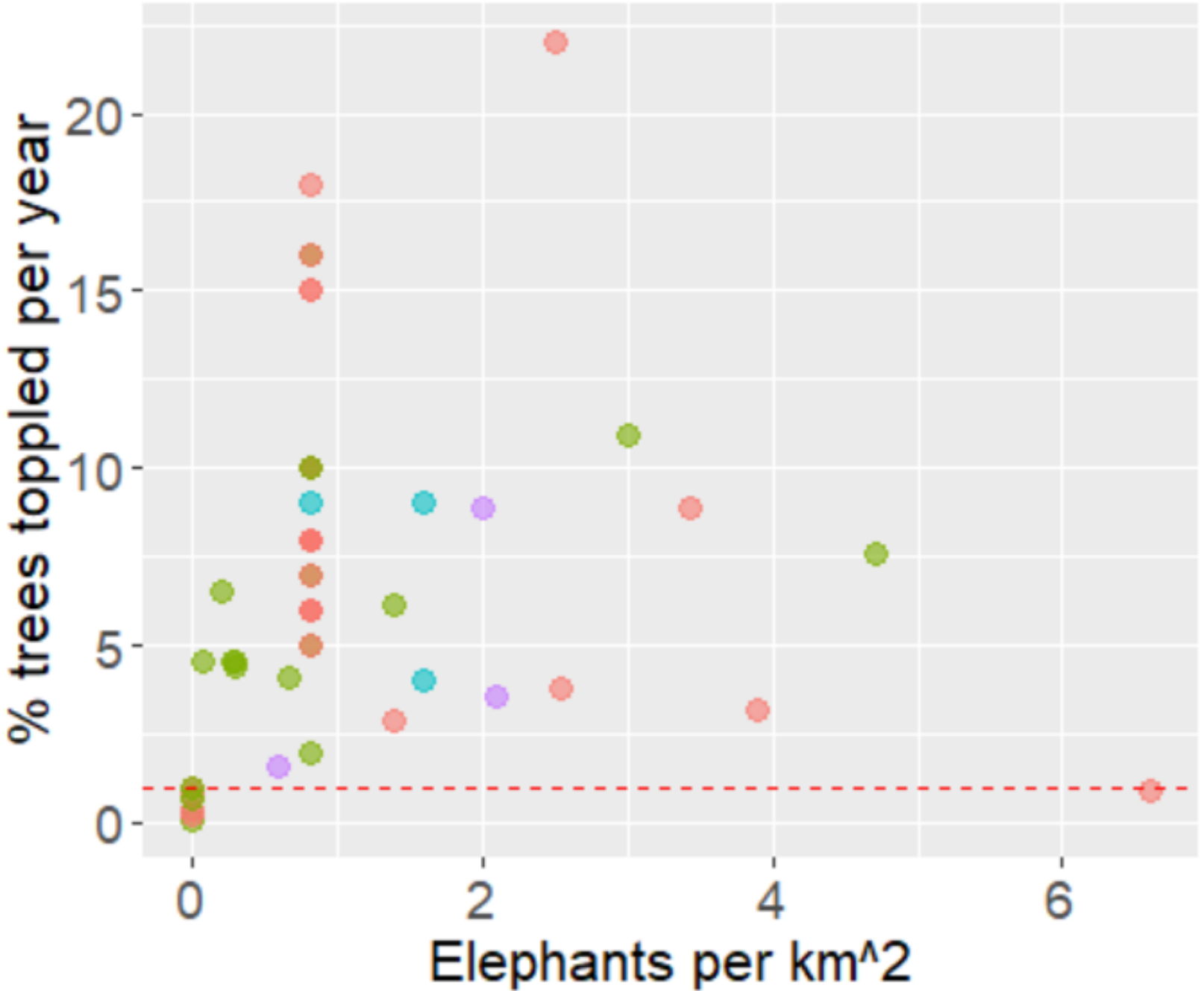


Do you know of more data sources?

Vegetation type	N datapoints
mixed Acacia	22
mixed Combretum	27
Mopane woodland	5
Miombo woodland	7

Datasets of sufficient extent (no isolated small plots)

Datasets where most tree size classes were sampled (not just very large trees).



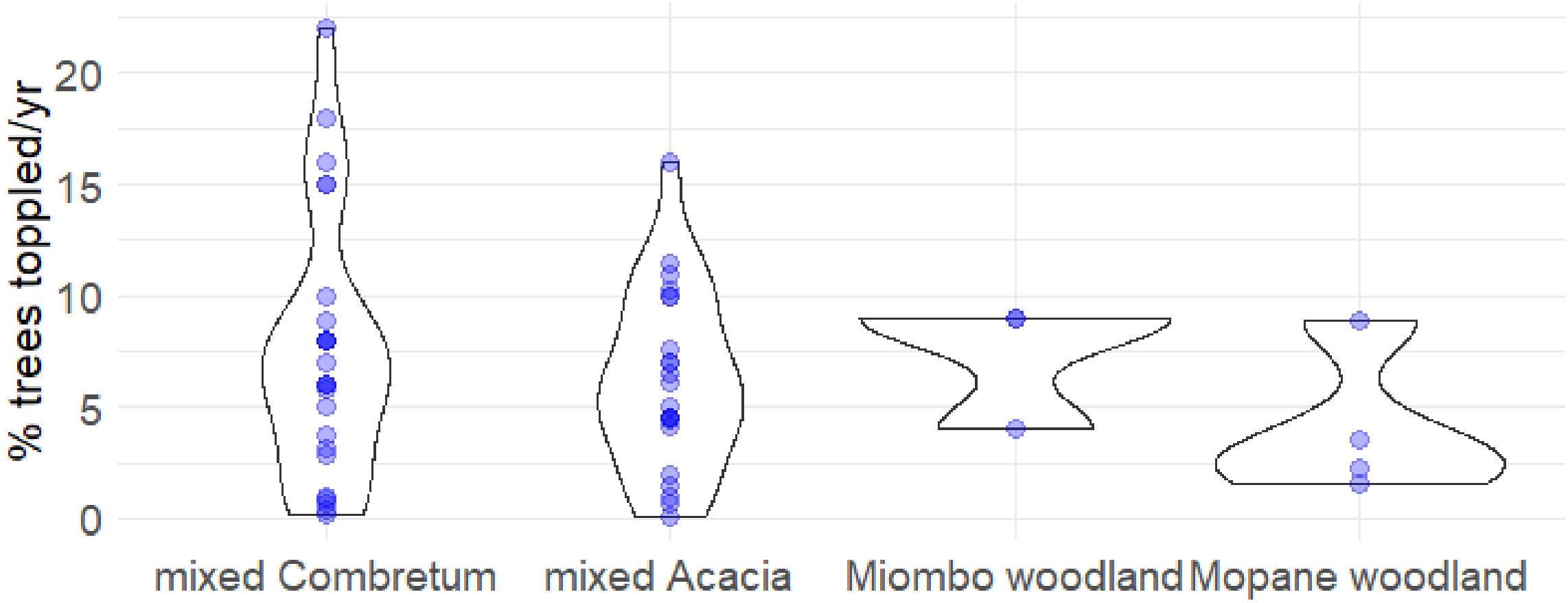
Results:

Maximum background rate: 1.4%

With elephants, always higher than background

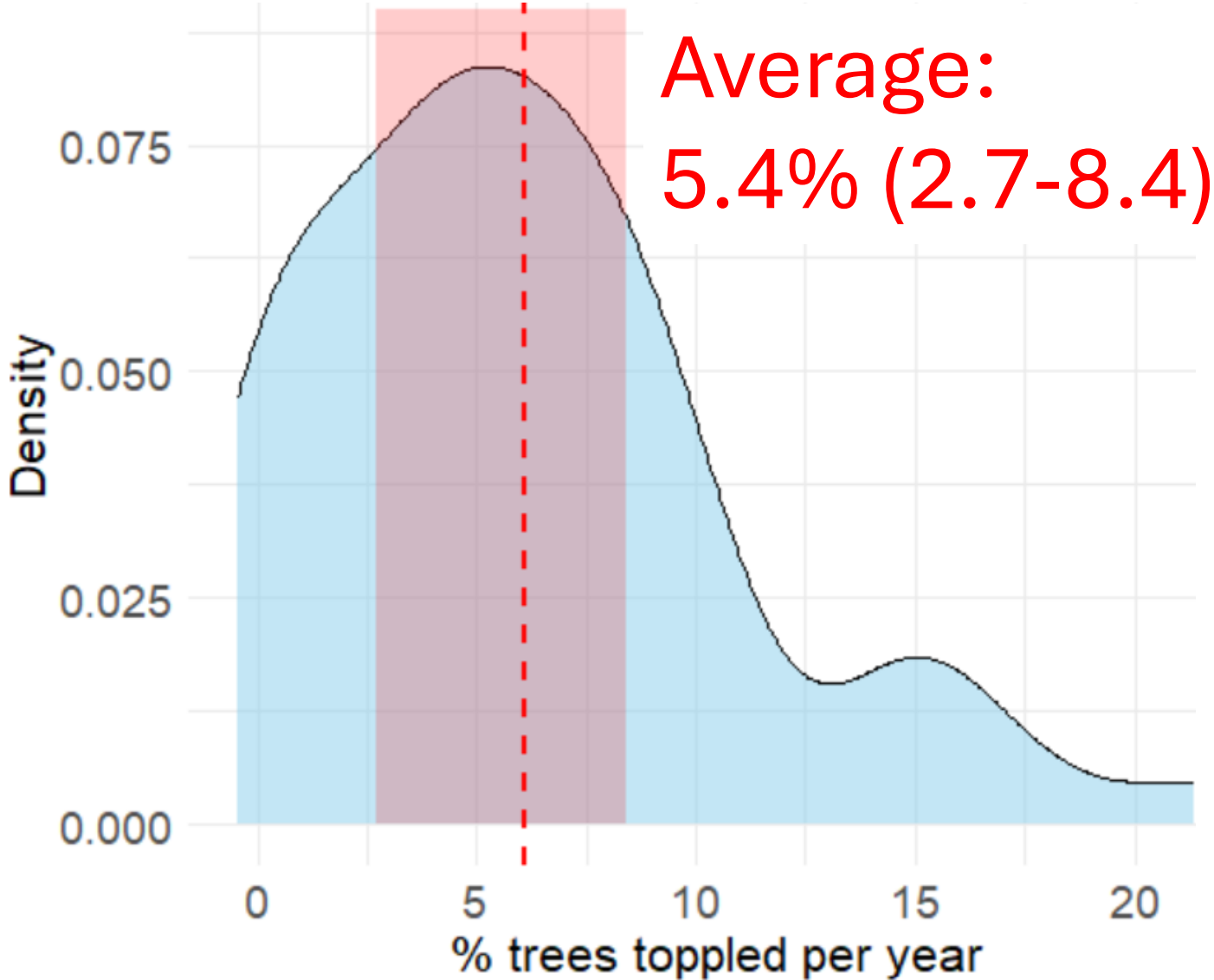
mixed Combretum
mixed Acacia
Miombo woodland
Mopane woodland

Results



No evidence for differential damage between vegetation types – more data needed

What can we say about tree turnover by elephants in African savannas?

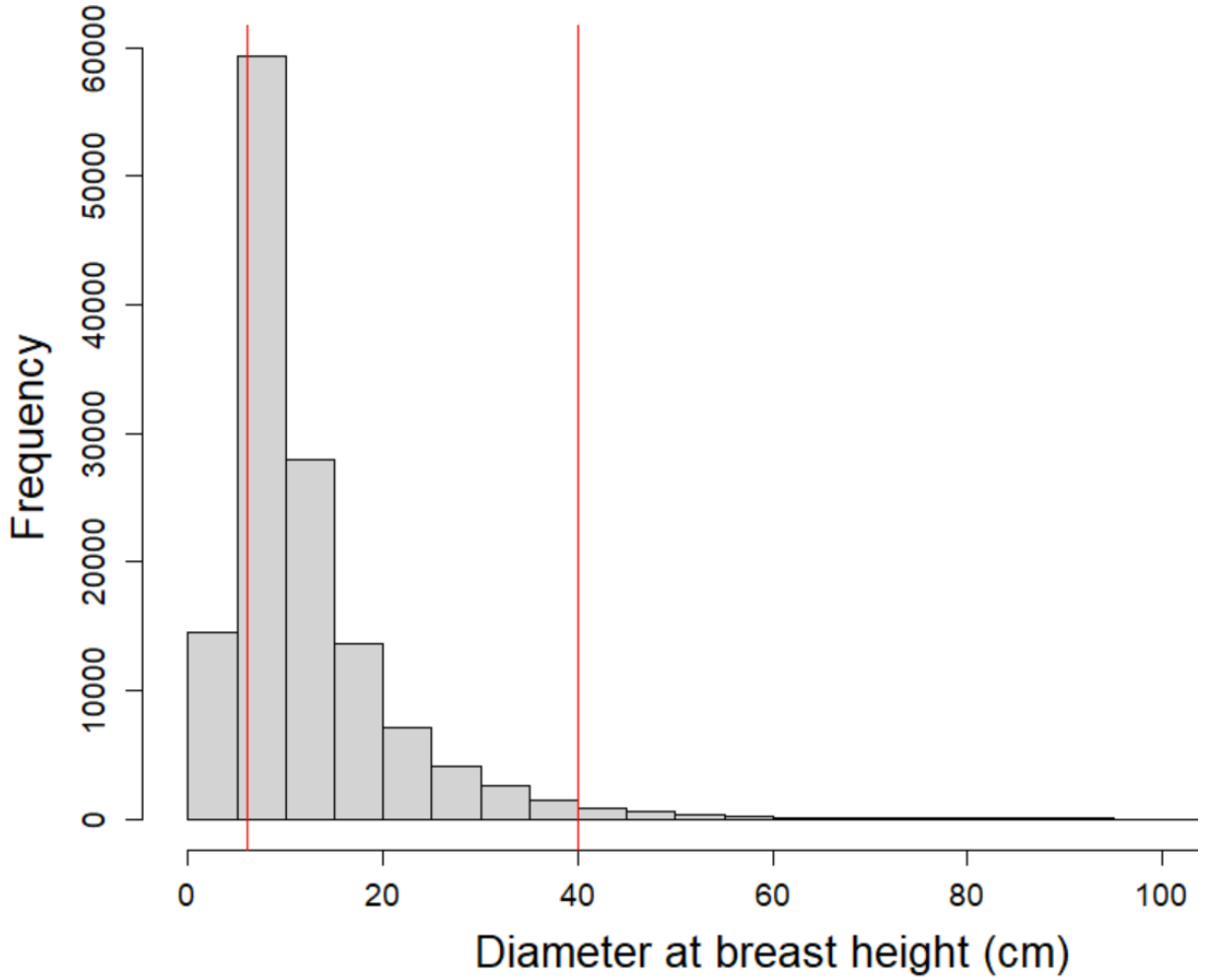


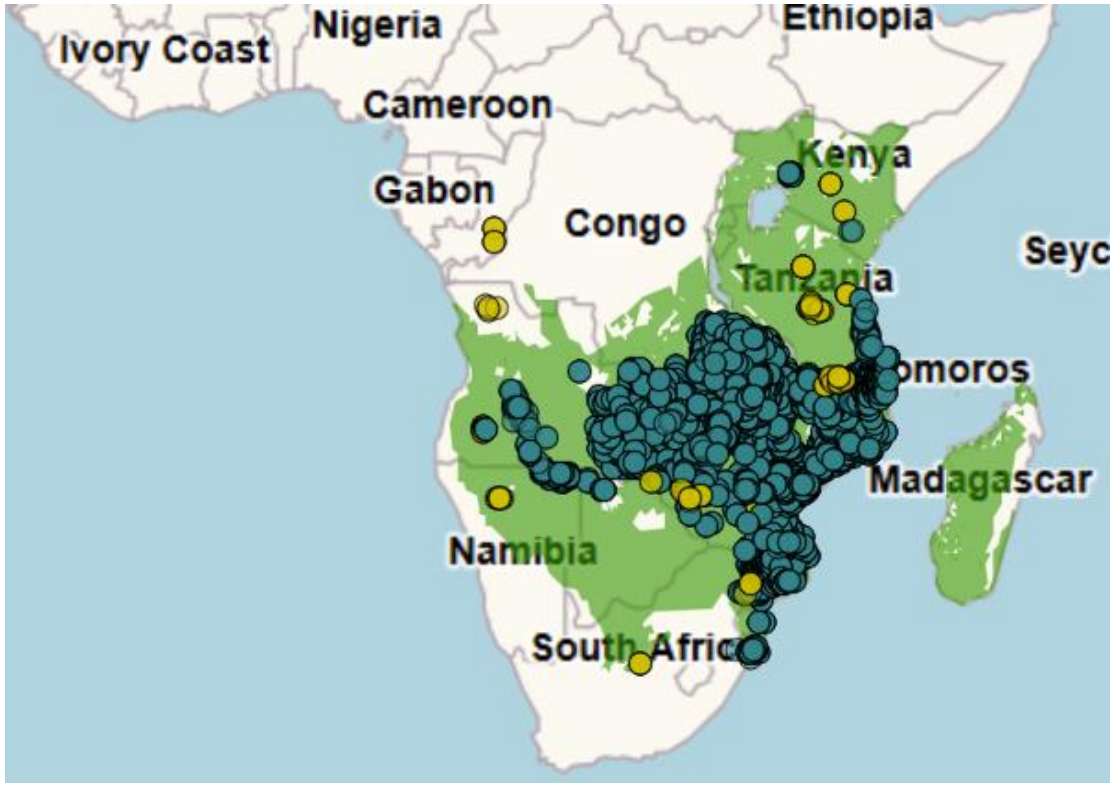
Rates < 2.7% are extreme

Rates > 8.4% are extreme

Note: not all of these trees are big

Converting from trees toppled to biomass lost



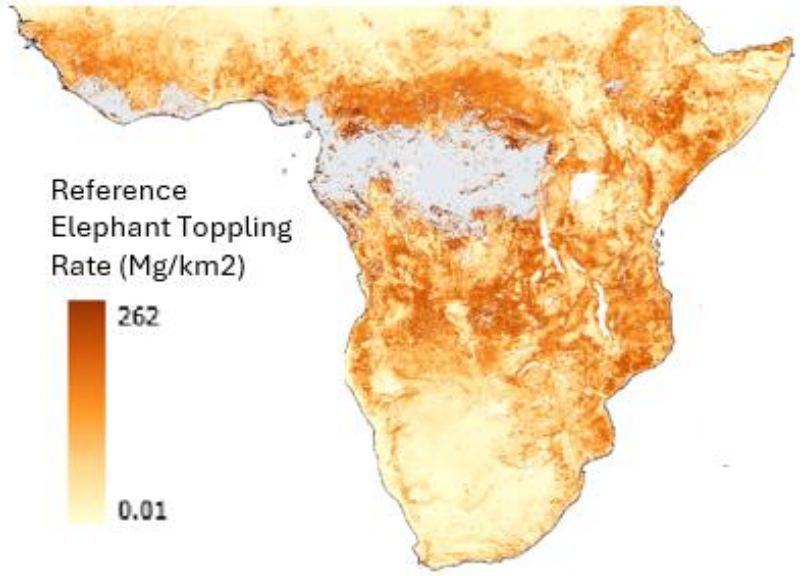


SEOSAW stem data from ~ 8976 plots across Africa: counts, diameter and biomass

https://seosaw.github.io/

Estimated historical biomass turnover by elephant

b



Compare with current human wood fuel consumption

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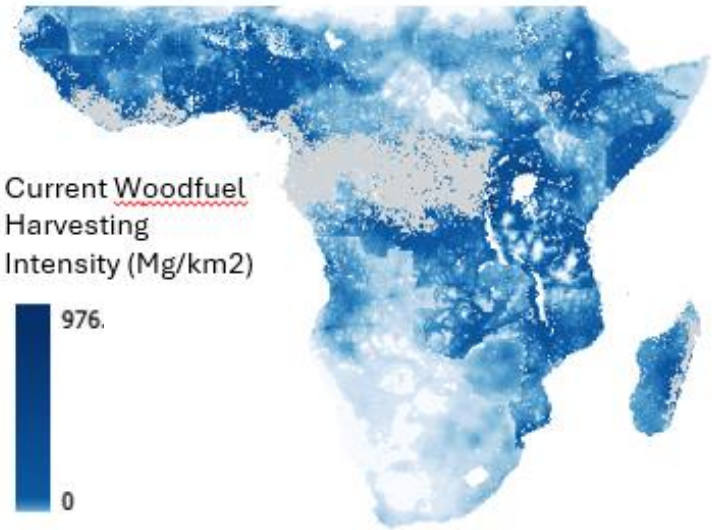

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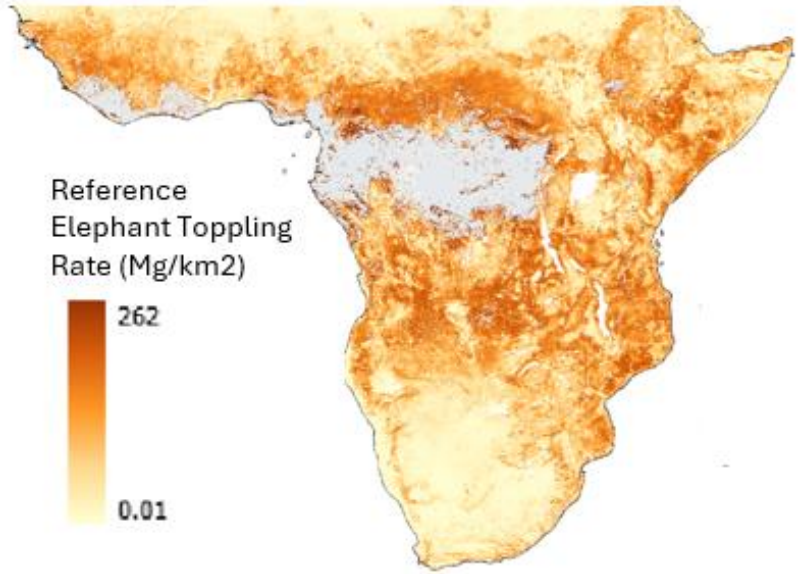
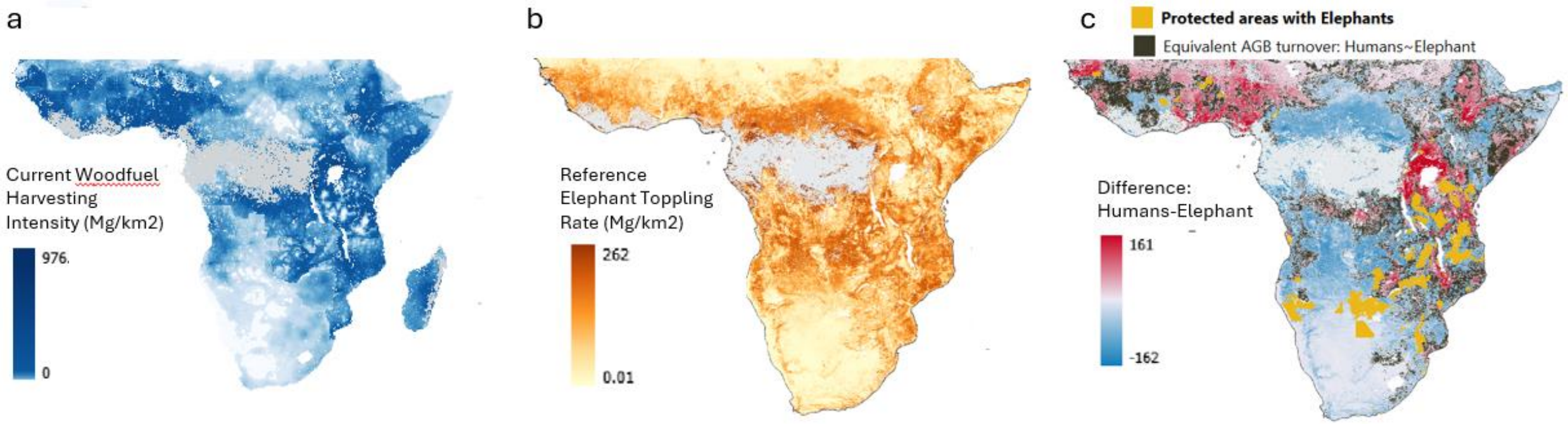
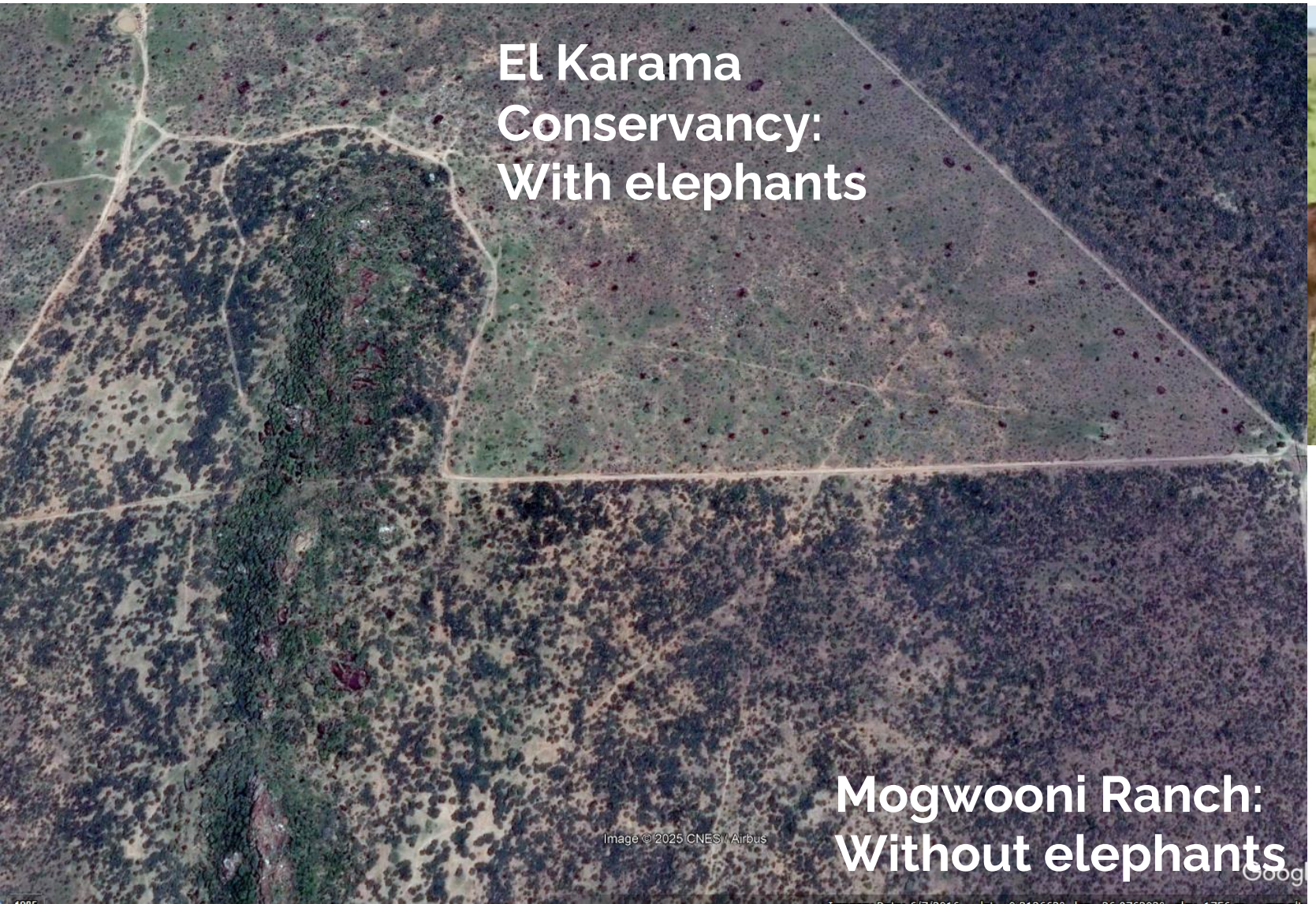


Map places with ecologically relevant rates of woodfuel harvesting



Black areas: human impacts are equivalent to the range of elephant impacts expected
Red – human impacts higher, Blue – human impacts lower, Yellow – ecosystems with elephants

In Kenya cattle farmers use people to maintain ecological functioning without elephants:



Mogwooni ranch hires people to harvest charcoal to maintain open savanna and control *Acacia drepanolobium:*
“rewilding with people”

Discussion:

Elephants are a problem: why compare one problem (elephants) with another problem (fuelwood harvesting)?

- Elephants have been knocking down between 2% and 8% of trees per year across Africa for a long time.
- The system has evolved with this "problem"

know of more data sources?

Lets value these landscapes for what they are:
Intact ecosystems within the expected range of structural variation.

What are we doing?

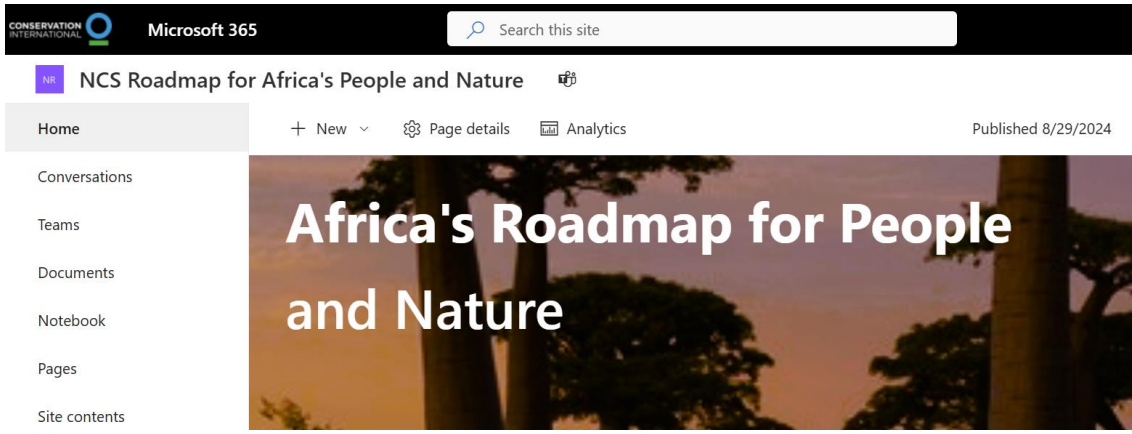
Working with global NGOs to recalibrate global opinions about restoration, carbon sequestration opportunities, and fuel wood harvesting

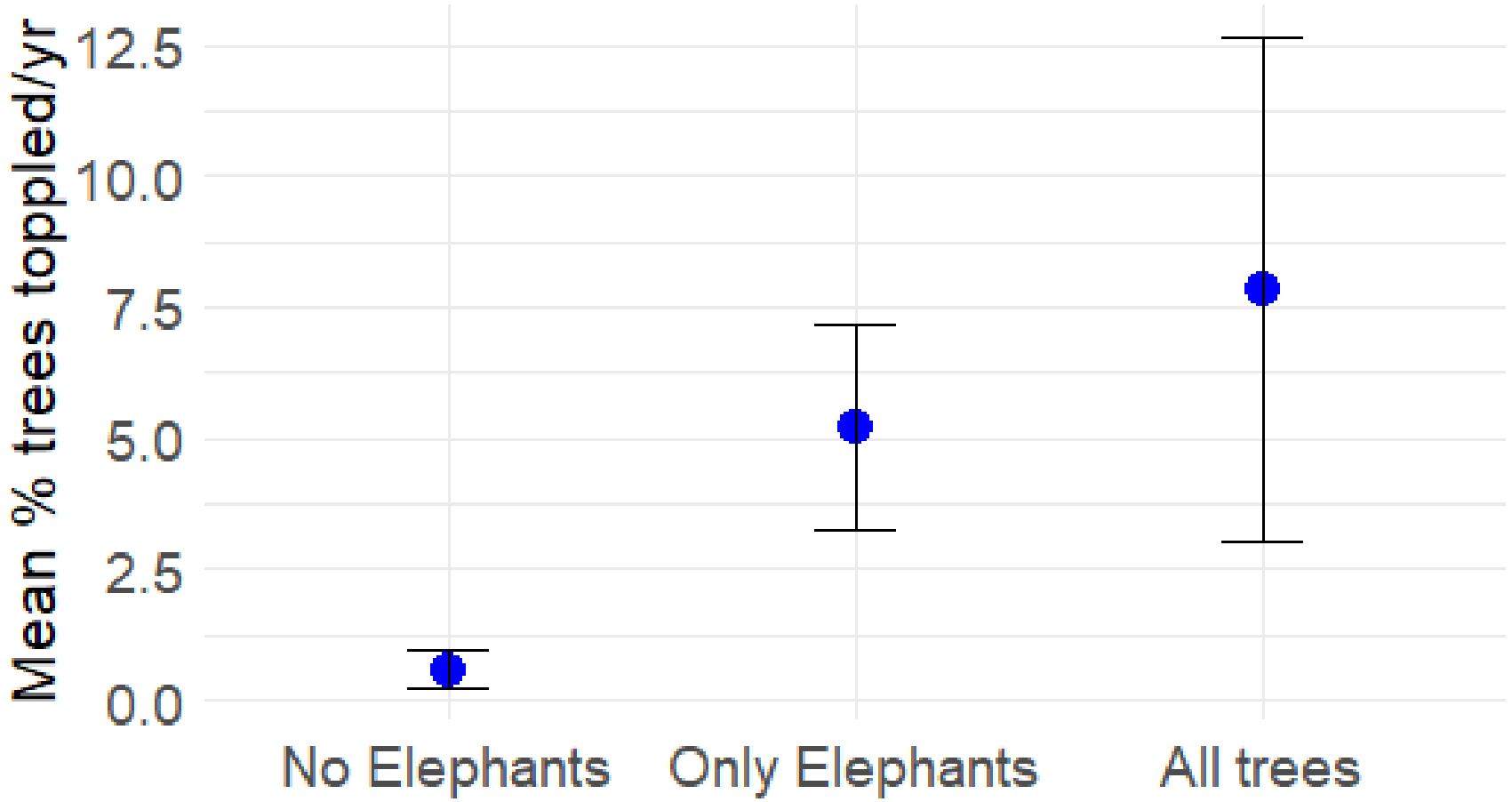
Sometimes the **appropriate intervention** is to hire people to come onto land and **cut down trees**.....our concepts of **restoration** and **rewilding** need to accommodate that

Bring ecological thinking into plans for Natural Climate Solutions in Africa

know of more data sources?

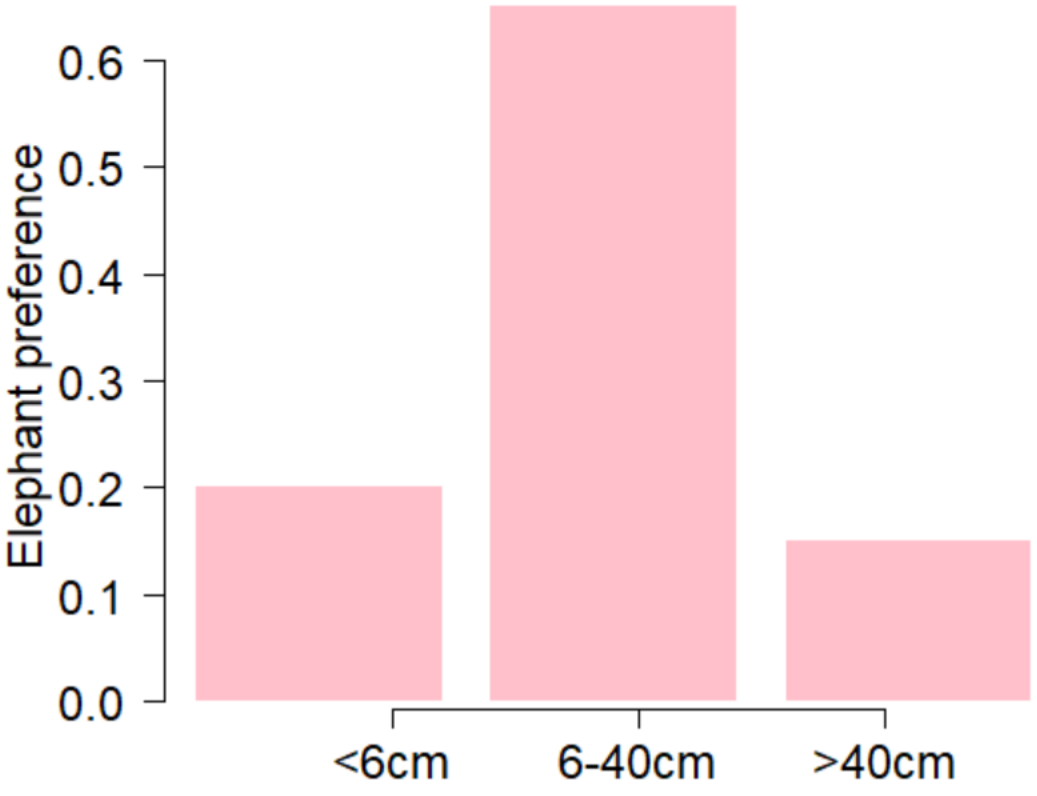
https://futureecosystemsafrica.org/



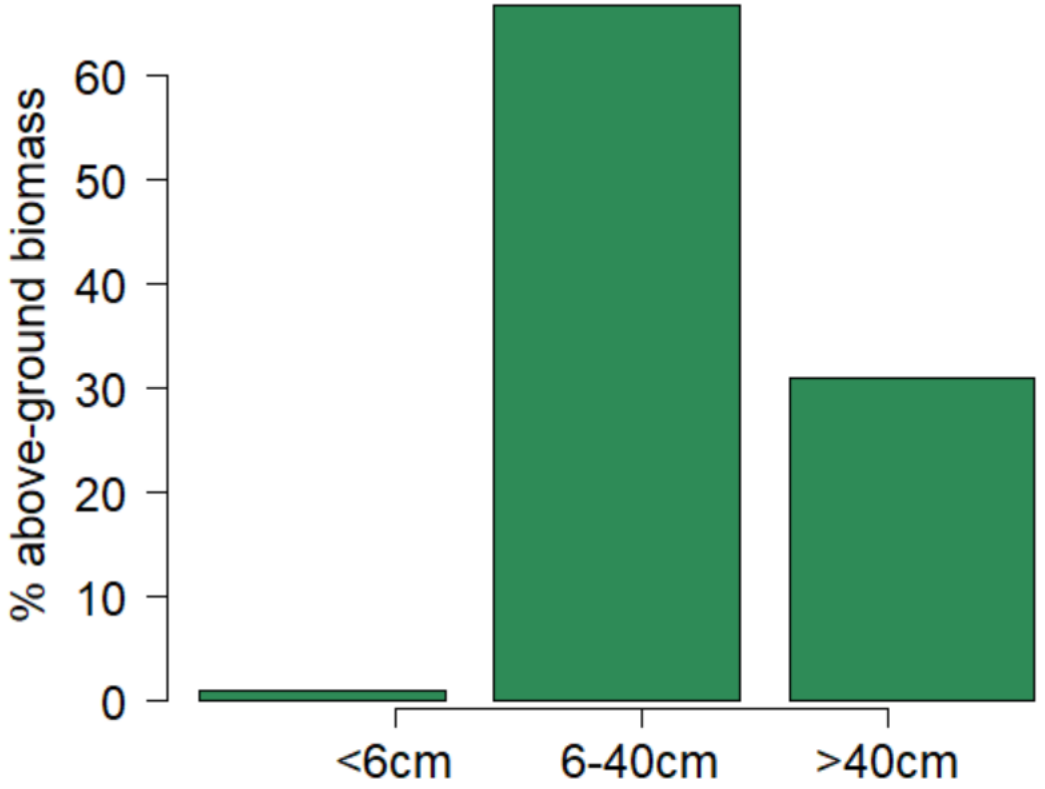


Effects are not additive: Elephants increase the background rate of tree death

Converting from trees toppled to biomass lost

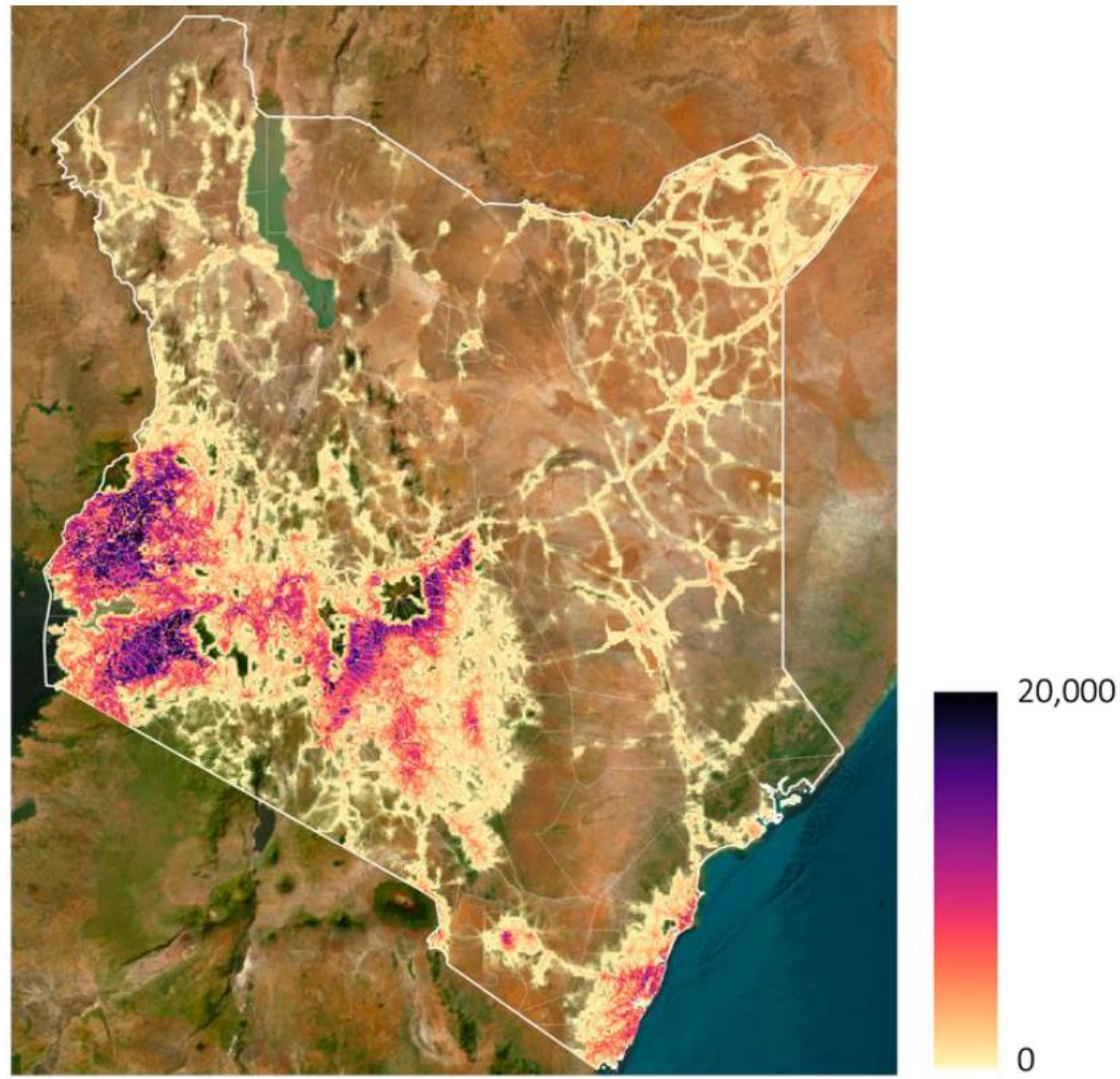


Proportion toppled trees in each size class (from meta-analysis)



Percentage biomass in each size class (from SEOSAW plots)

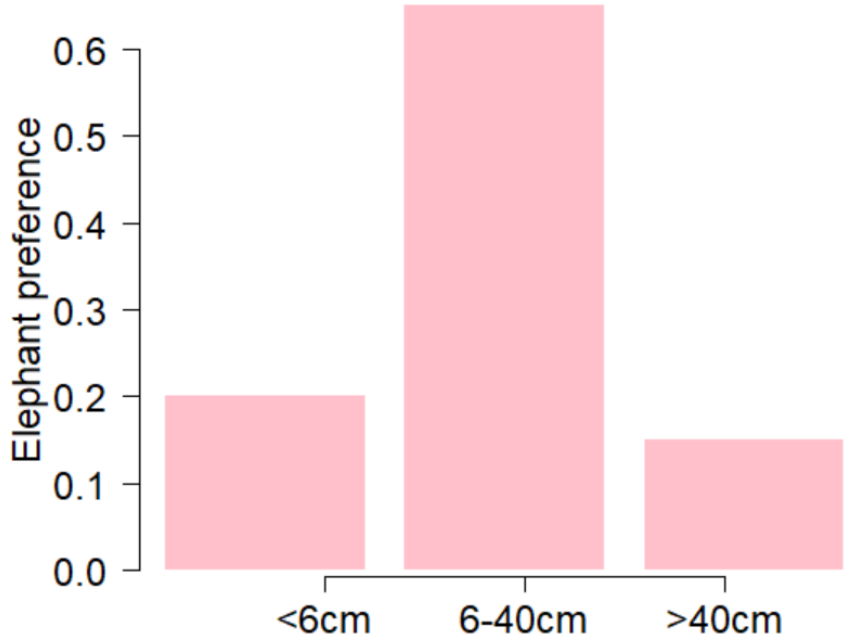
Figure 5: Woodfuel consumption between 2010 and 2050 measured in tons per km²



Methods: Estimating toppling rates in different landscapes

- Chose to work at a landscape scale (i.e. differential elephant impacts within the landscape ignored for this analysis).
- Looked for predictors by:
  - Elephant density
  - Tree density
  - Vegetation type

- Elephants as episodic disturbances?
  - Better theoretical framework to use.



X percent of the trees toppled were 6-40cm, so x% of the 6-40% biomass is removed
Do this for each size class and sum.