



# Projecting the Future of African Rangelands under Climate Change using the Af-Range Ecosystem Model

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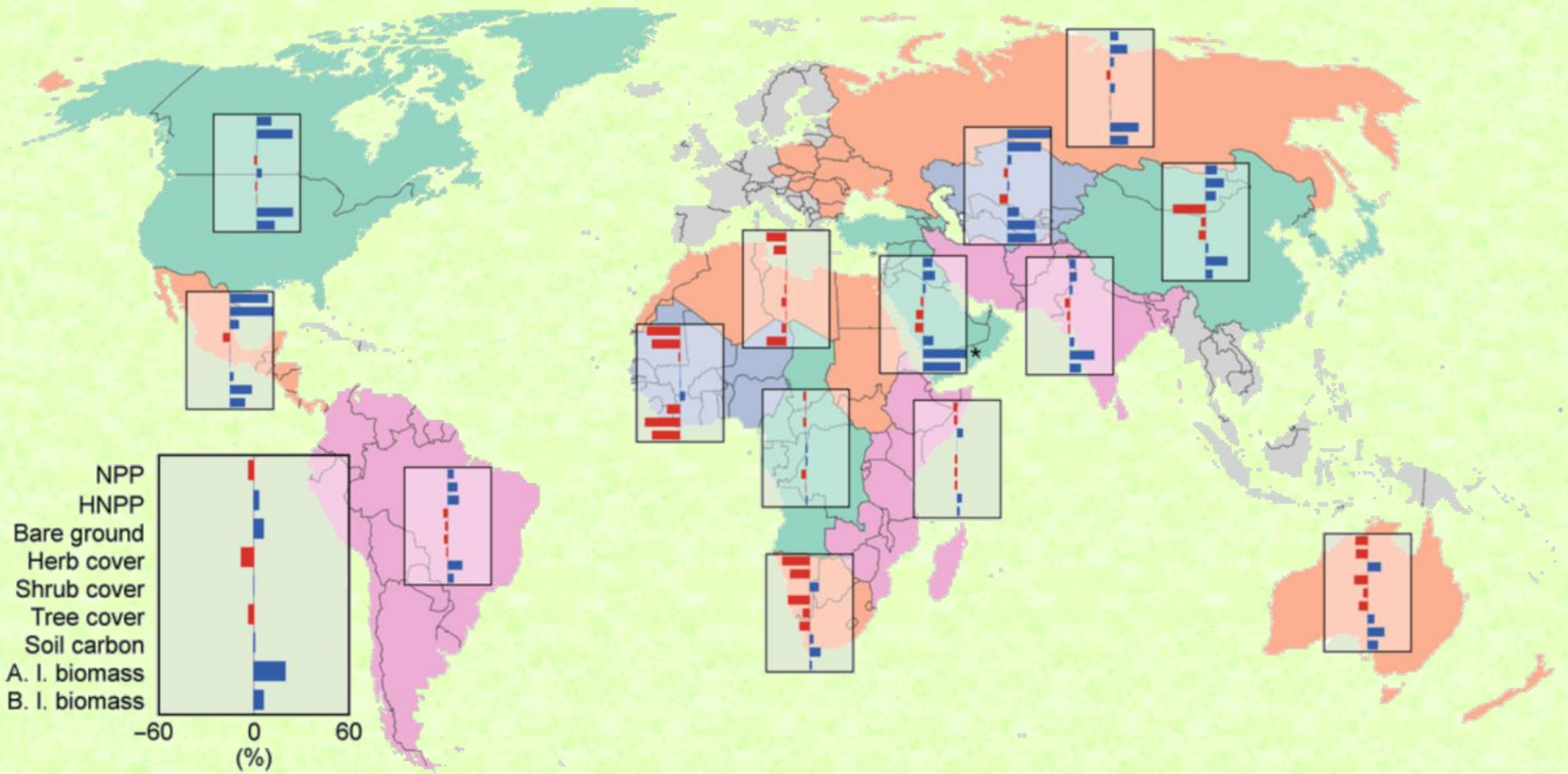
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Colorado State University





NPP – Annual net primary production  
HNPP – Herbaceous annual net primary production

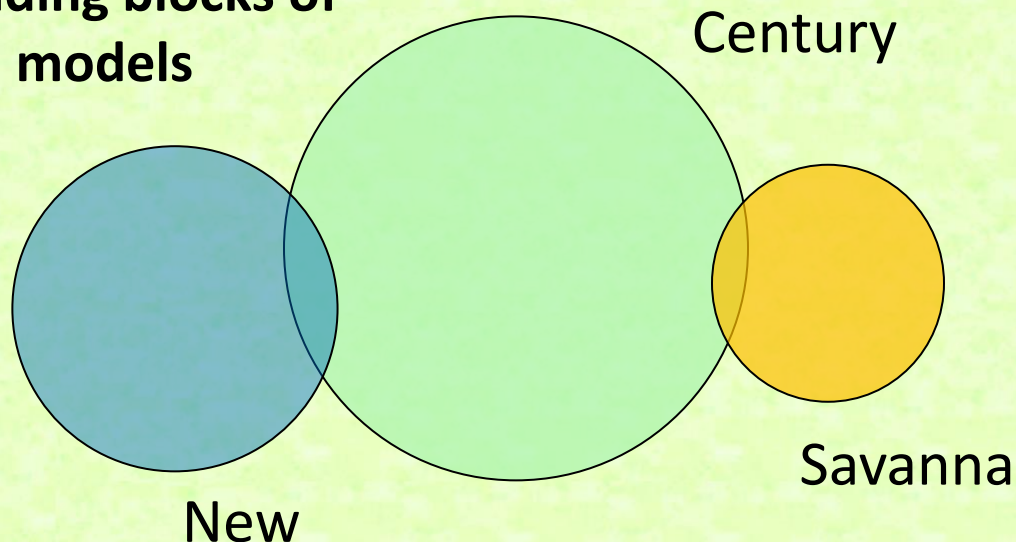
A. I. biomass – Aboveground live biomass  
B. I. biomass – Belowground live biomass

Boone et al. (2018)

We created the **L-Range** suite of models to:

- Represent rangelands, although used more broadly now
- Respond to main climate variables
- Represent main functional biomass groups
- Responsive to fire, grazing intensity, and other management practices

The building blocks of  
L-Range models



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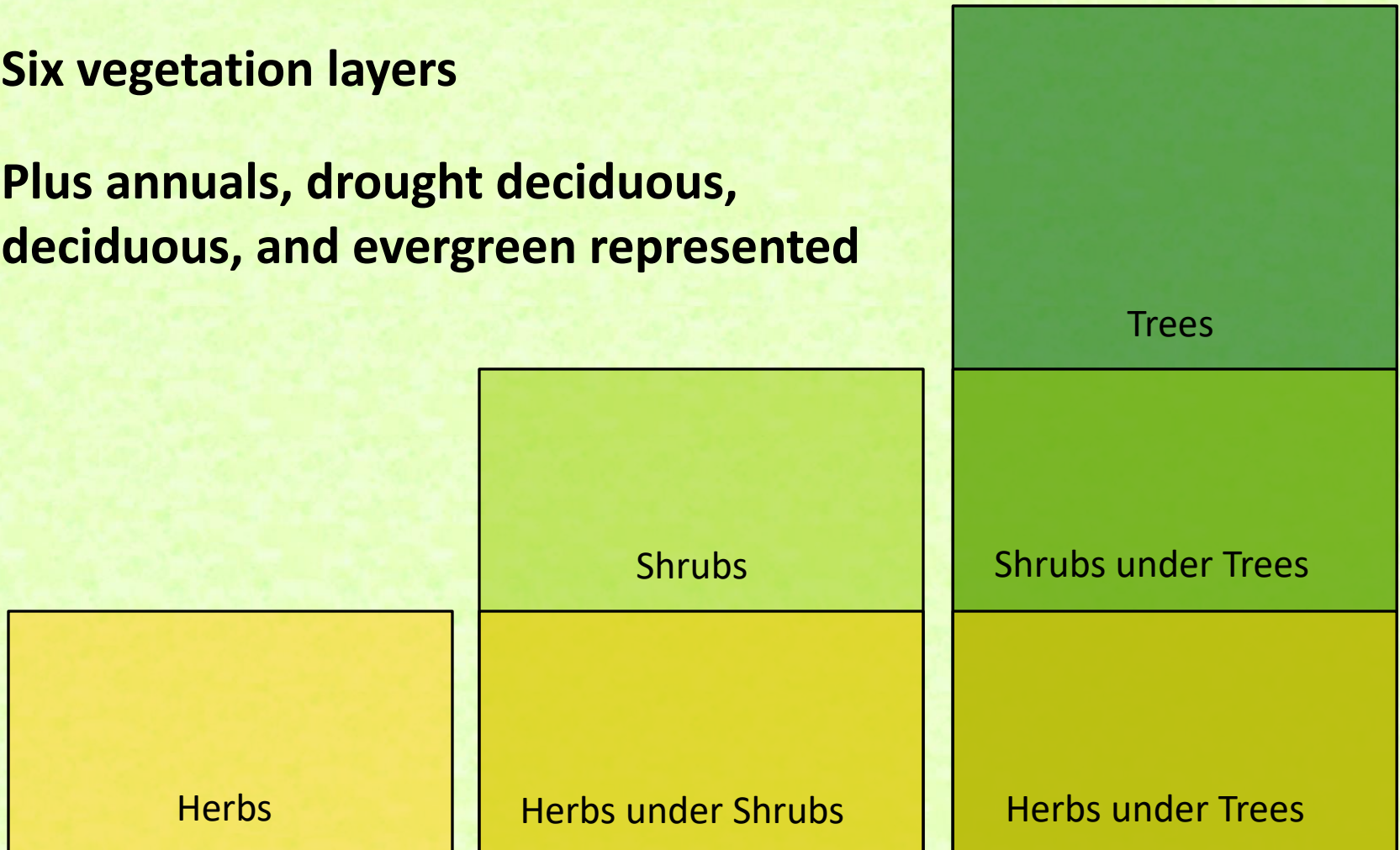
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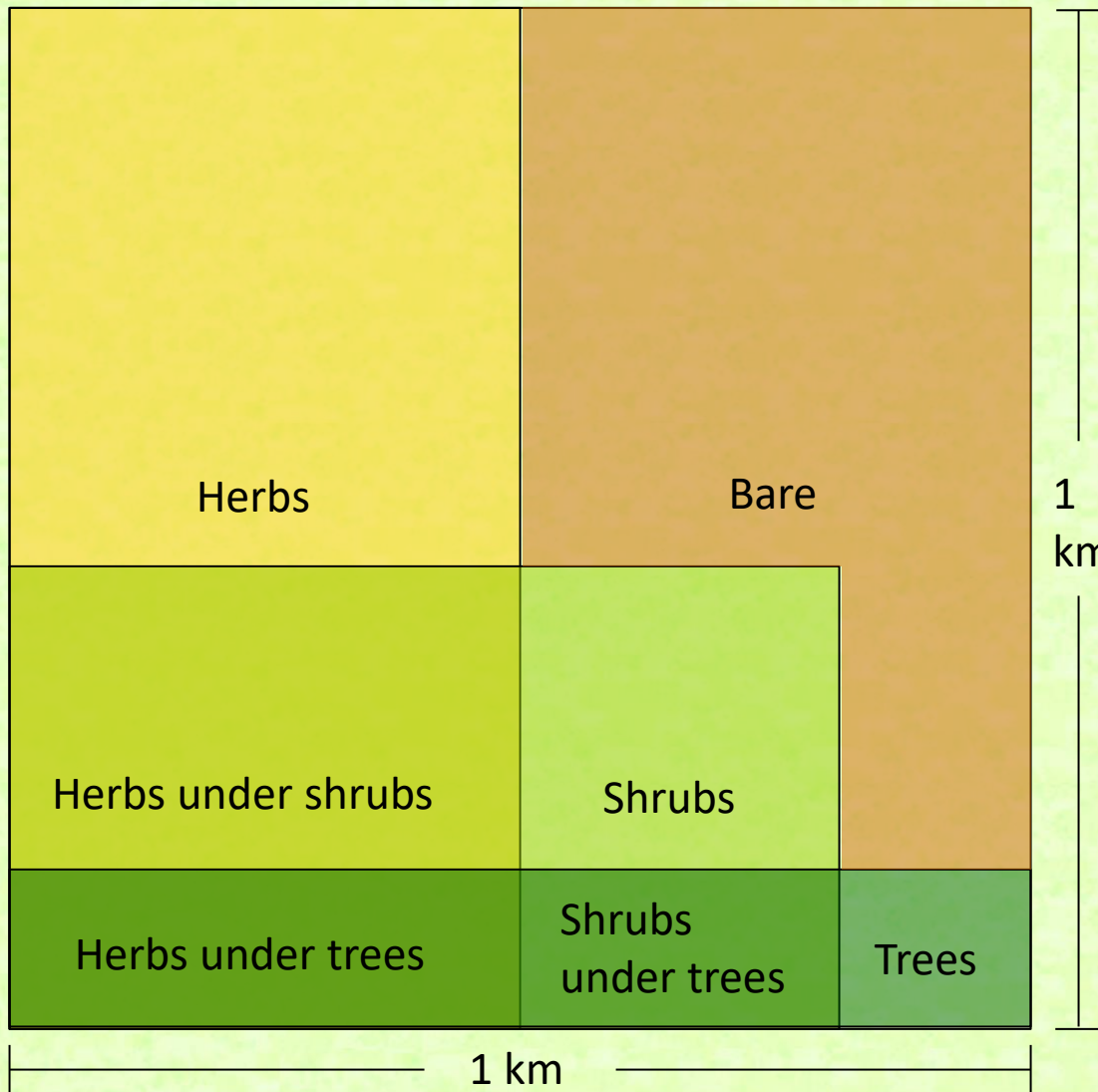


**Three vegetation facets**

**Six vegetation layers**

**Plus annuals, drought deciduous,  
deciduous, and evergreen represented**





**Populations on a 1 km<sup>2</sup> area per land unit are simulated**

**Establishment influenced by:**

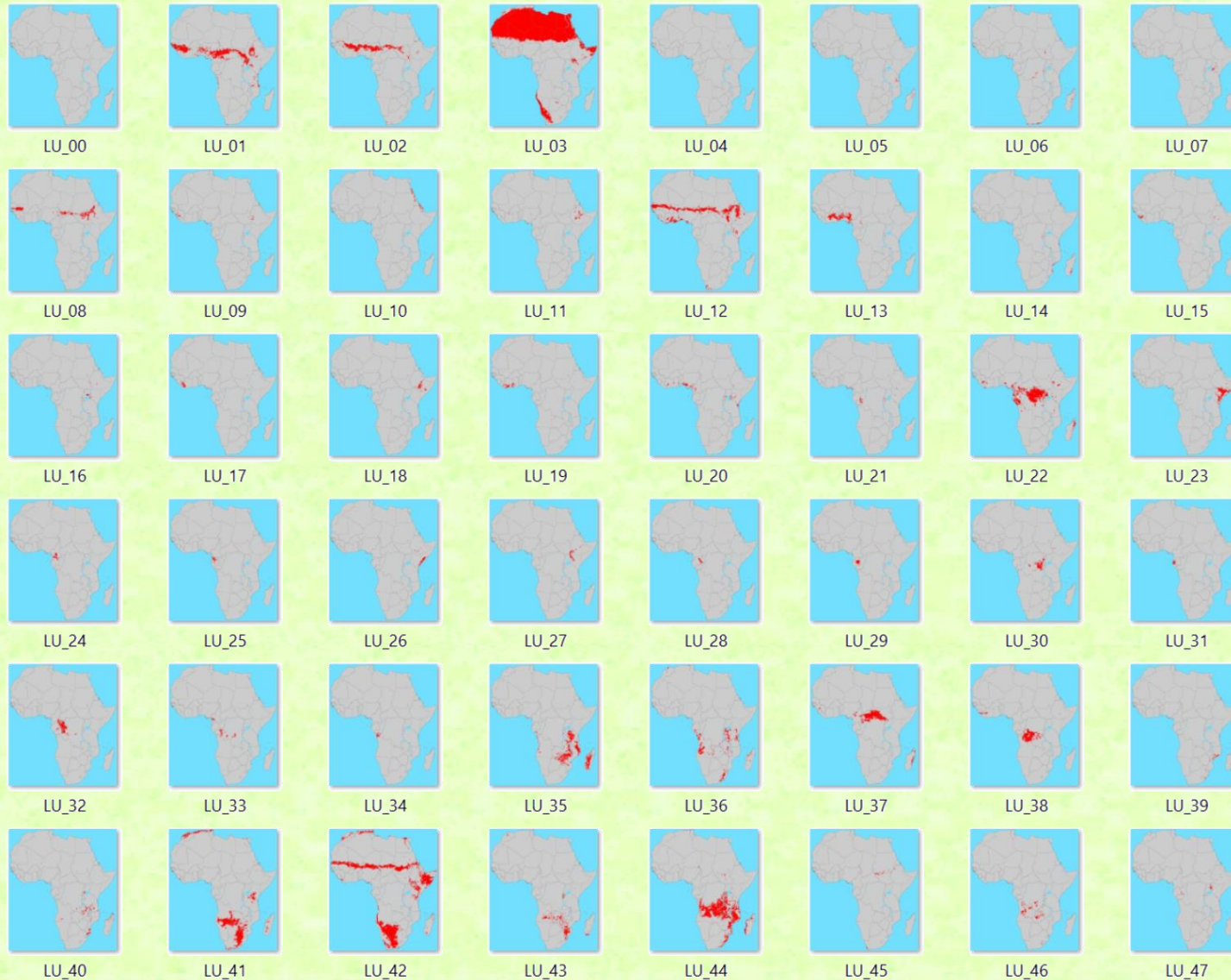
- Relative seed production
- Water:PET
- Surface litter
- Herbaceous roots
- Woody cover

**Death influenced by:**

- Nominal death rate
- Water:PET
- Grazing
- Annuals
- Shading



# Differences in landscapes are addressed with different landscape units





## Herbivores are Represented

Each 20 x 20 km landscape cell includes 10 herbivore populations

They can be set up to represent anything a user wishes

In the draft application seven are used and they are:

- Cattle
- Goats
- Sheep
- Camels
- Donkeys
- Wild grazers
- Wild mixed grazer-browsers



## L-Range:

**130+ (selectable) spatial surfaces produced each month**

### Such as:

- Heat accumulation and Plant phenology
- Facet cover (herbs, shrubs, trees); Bare cover
- Total above- and belowground biomass
- Shrub and tree carbon and nitrogen
- Fast, Intermediate, and Passive soil carbon and nitrogen
- Monthly net primary production
- Litter structural and metabolic carbon and nitrogen
- Leaf, Seed, Fine and Coarse branch and root carbon, nitrogen
- Leaf area index
- Fire severity and Burned carbon and nitrogen

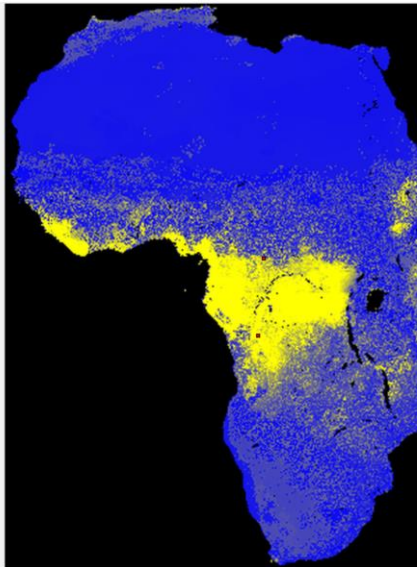
# Tree cover (%)

## Fraction live biomass removed by grazing (prop.)

## Total aboveground live biomass (g m<sup>-2</sup>)

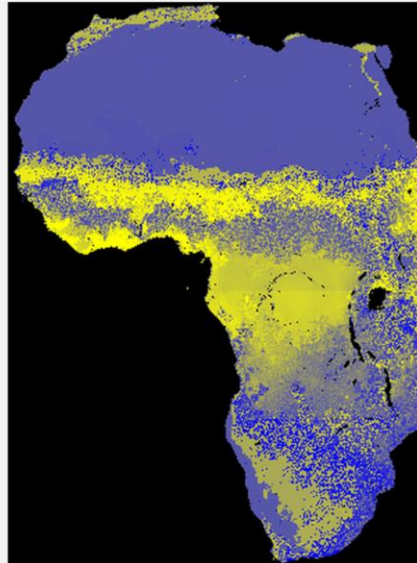
AF-Range Viewer

- total\_aground\_live\_biomass
- total\_bground\_live\_biomass
- total\_litter\_carbon
- total\_litter\_nitrogen
- root\_shoot\_ratio
- tree\_basal\_area
- soil\_surface\_temperature
- sand
- silt
- clay
- mineral\_nitrogen
- field\_capacity
- wilting\_point
- soil\_total\_carbon
- tree\_carbon
- live\_nitrogen
- shrub\_carbon
- shrub\_nitrogen
- carbon\_nitrogen\_ratio
- fast\_soil\_carbon
- intermediate\_soil\_carbon
- passive\_soil\_carbon
- fast\_soil\_nitrogen
- intermediate\_soil\_nitrogen
- passive\_soil\_nitrogen
- potential\_production
- belowground\_pot\_production
- aboveground\_pot\_production
- total\_pot\_production
- co2\_effect\_on\_production
- total\_pot\_produced\_limited\_by\_n
- monthly\_net\_primary\_prod
- fraction\_live\_removed\_grazing
- fraction\_dead\_removed\_grazin
- temp\_effect\_on\_decomp
- water\_effect\_on\_decomp
- anaerobic\_effect\_on\_decomp
- all\_effects\_on\_decomp
- dead\_fine\_root\_carbon
- dead\_fine\_root\_nitrogen
- dead\_standing\_carbon
- dead\_standing\_nitrogen



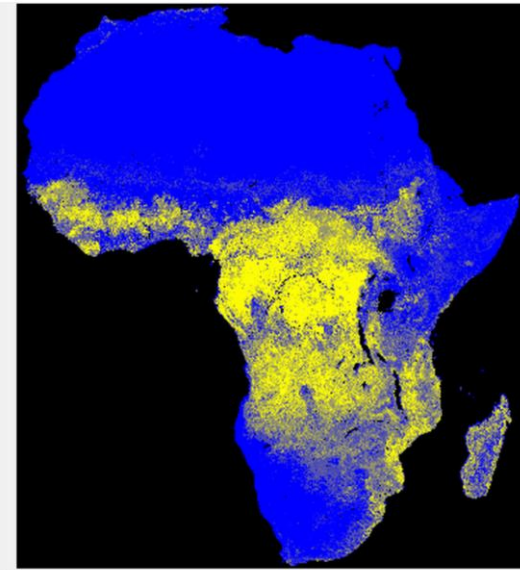
AF-Range Viewer

- intermediate\_soil\_carbon
- passive\_soil\_carbon
- fast\_soil\_nitrogen
- intermediate\_soil\_nitrogen
- passive\_soil\_nitrogen
- potential\_production
- belowground\_pot\_production
- aboveground\_pot\_production
- total\_pot\_production
- co2\_effect\_on\_production
- total\_pot\_produced\_limited\_by\_n
- monthly\_net\_primary\_prod
- fraction\_live\_removed\_grazing
- fraction\_dead\_removed\_grazin
- temp\_effect\_on\_decomp
- water\_effect\_on\_decomp
- anaerobic\_effect\_on\_decomp
- all\_effects\_on\_decomp
- dead\_fine\_root\_carbon
- dead\_fine\_root\_nitrogen
- dead\_standing\_carbon
- dead\_standing\_nitrogen
- dead\_seed\_carbon
- dead\_seed\_nitrogen
- dead\_leaf\_carbon
- dead\_leaf\_nitrogen
- dead\_fine\_branch\_carbon
- dead\_fine\_branch\_nitrogen
- dead\_total\_fine\_branch\_nitro
- dead\_coarse\_root\_carbon
- dead\_total\_coarse\_root\_carbon
- dead\_coarse\_root\_nitrogen
- dead\_total\_coarse\_root\_nitro
- dead\_coarse\_branch\_carbon
- dead\_total\_coarse\_branch\_car
- dead\_coarse\_branch\_nitrogen
- dead\_total\_coarse\_branch\_nitr
- lignin\_fine\_root
- lignin\_coarse\_root
- lignin\_fine\_branch
- lignin\_coarse\_branch



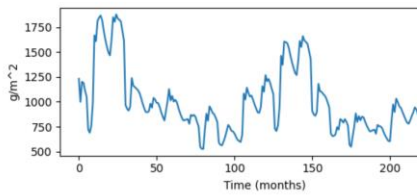
AF-Range Viewer

- x\_loc
- y\_loc
- range\_type
- precip
- max\_temp
- min\_temp
- day\_length
- heat\_accumulation
- pot\_evap
- evaporation
- snow
- snow\_liquid
- melt
- pet\_remaining
- ppt\_soil
- runoff
- ratio\_water\_pet
- pet\_top\_soil
- n\_leached
- holding\_tank
- transpiration
- relative\_water\_content
- water\_available
- annual\_evapotranspiration
- tree\_cover
- bare\_cover
- total\_population
- prop\_annual\_decid
- total\_aground\_live\_biomass
- total\_bground\_live\_biomass
- total\_litter\_carbon
- total\_litter\_nitrogen
- root\_shoot\_ratio
- tree\_basal\_area
- soil\_surface\_temperature
- sand
- silt
- clay
- mineral\_nitrogen
- field\_capacity
- wilting\_point
- soil\_total\_carbon



- Facet 1
- Facet 2
- Facet 3

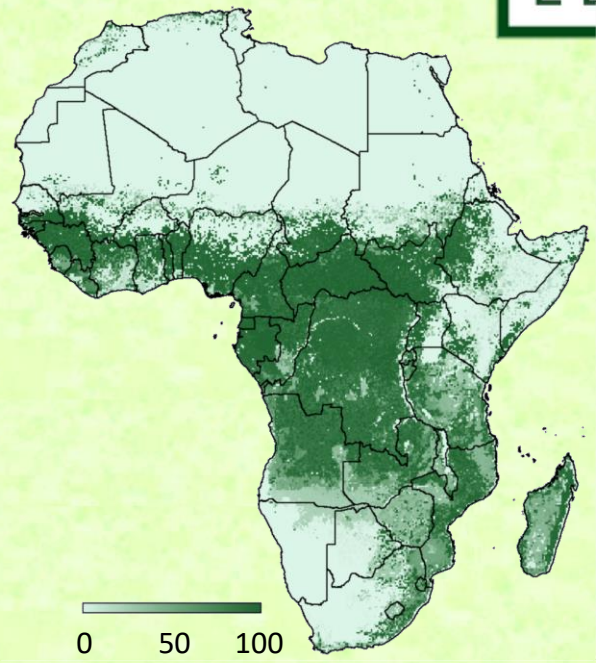
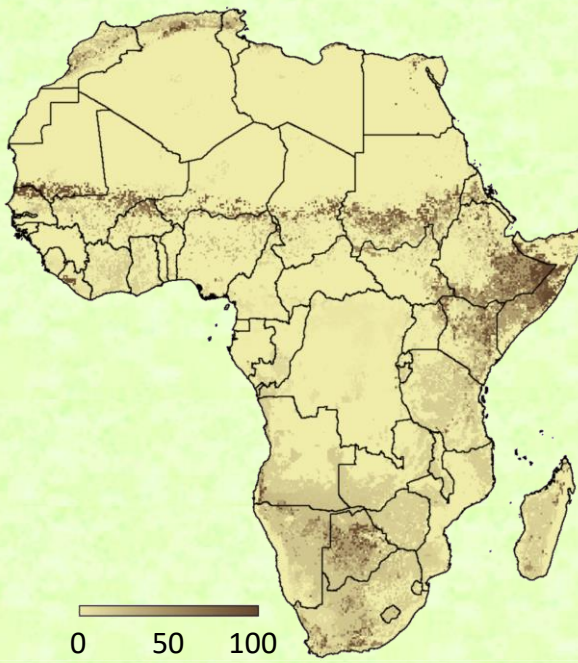
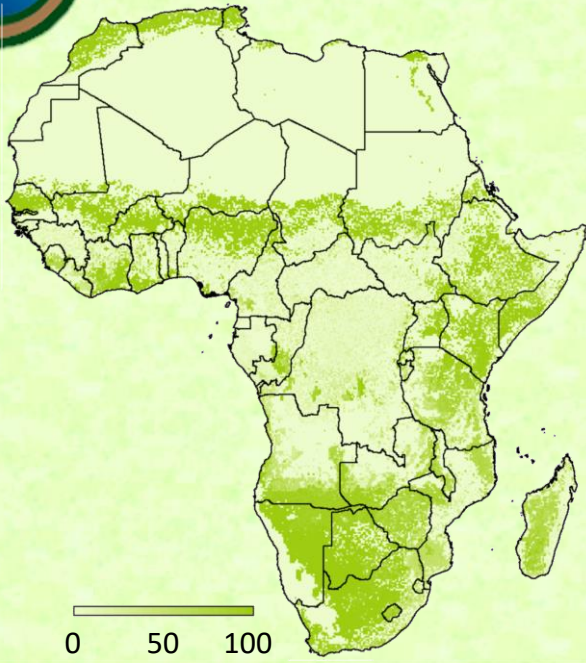
The proportion occupied by each facet (Proportion), with 3 facets



Total aboveground live biomass (g m<sup>-2</sup>) (g m<sup>-2</sup>)



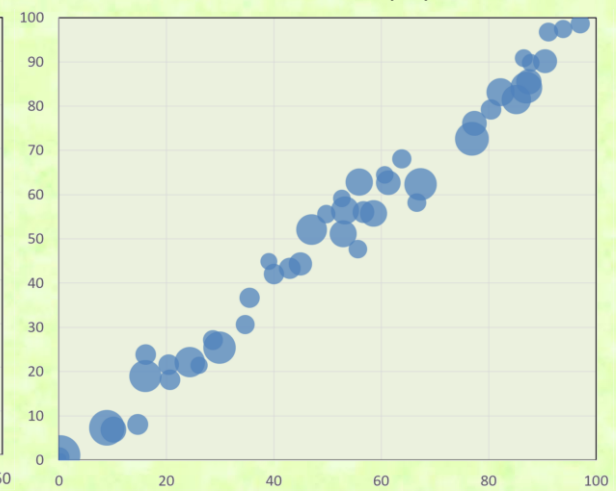
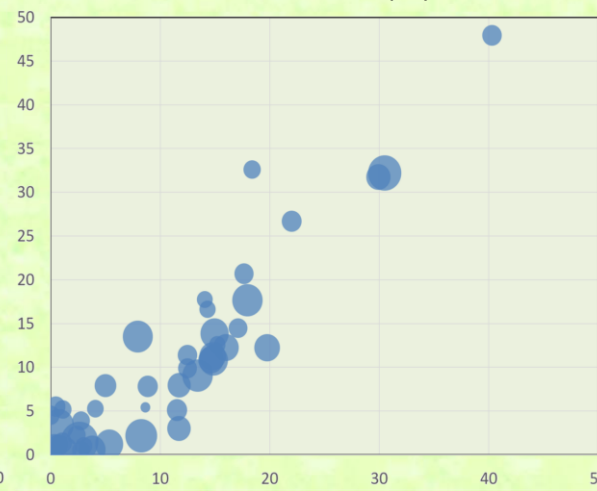
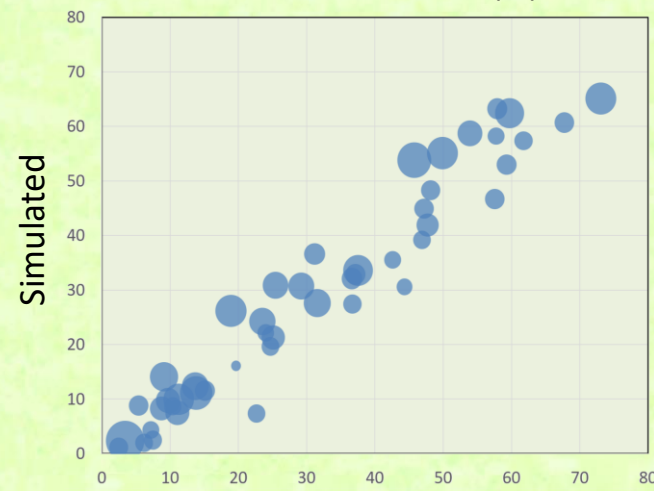
2022



Herbaceous Cover (%)

Shrub Cover (%)

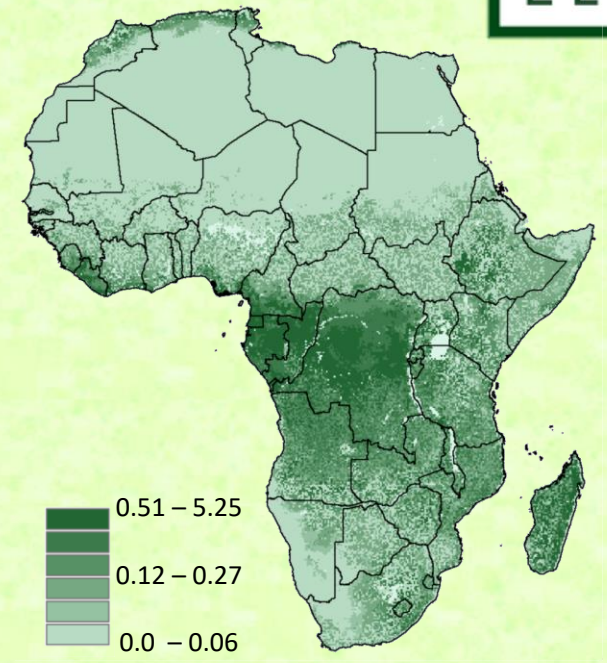
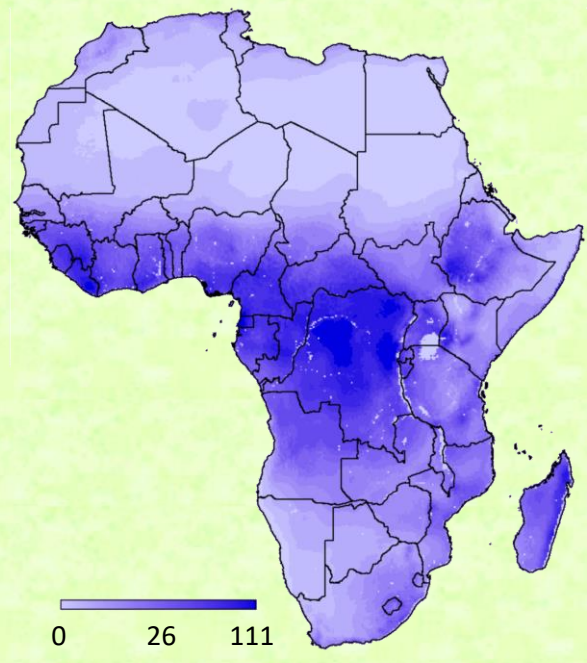
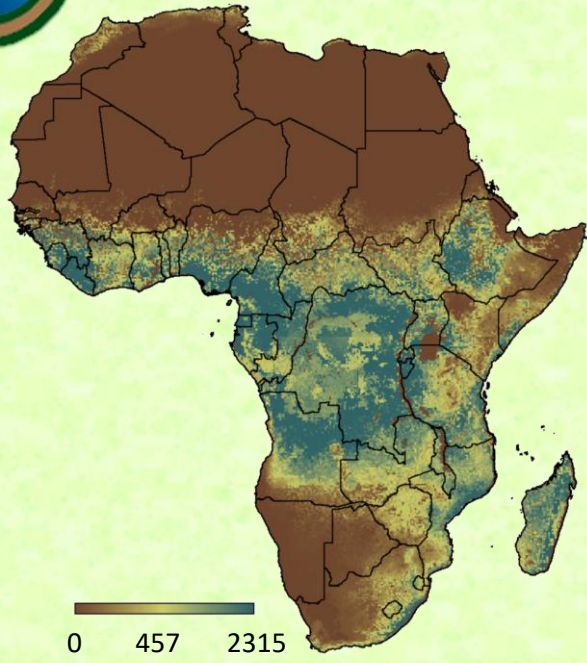
Tree Cover (%)



\* Herbivores held constant



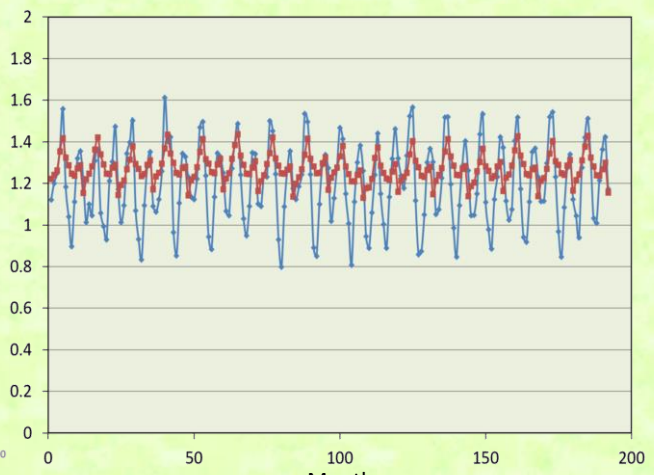
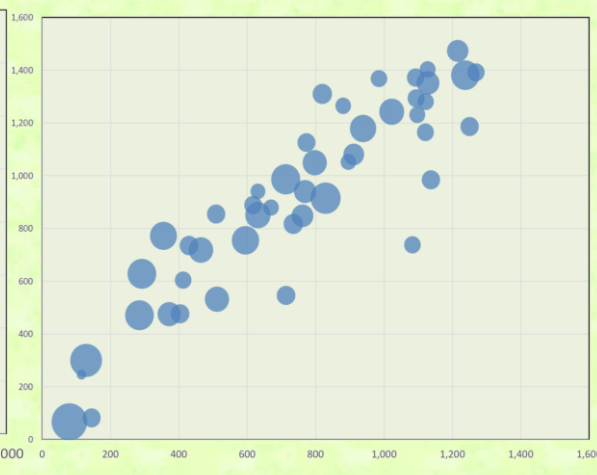
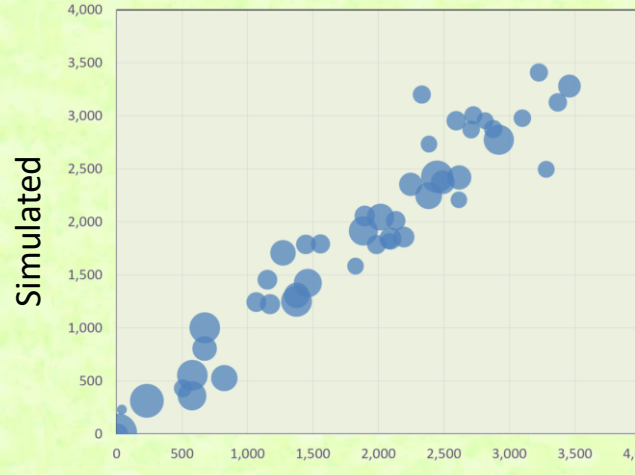
2022



Annual Net Primary Production ( $\text{g m}^{-2} \text{yr}^{-1}$ )

Evapotranspiration ( $\text{cm yr}^{-1}$ )

Leaf Area Index



\* Herbivores held constant

Observed

— Observed — Simulated



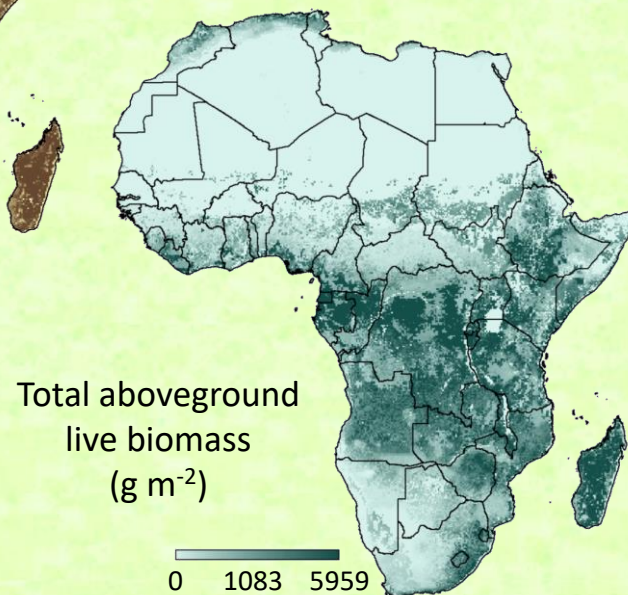
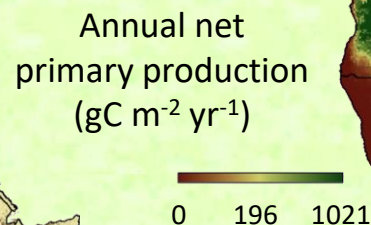
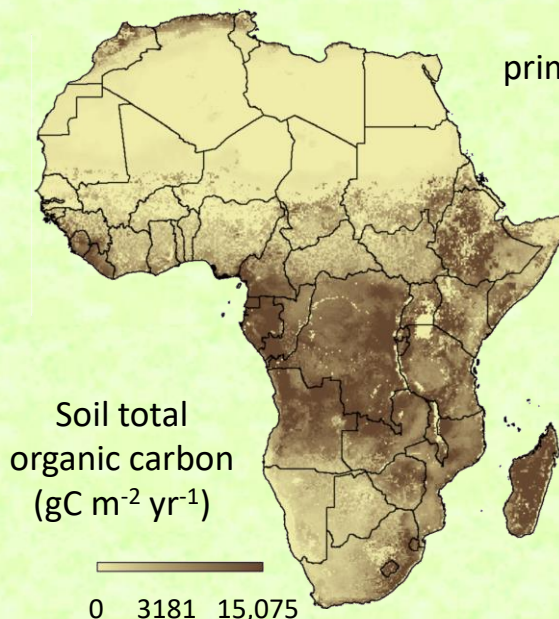
## Discovery through Scenario Analyses

- Climate change
- Cover change
- Stocking rates
- Herbivore dynamics
- Herbivore mobility
- Soil carbon dynamics
- Soil nitrogen dynamics
- Fire, fertilization
- More frequent droughts
- Coupled systems modeling

2070

ACCESS RCP 8.5

Draft: Do not cite

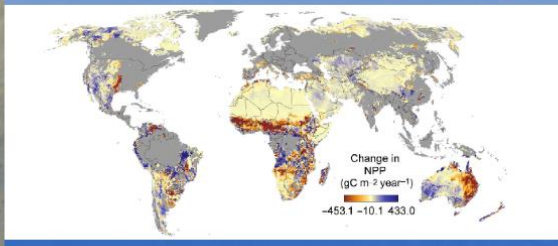




# The L-Range Model Family

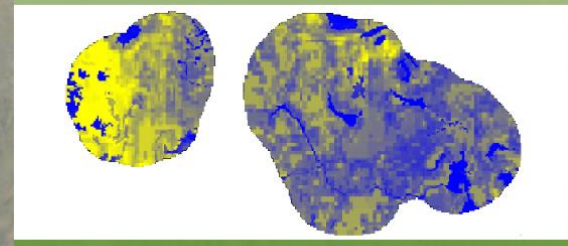
## G-Range

**G-Range** is an ecosystem model that simulates dynamics in biogeochemistry, plant cover, and plant production for rangelands at a **global** scale.



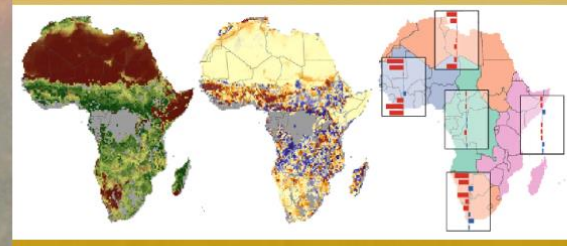
## L-Range

**L-Range** is an ecosystem model that simulations dynamics in biogeochemistry, plant cover, and plant productivity for landscapes at a **local** scale. The tool can be applied to very large or very small areas, and versions can join with models representing human decision in a coupled-systems approach.



## Af-Range

**Af-Range** is an application of L-Range to the **African continent** that may be used in analyses. Af-Range can represent the dynamics of domestic and wild herbivores across the continent.



**L-Range.com**



*The End*

*Questions?*

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