



World Health
Organization

Mechanistic models of snakebite risk:

A bottom up approach for estimating risk in a data sparse discipline

Anna Pintor, Mike Turner, David Williams

July-2025

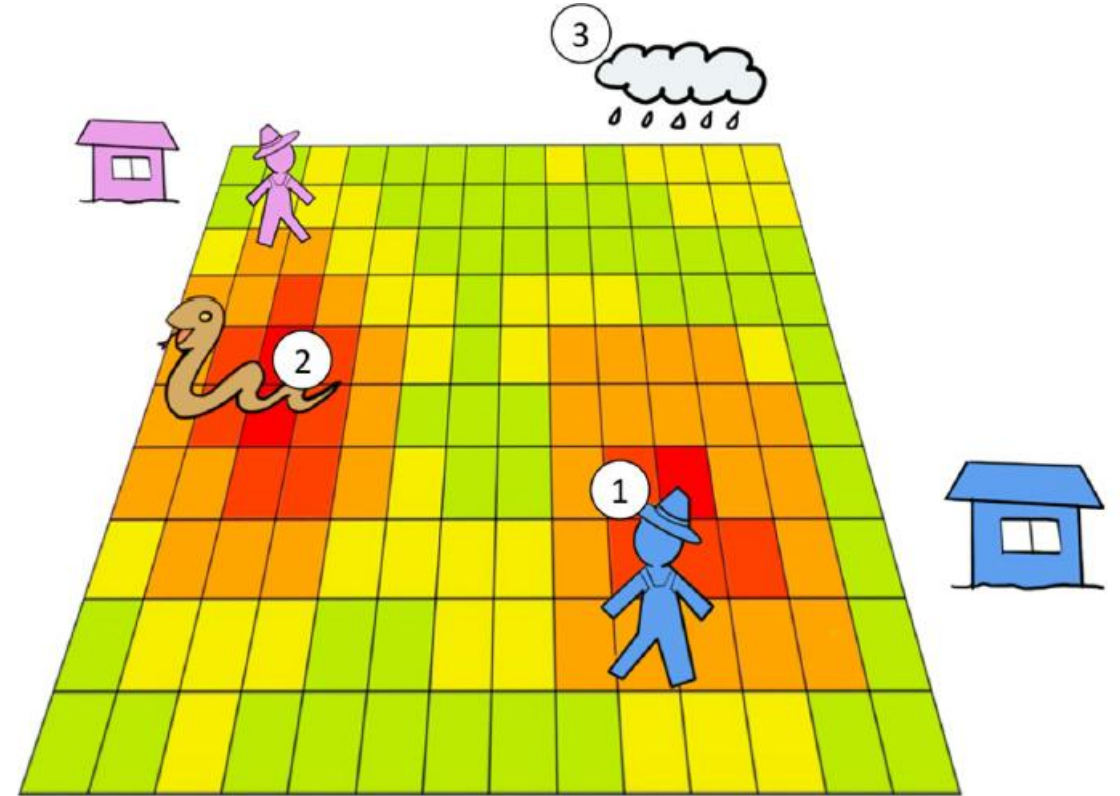
Snakebite, a neglected tropical disease

- Category A neglected tropical disease
- Currently over 500 species of medically relevant snakes
- Data on snake distributions and snakebite cases often sparse
- Highest burden in rural areas of the developing world, where data collection is most neglected



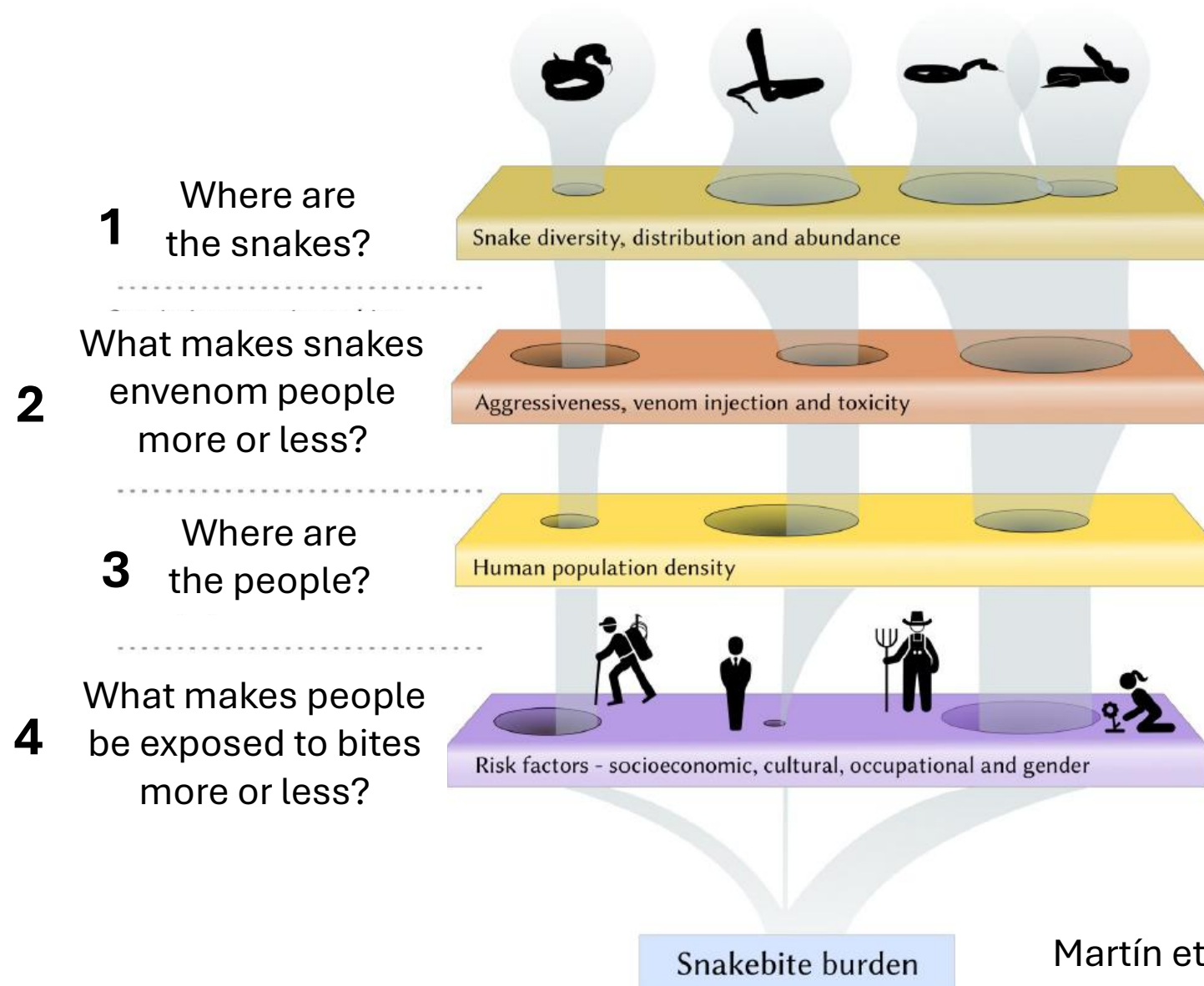
The mechanisms behind snakebite

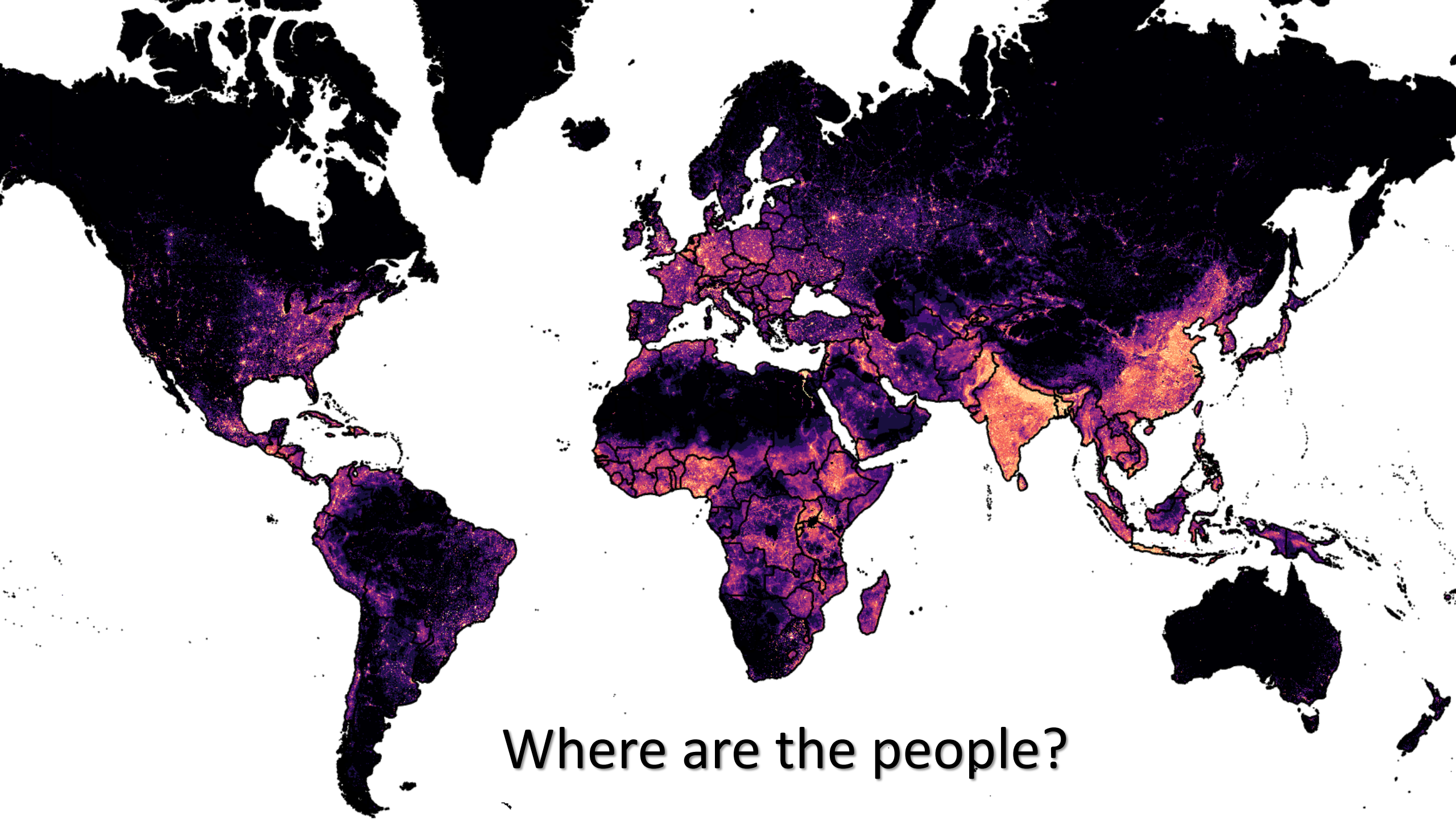
- If we don't have hard data on how many people are bitten & where, what do we do?
- Option: “Bottom up”, mechanistic estimates of snake-human conflict
- Describe how snakes & humans share space



Goldstein et al. 2021: Integrating human behavior and snake ecology with agent-based models to predict snakebite in high risk landscapes

The mechanisms behind snakebite



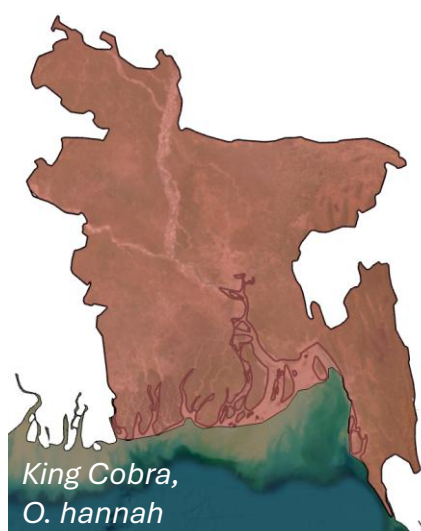
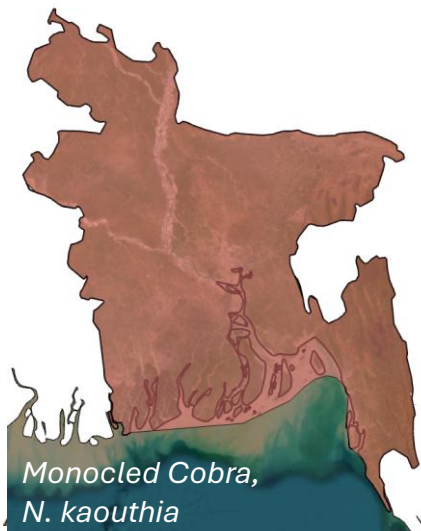
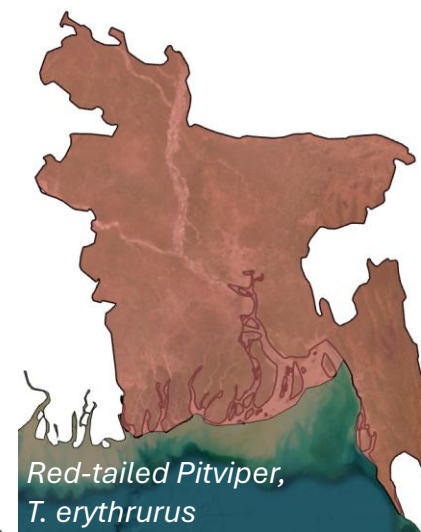
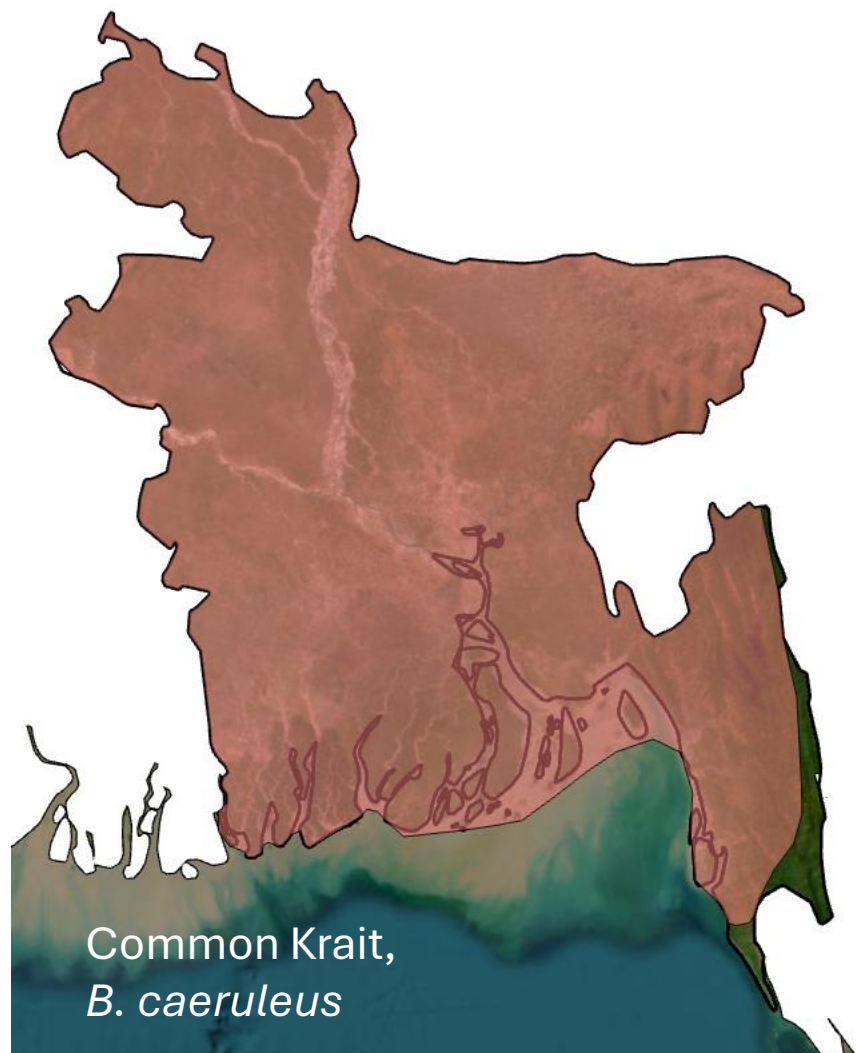


Where are the people?



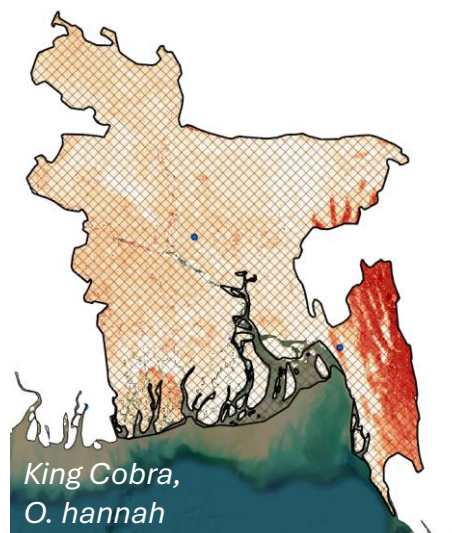
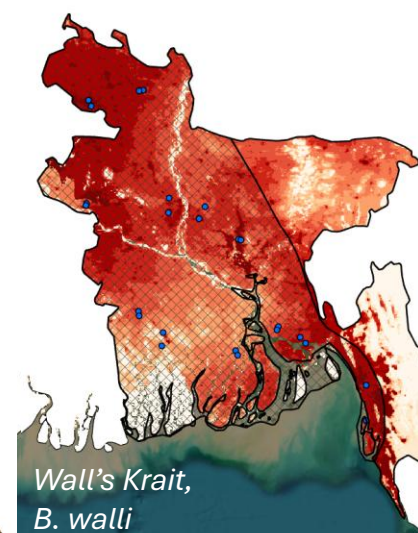
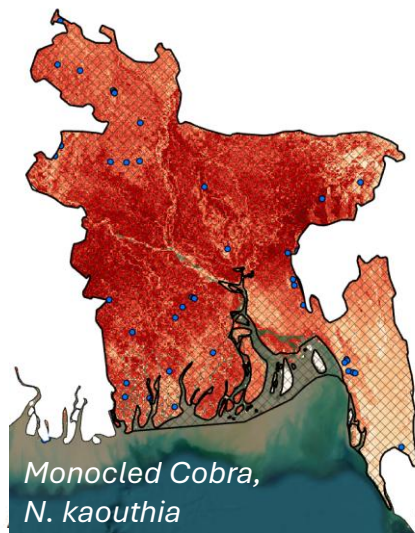
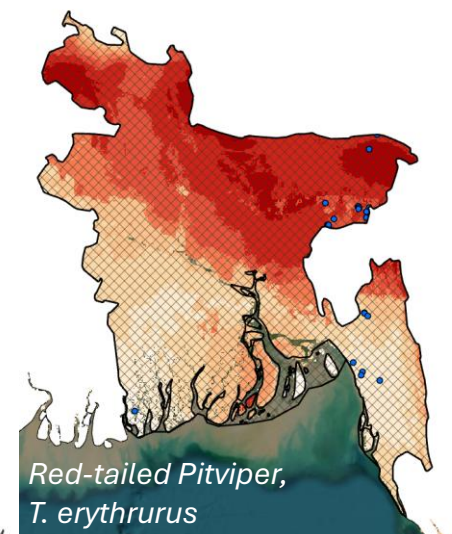
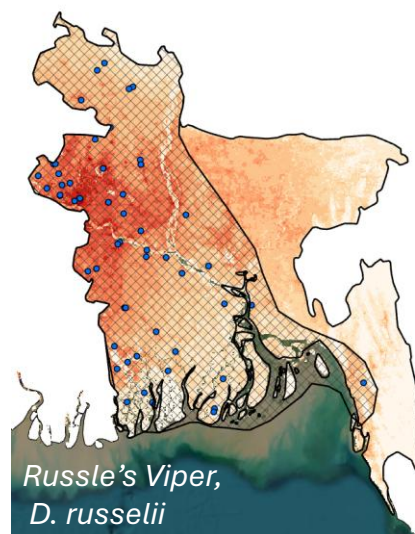
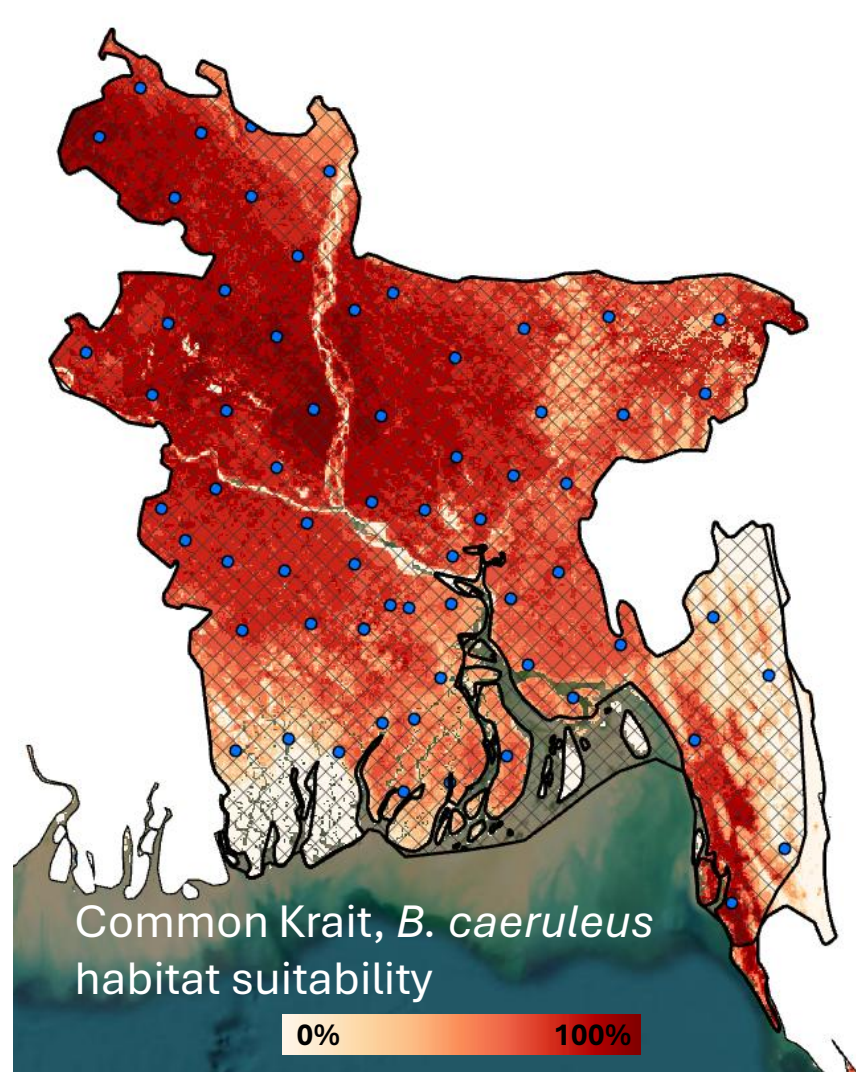
Where are the snakes?

Where are the snakes? Bangladesh Case Study



... *B. niger*, *N. naja*, *B. lividus*,
T. popeiorum, *T. yunnanensis*

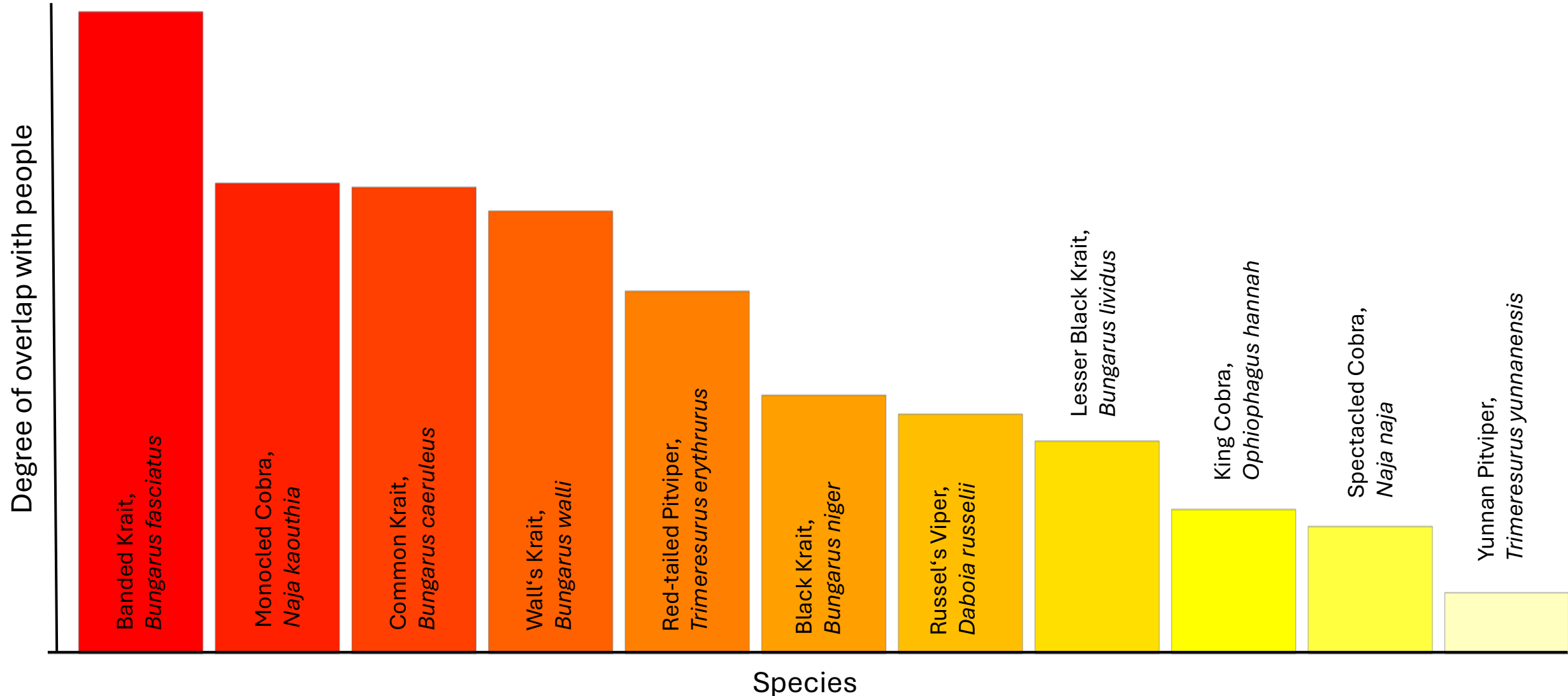
Where are the snakes? Bangladesh Case Study



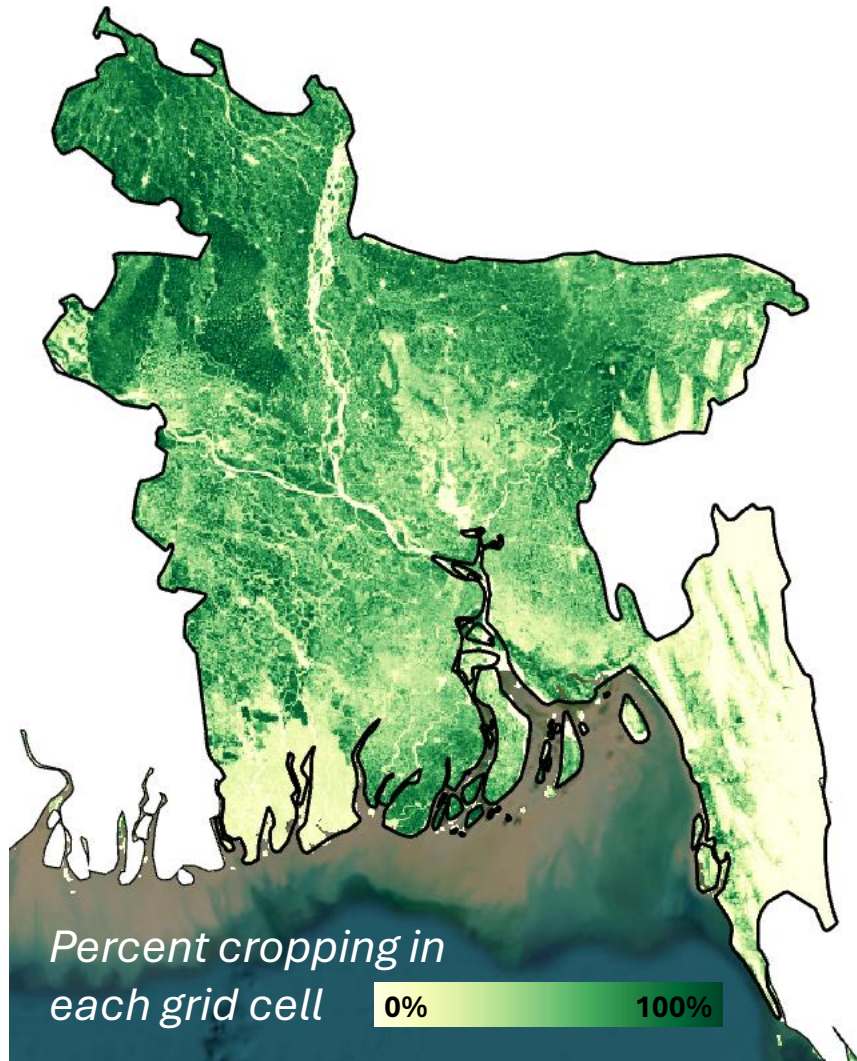
... *B. niger*, *N. naja*, *B. lividus*,
T. popeiorum, *T. yunnanensis*

Which snakes co-occur the most with people?

Medically Important Snakes of Bangladesh



What makes people exposed to bites?



1. Engagement in agricultural activities

2. Poverty

- poor housing conditions that allow snakes to enter
- Lack of protective equipment

3. Leisure activities (e.g. hiking)

4. Gender roles

5. Purposeful interaction with snakes

- Snake charming
- Hunting for food or pet trade
- Snake Culling

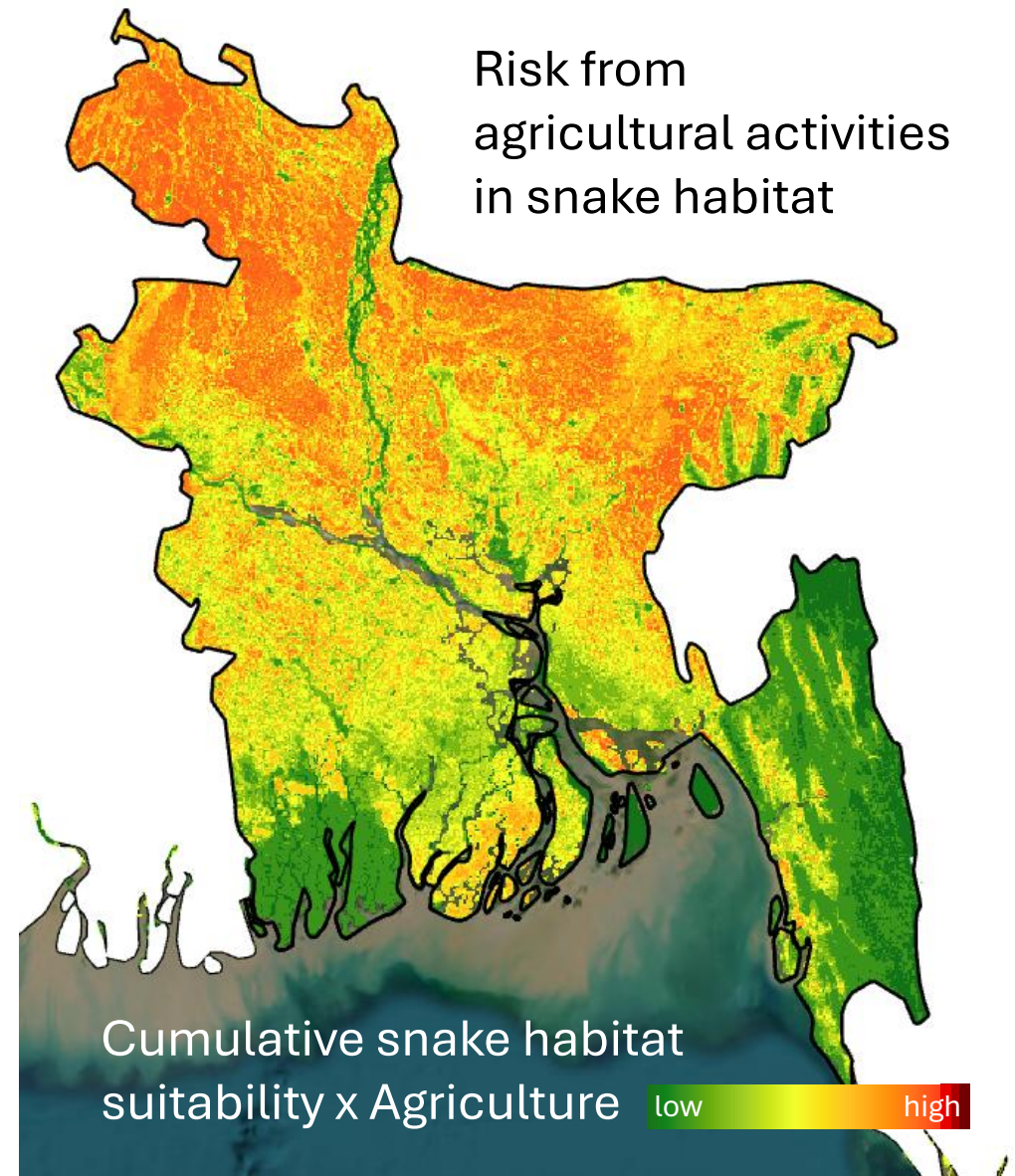
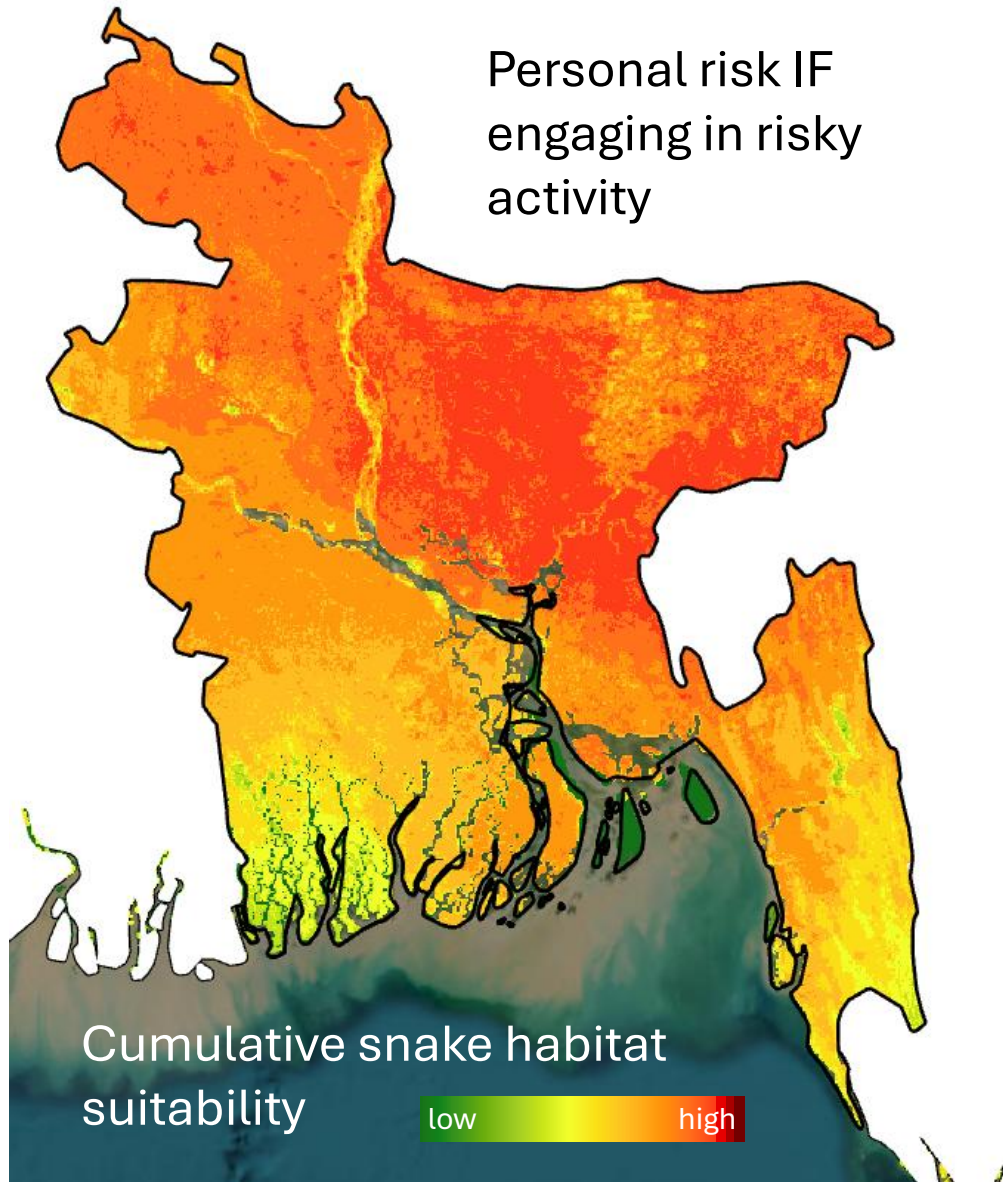
Often correlated

Good spatial data available

Inter-personal variation

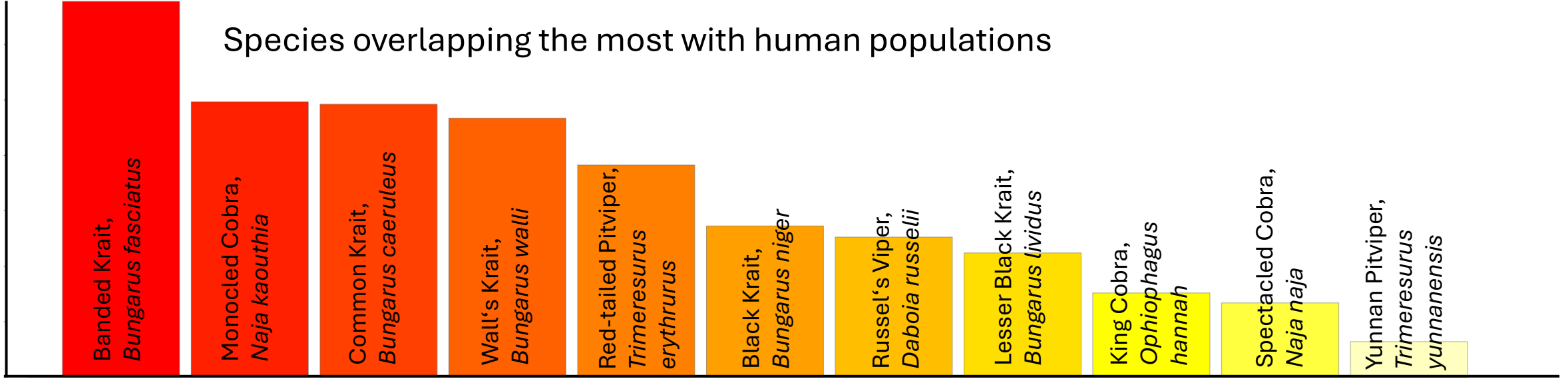
less spatially predictable

What makes people exposed to bites?

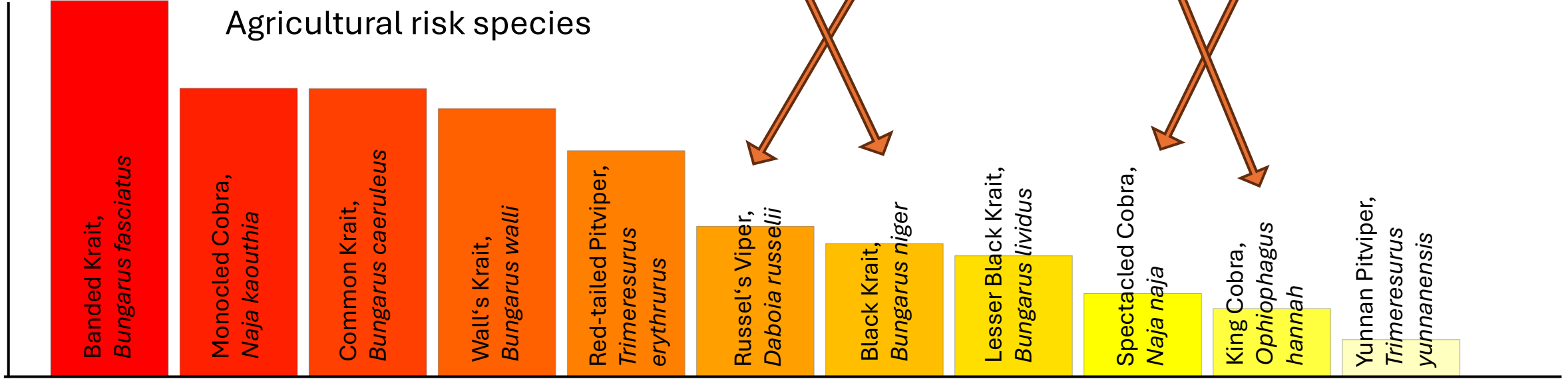


Degree of overlap with people

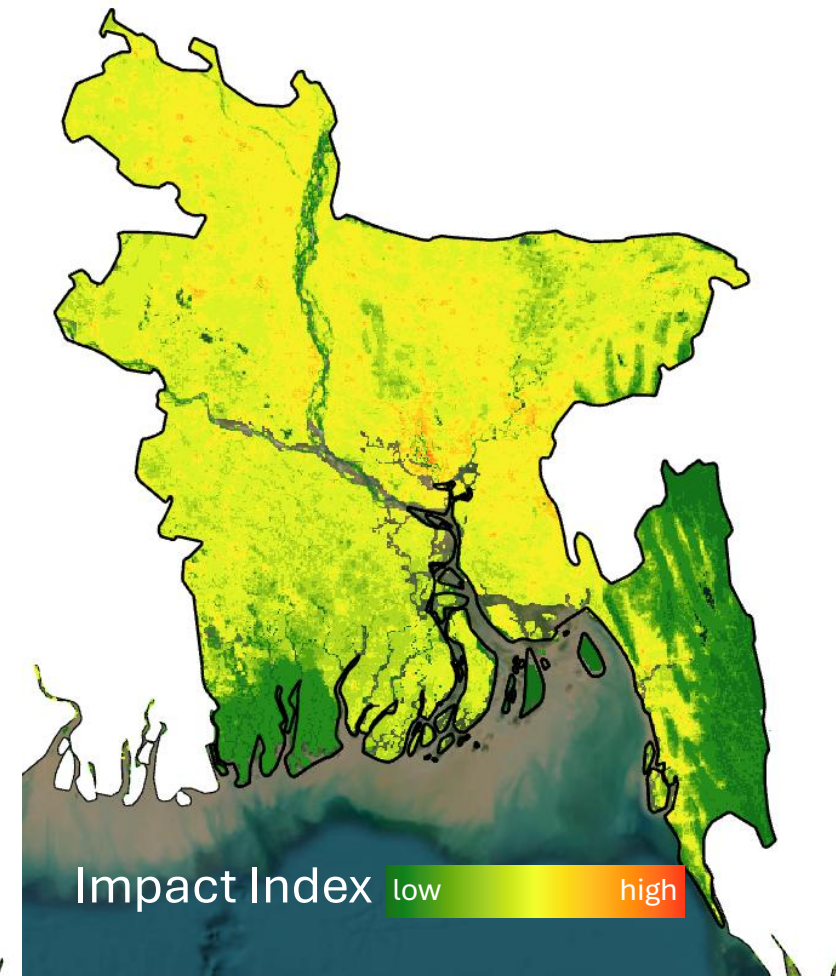
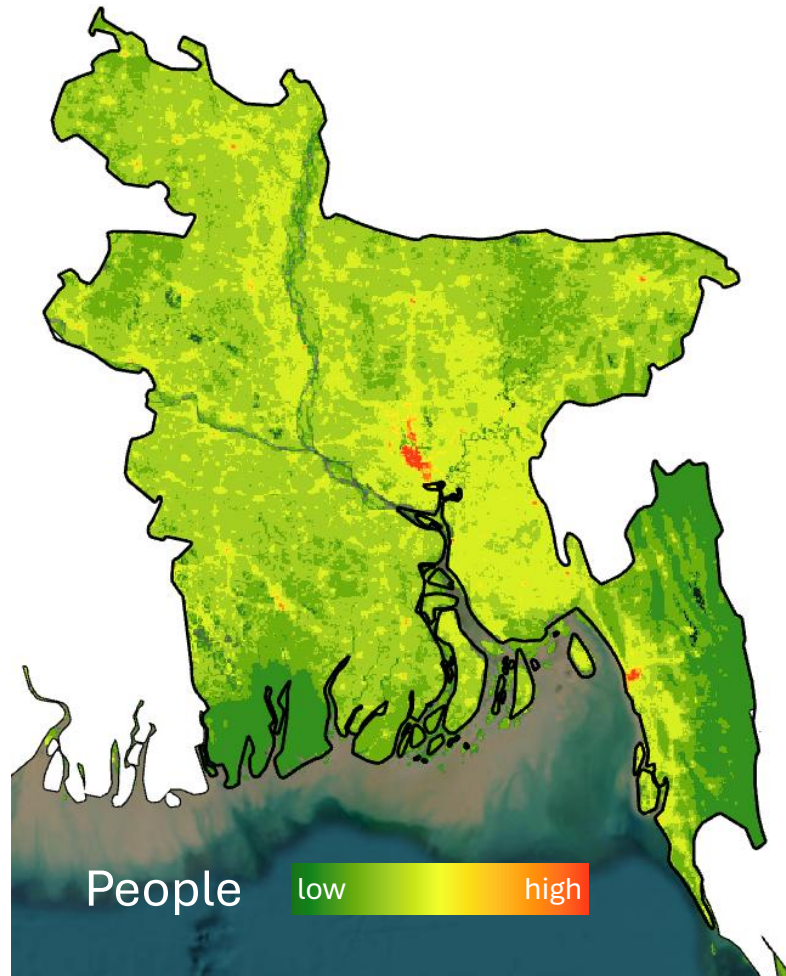
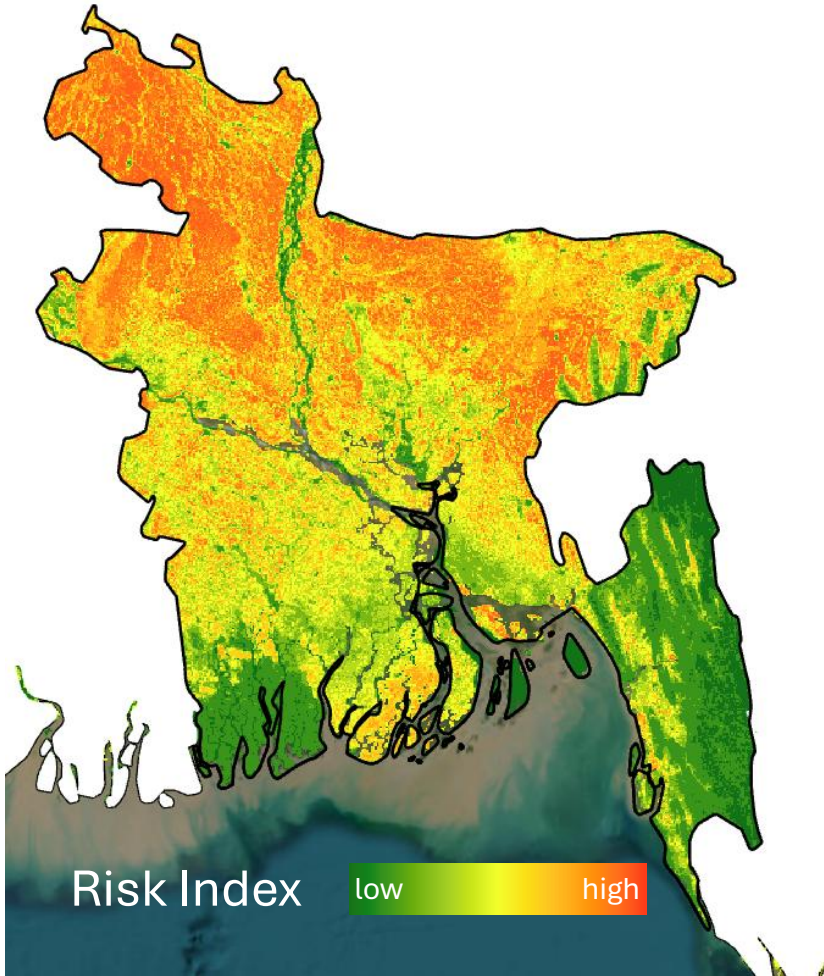
Species overlapping the most with human populations



Agricultural risk species



Combining snakes, people, and risk factors?



What makes snakes envenom people?

Bite reducing traits

- **Large size = low abundance**
- Arboreal; Fossorial; Aquatic
- Active
- Conspicuousness
- Small or rear fangs
- Propensity to flee
- Dry bites
- Affiliation with natural microhabitats

Bite increasing traits

- **Small size = high abundance**
- Terrestrial
- Sedentary
- Camouflage
- Long fangs
- Propensity to bite
- Wet bites
- Affiliation with disturbed microhabitats



What makes snakes envenom people?

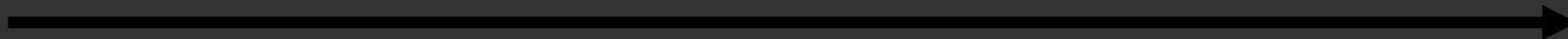
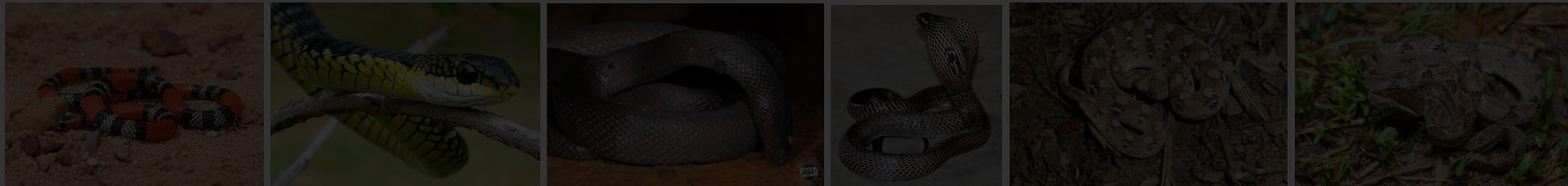
Bite reducing traits

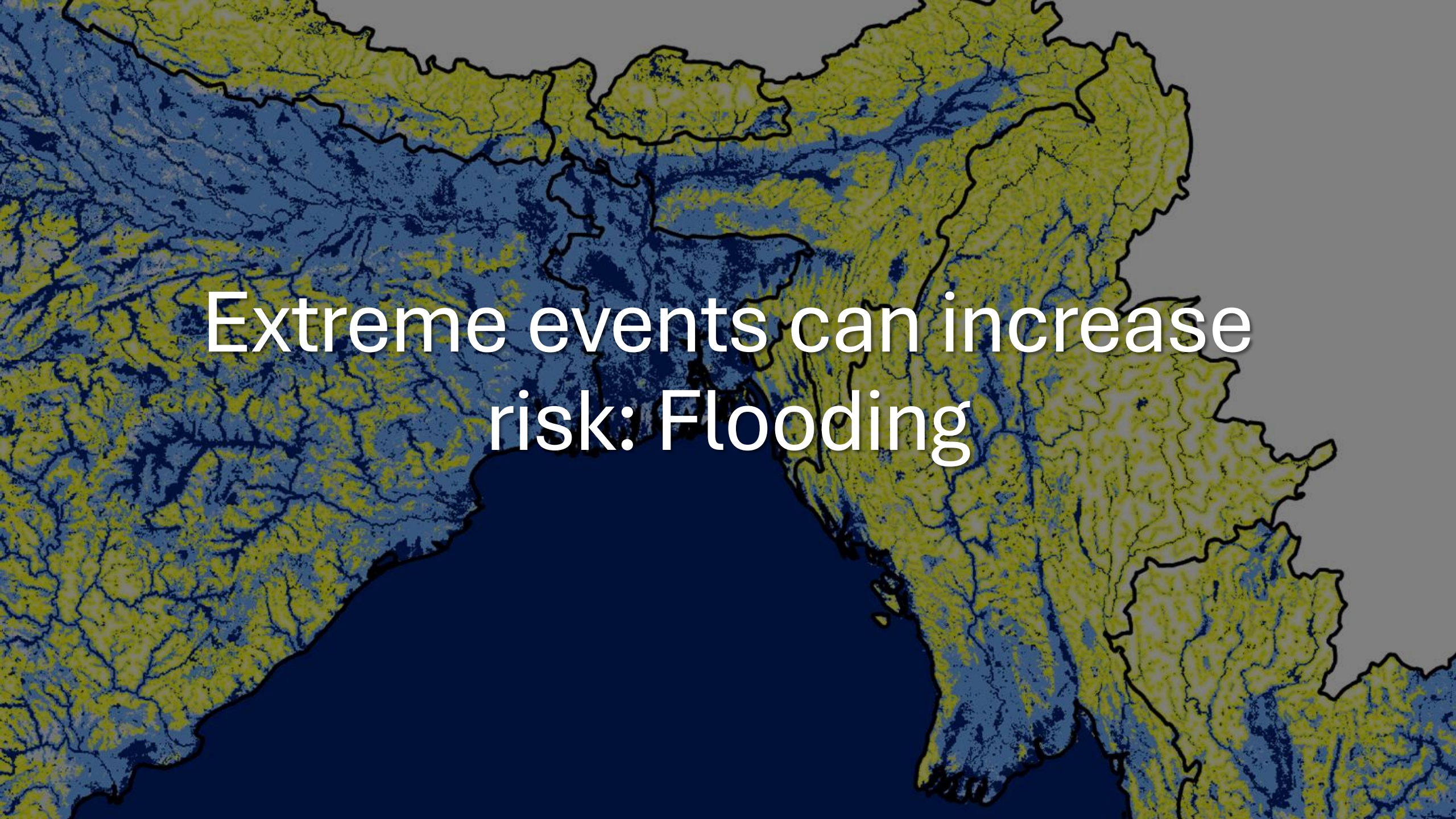
- **Large size = low abundance**
- Arboreal; Fossorial; Aquatic
- Conspicuousness (colour, behaviour)
- Small or rear fangs
- Propensity to flee

Bite increasing traits

- **Small size = high abundance**
- Terrestrial
- Sedentary
- Camouflage
- Propensity to bite & inject venom
- Affiliation with disturbed areas (farming, housing)

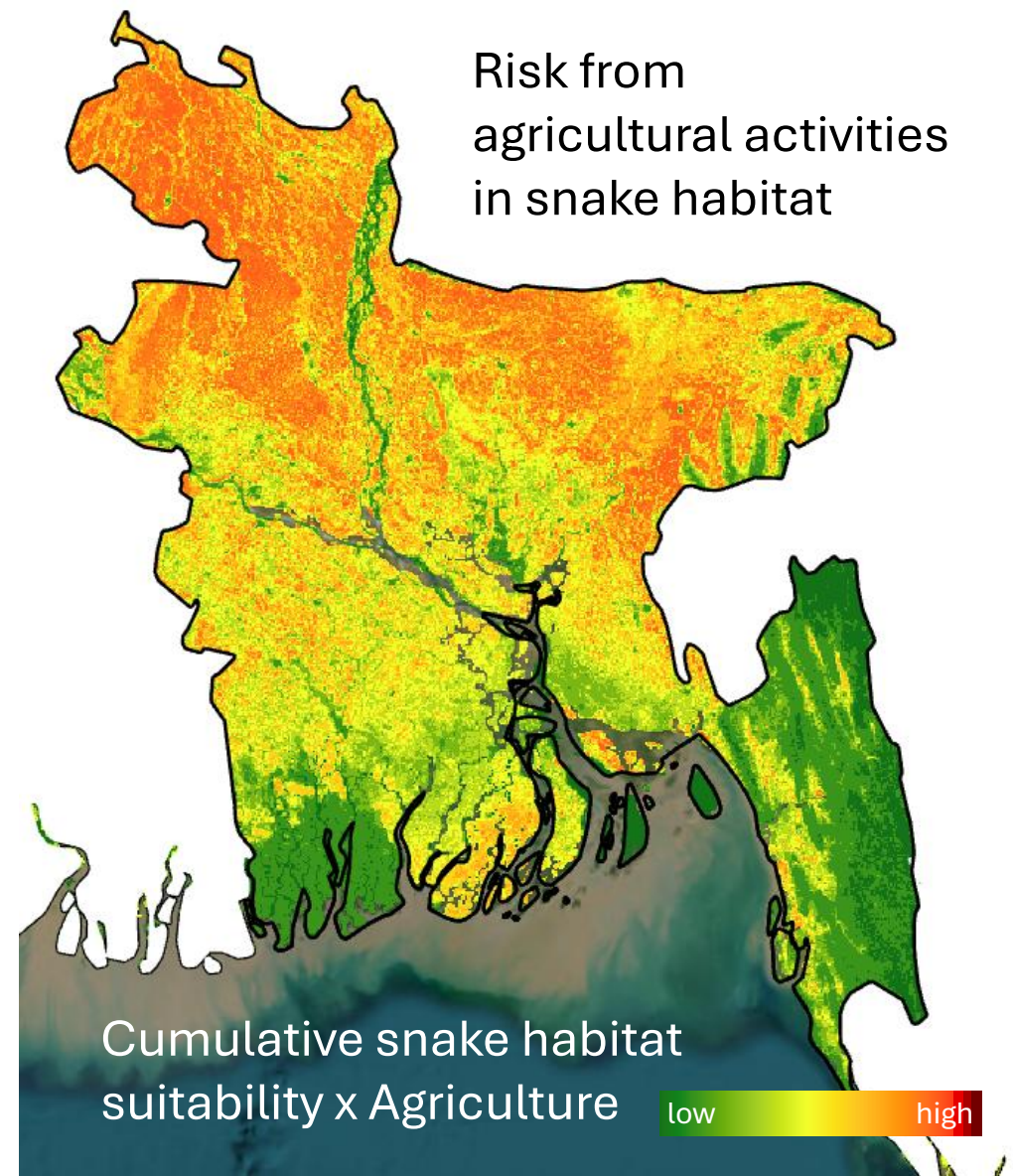
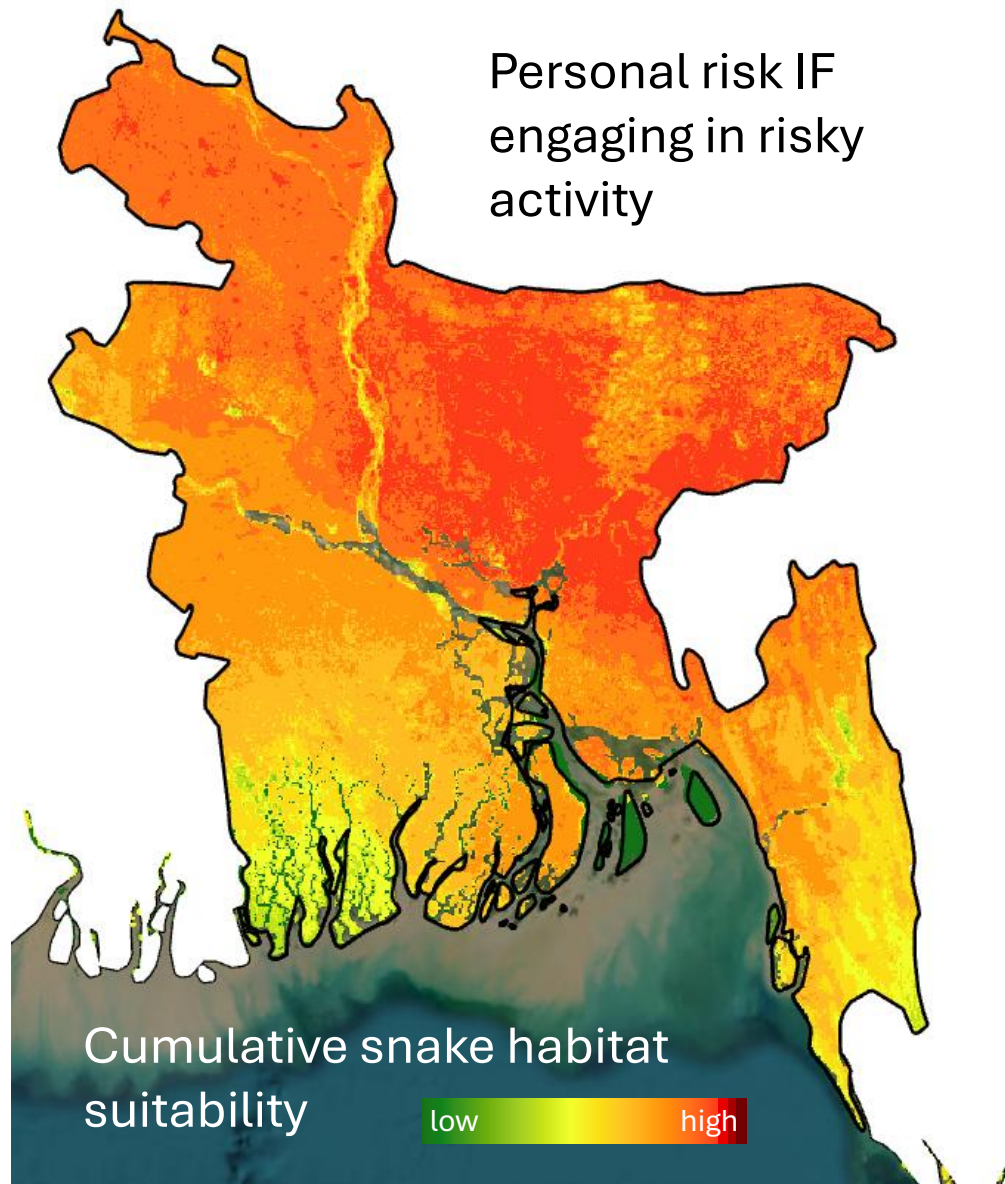
Work in progress



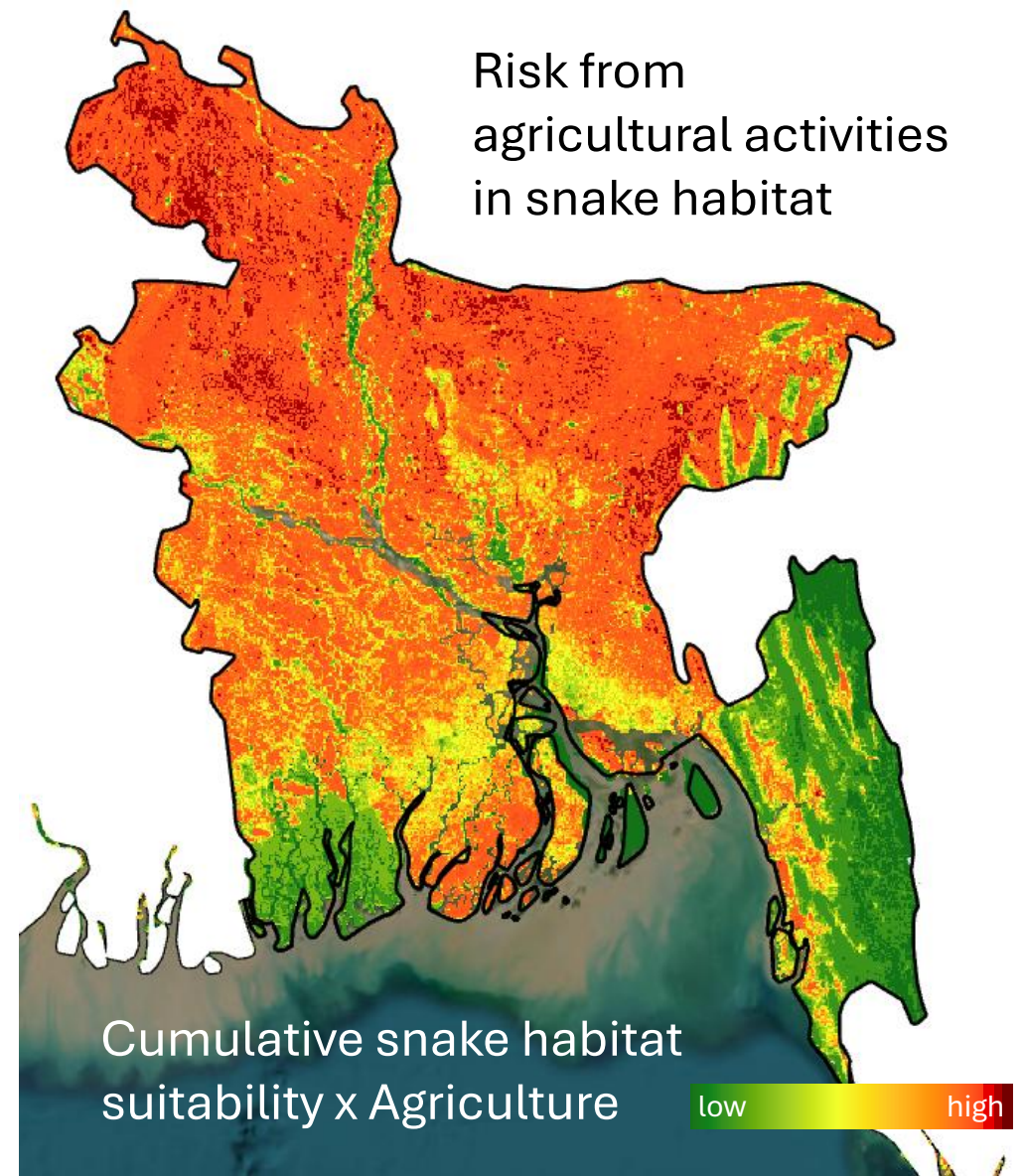
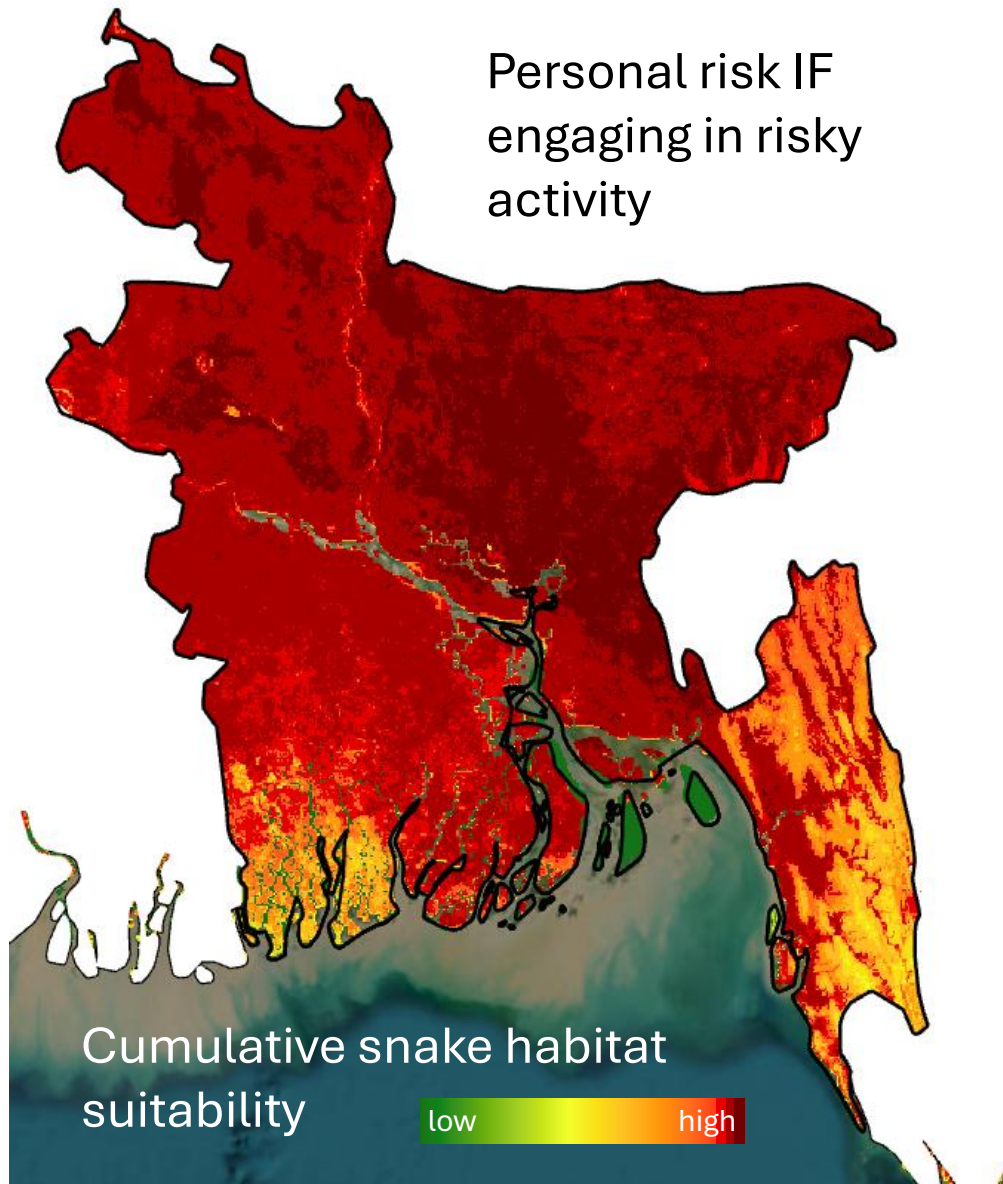


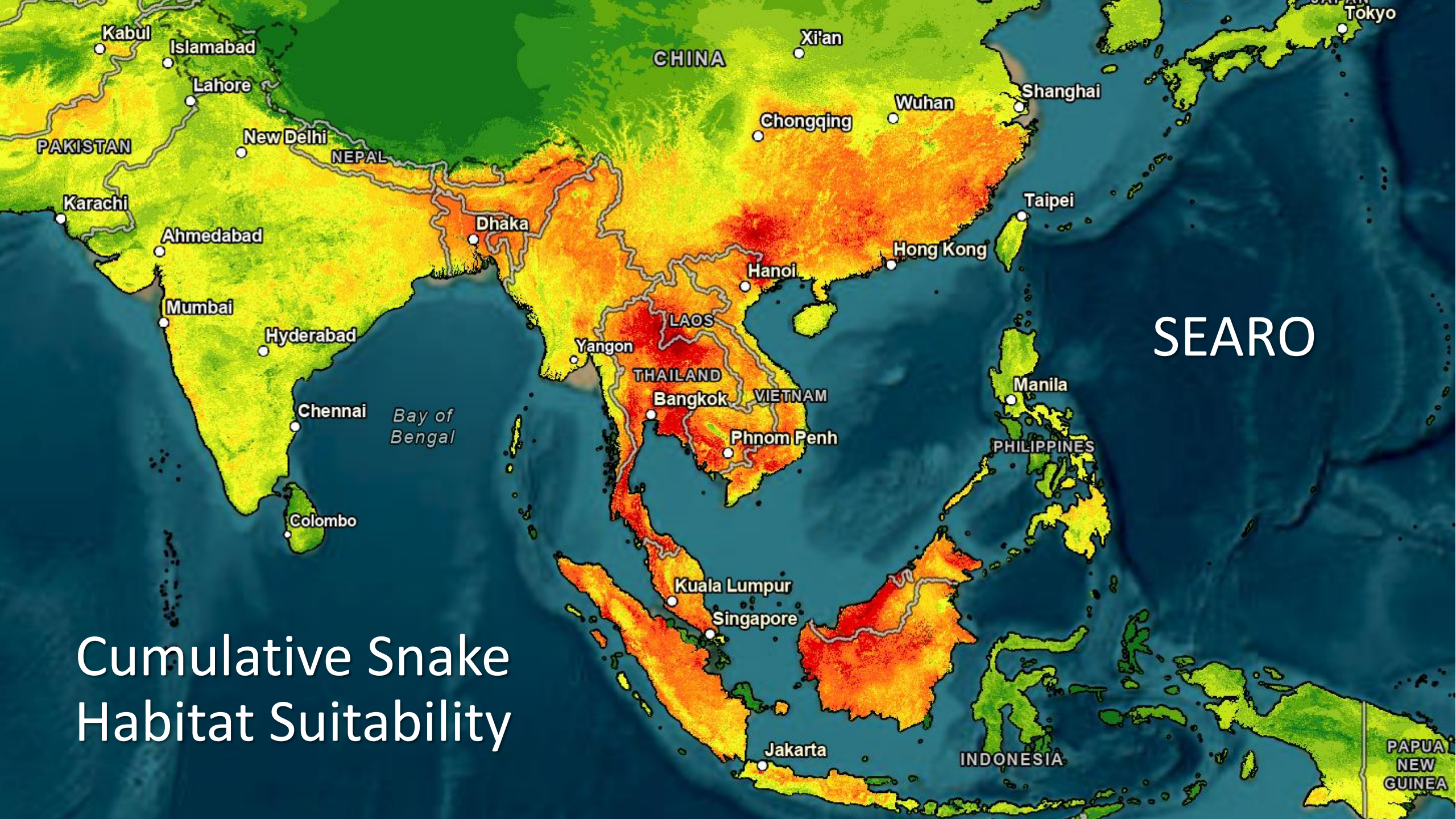
Extreme events can increase
risk: Flooding

What makes people exposed to bites? No Flooding



What makes people exposed to bites? Flooding





Cumulative Snake Habitat Suitability

SEARO



Overlap of Agriculture
and Snakes

Where to from here?



1. Climate Change ☒
2. Snake traits/ weighting
3. Accessibility to healthcare
 1. Health facilities (location and capacity)
 2. Transport infrastructure
4. Epidemiology
 1. Ground truthing our predictions
 2. Models of observed snakebite cases

Questions?

Dr Anna Pintor

PintorA@who.int

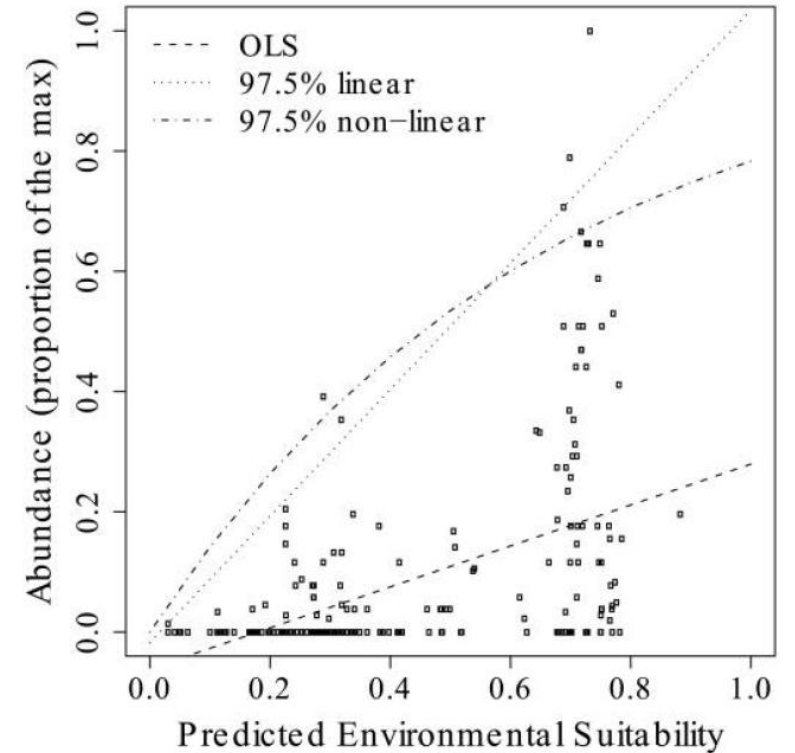
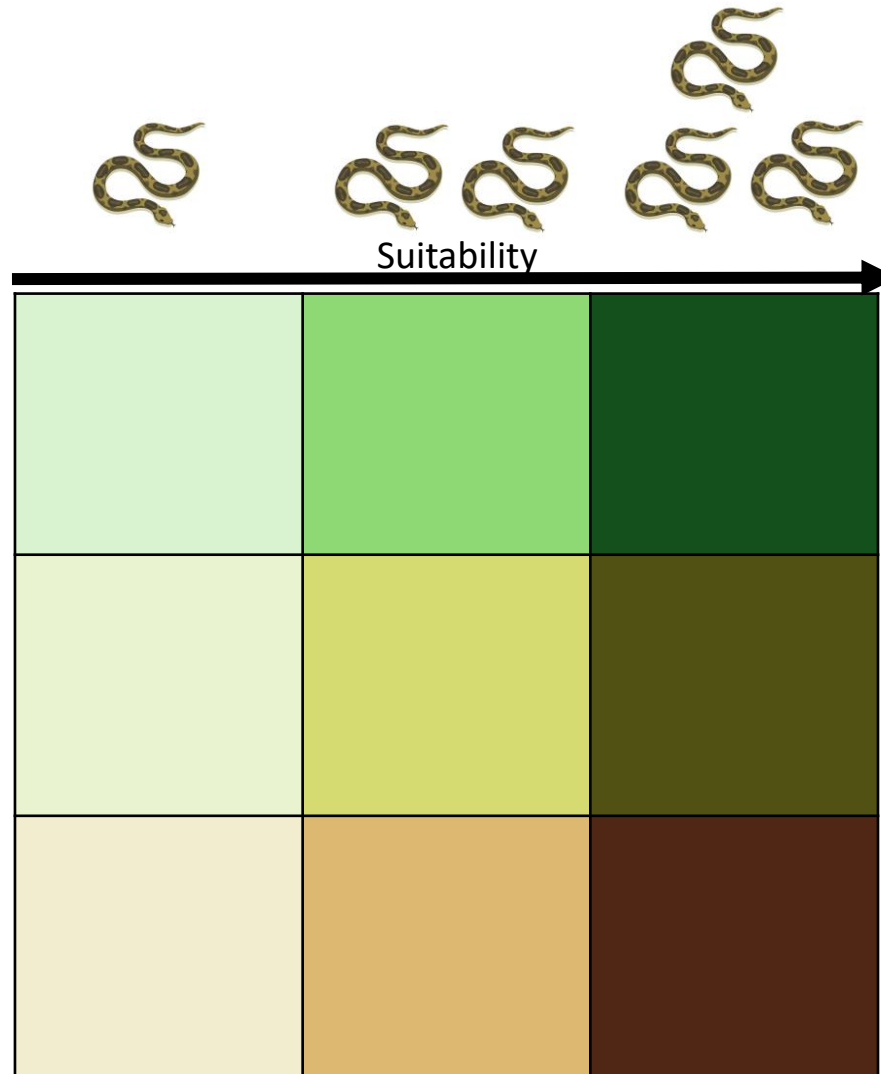


Extra slides for questions...

Modelling the mechanisms

Snake Populations

1. Distribution
2. Abundance

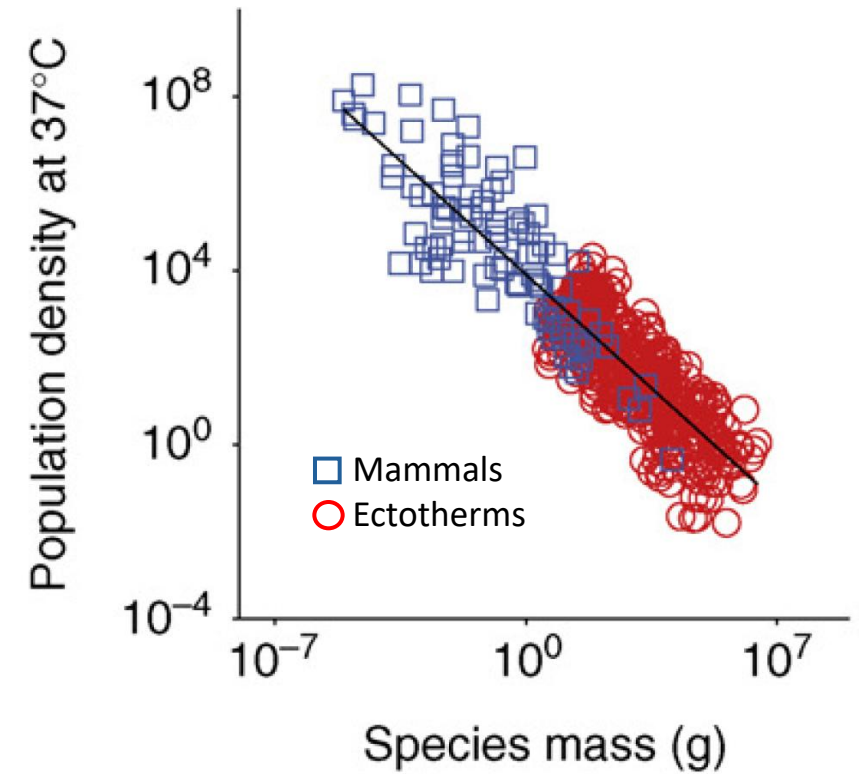
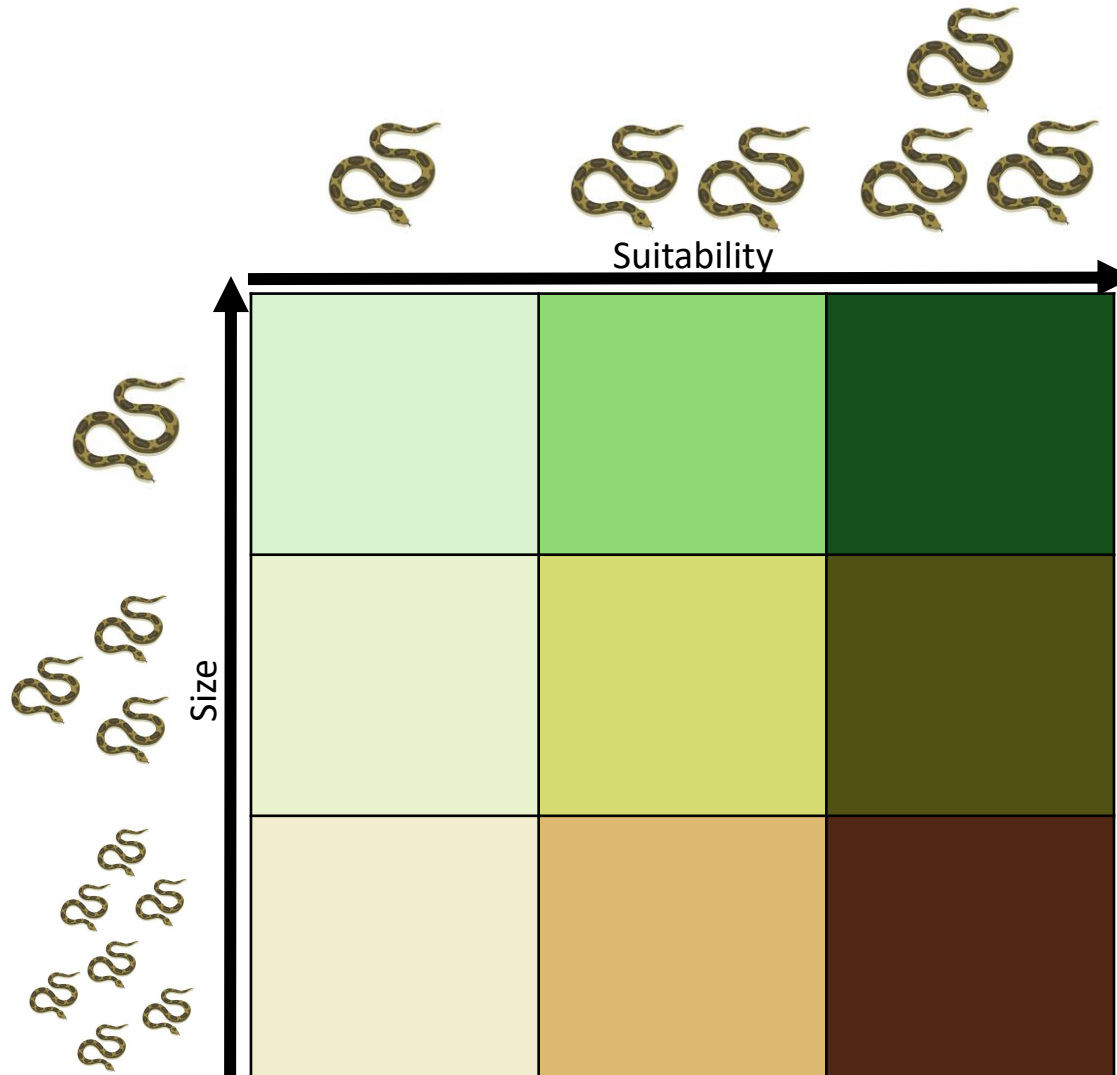


Quantile regression of suitability-abundance relationship; VanDerWal et al. 2009

Modelling the mechanisms

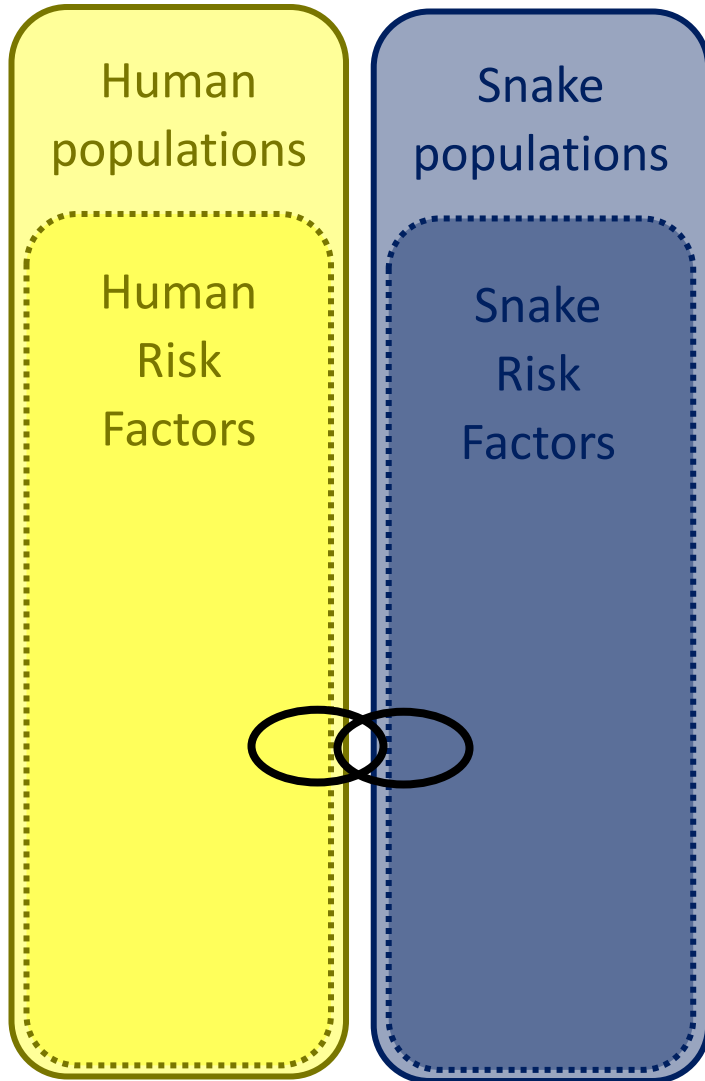
Snake Populations

1. Distribution
2. Abundance



Global size–density relationship; White et al. 2007

Establishing the link

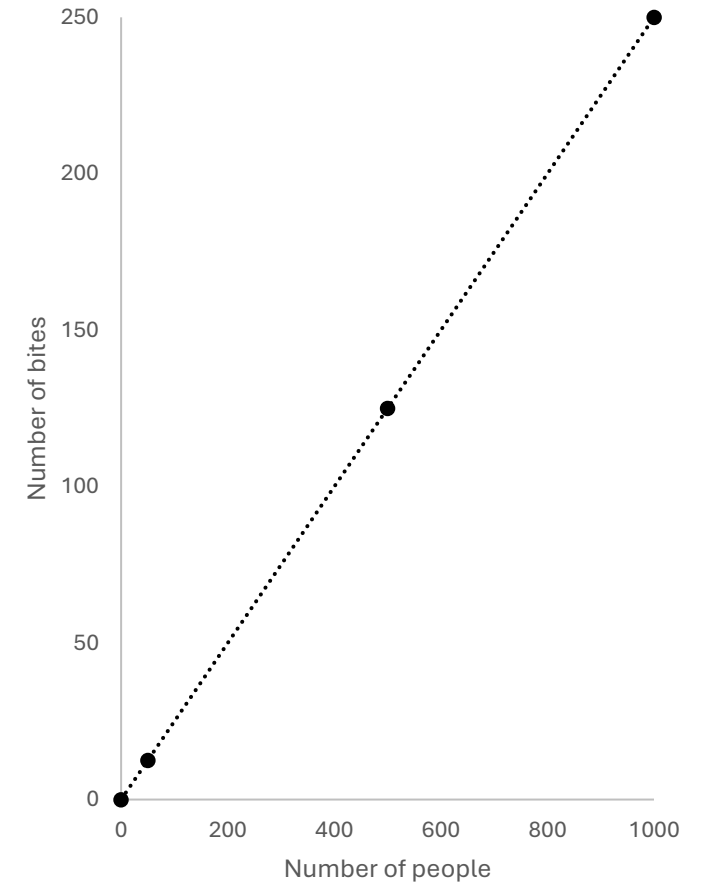


Simple law-of-mass-action model:

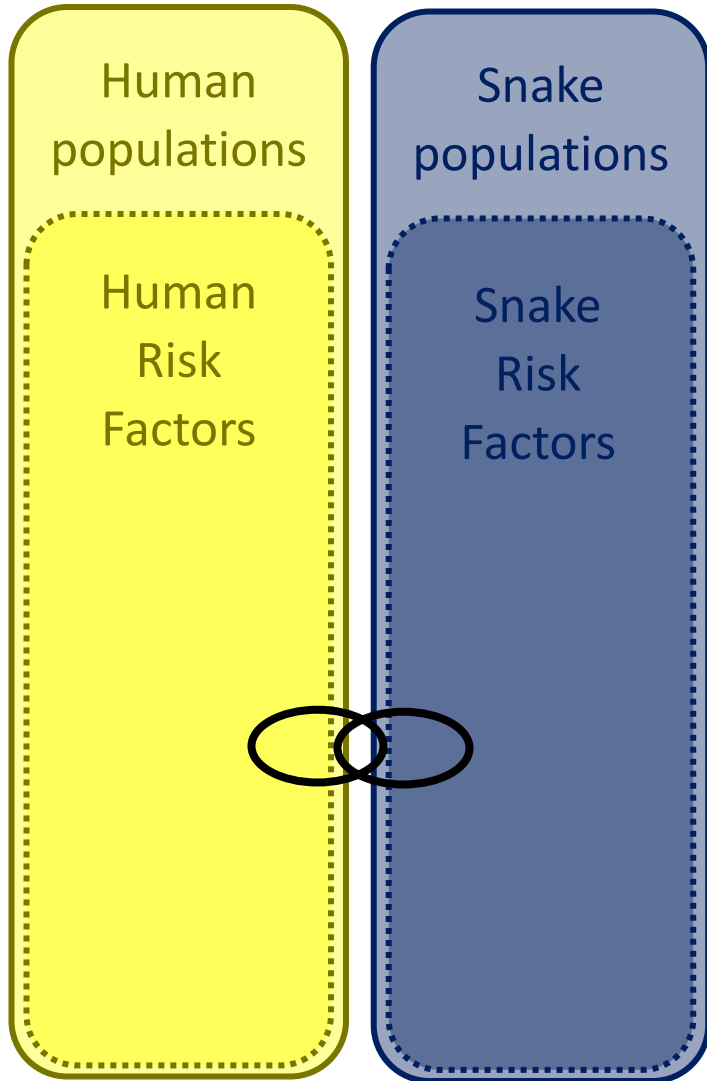
- Bites depend on human (H) & snake (S) numbers and their contact rate (β)

$$B = \beta * S * H \quad \text{or} \quad B = \beta * sS * hH$$

- Constant β -> independent of snake or human population density
- Problem:
 - 50 snakes & 50 people; $\beta = 0.5\%$:
 $50 * 50 * 0.005 = 12.5$ bites
 - $50 * 1000 * 0.005 = 250$ bites!
 - $1000 * 50 * 0.005 = 250$ bites!
- Even when weighted by traits



Establishing the link



Host-vector (human-snake) model:

- Bites limited by snakes' lack of ability to bite everybody ('s'≤1), and people's ability to prevent bites ('h'≤1)

$$B = \frac{(sS) * (hH)}{(sS) + (hH)}$$

- As snake or human population density increases, bites reach an asymptote
- Work in progress...

