



NOAA OCEAN ACIDIFICATION PROGRAM

Spatial Vulnerability Assessment across Main Hawaiian Islands

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VULNERABILITY FRAMEWORK

Marshall et al., 2009

Exposure

Sensitivity

Susceptibility to harm from stressors—dependence on resource systems affected by climate change

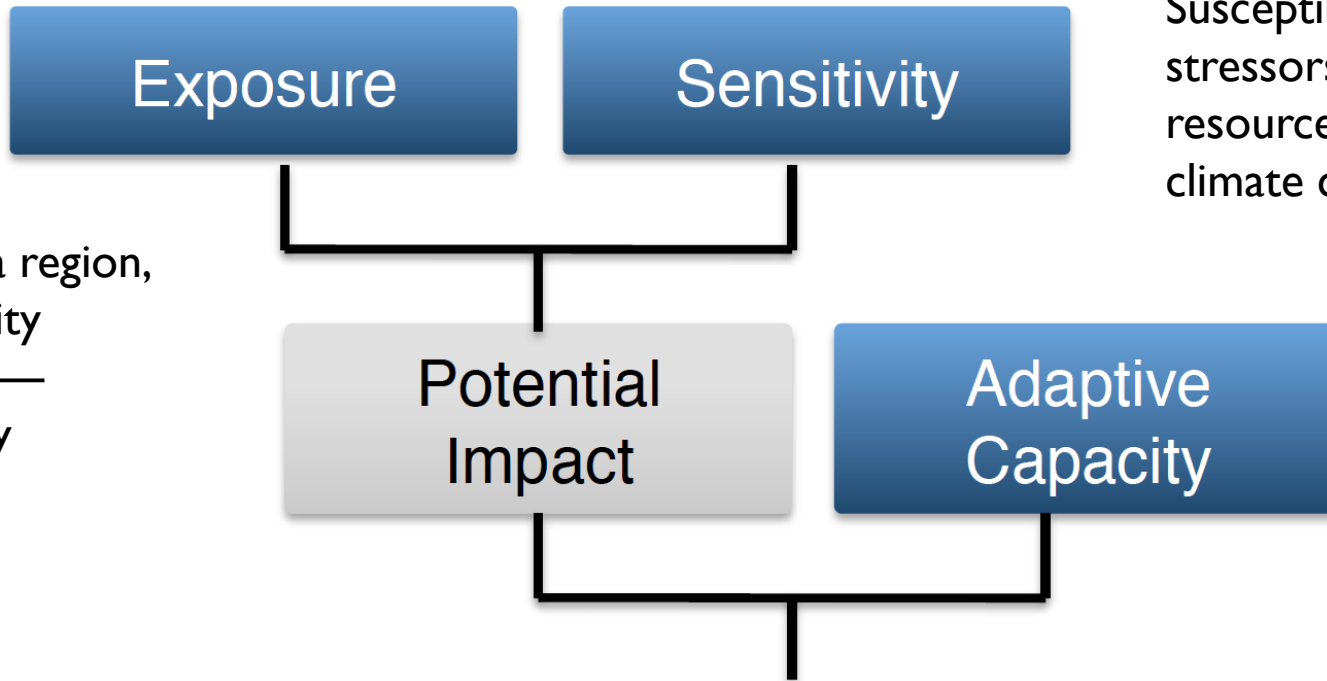
The extent to which a region, resource, or community experiences stressors—ecological vulnerability

Potential
Impact

Adaptive
Capacity

The ability to cope with stress and recover

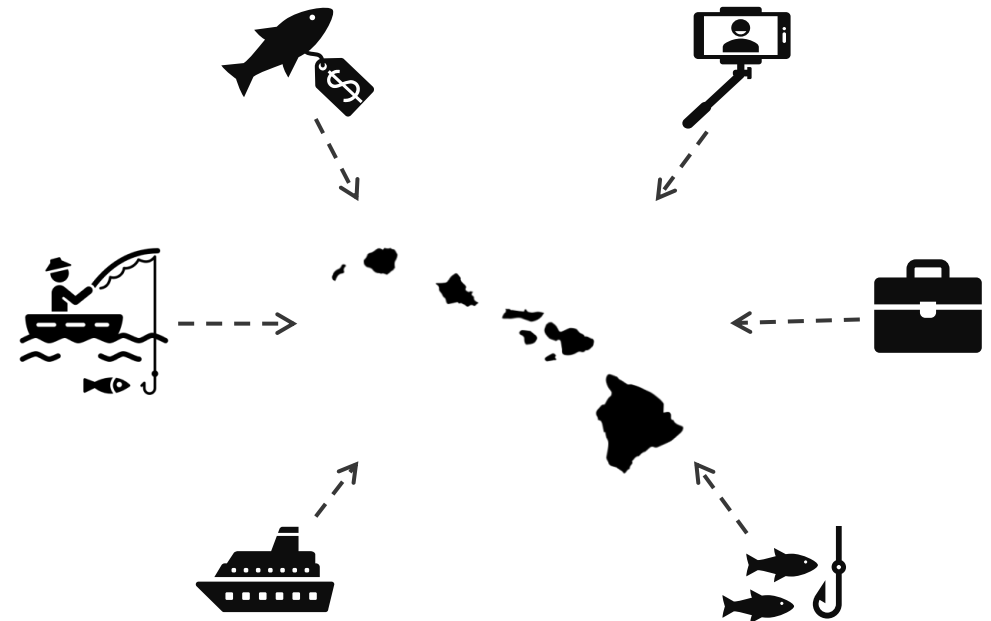
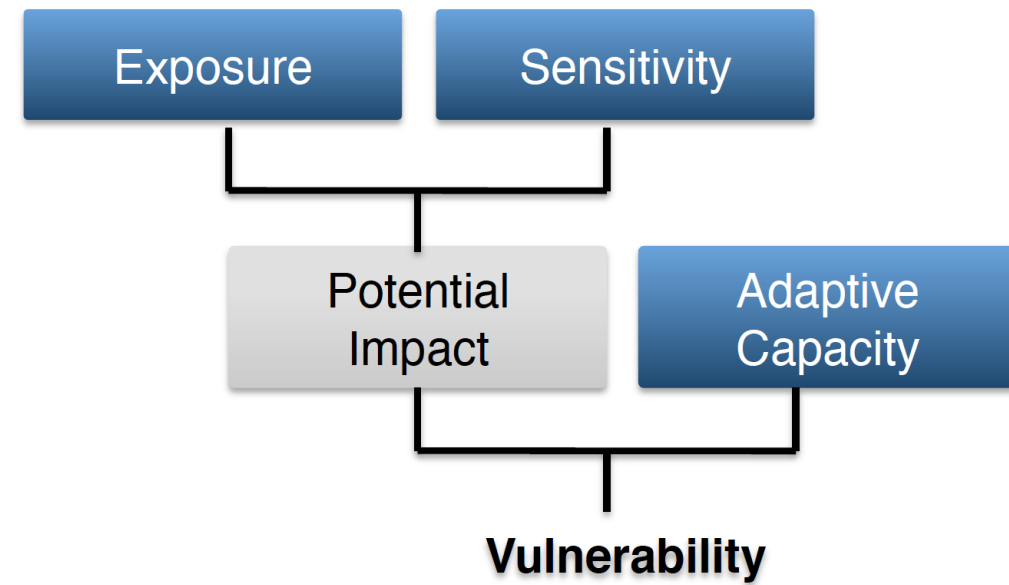
Vulnerability



BUILDING INDICES FOR 3 DIMENSIONS OF VULNERABILITY

- Data Envelopment Analysis (DEA)
 - Scores system performance based on multiple indicators
 - Flexible and data driven
 - No subjective weighting
 - Build composite indices to identify vulnerable communities

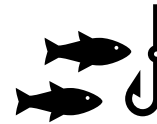
$$\text{Vulnerability} = \frac{\text{Exposure} \times \text{Sensitivity}}{\text{Adaptive Capacity}}$$



BUILDING INDICES FOR 3 DIMENSIONS OF VULNERABILITY

- Exposure
 - More stressed = high exposure

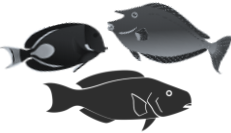
Atlantis Projections



Biomass of targeted
species



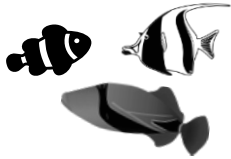
Reef herbivore biomass



Coral cover

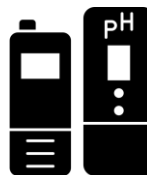
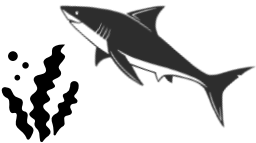


Reef fish diversity



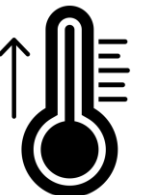
Megafauna abundance

Mean trophic level



pH

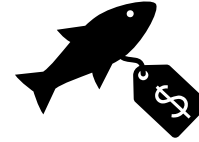
Temperature



BUILDING INDICES FOR 3 DIMENSIONS OF VULNERABILITY

- Exposure
 - More stressed = high exposure
- Sensitivity
 - More dependent = high sensitivity

Snapshot (multiple sources)



Commercial Catch
(Ocean Tipping Points)

Recreational Catch
(Ocean Tipping Points)



Recreational Trips
(CSVI)

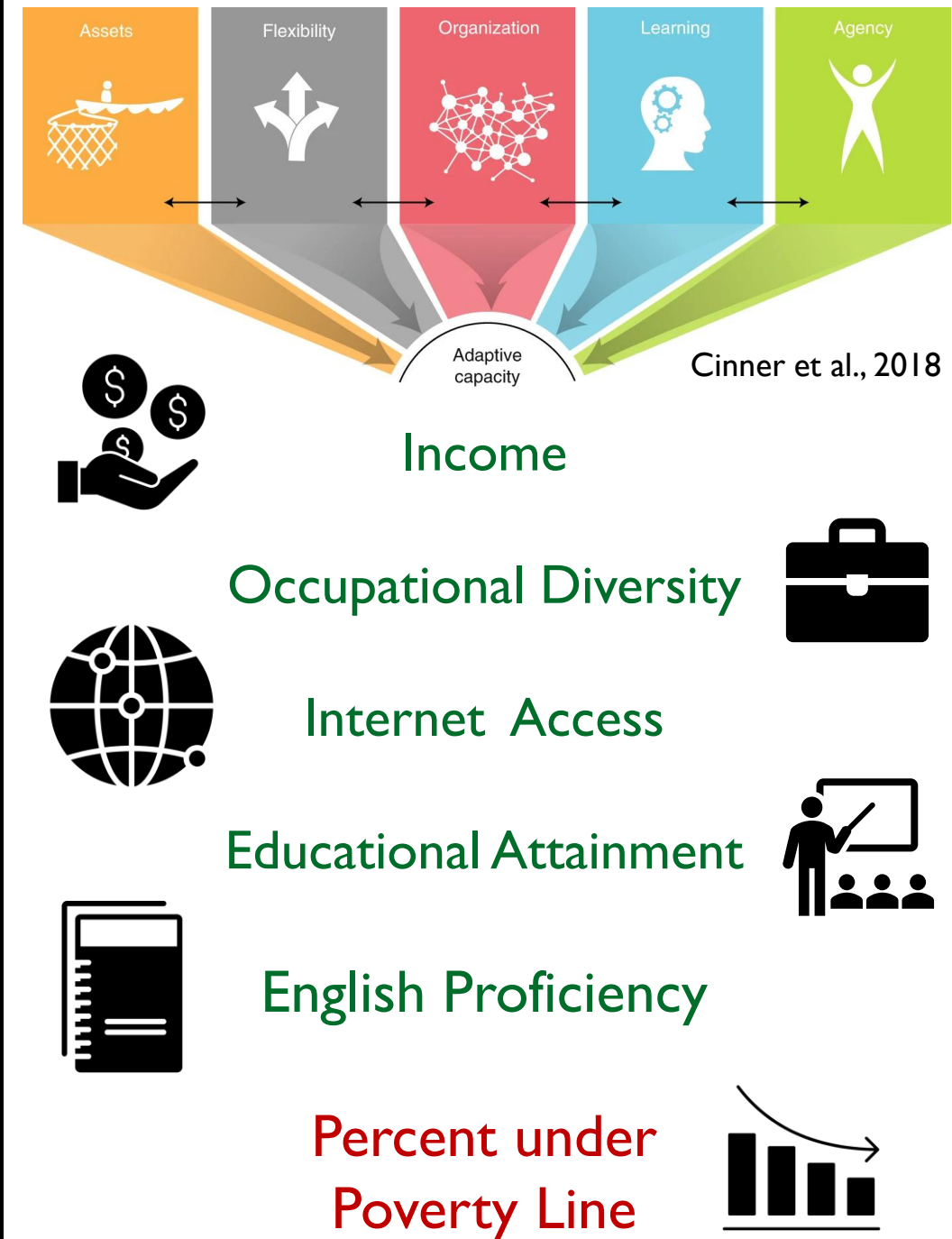
Fishery Revenue
(CSVI)



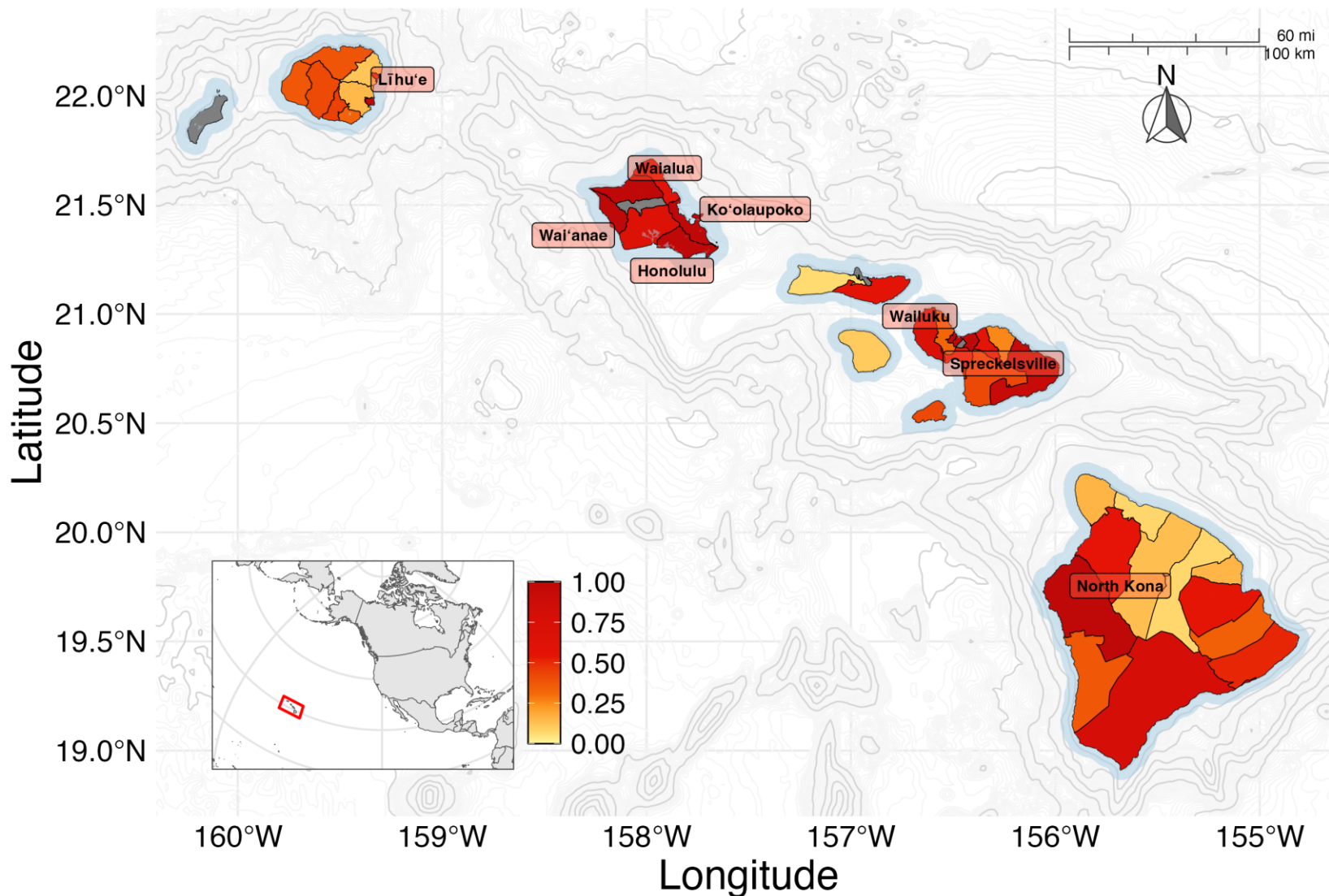
**Recreational Site
Popularity**
(Google Ratings)

BUILDING INDICES FOR 3 DIMENSIONS OF VULNERABILITY

- Exposure
 - More stressed = high exposure
- Sensitivity
 - More dependent = high sensitivity
- Adaptive Capacity
 - Higher coping ability = high adaptive capacity
 - Cinner et al., 2018 framework
 - ACS 5 year average (2019-2023)

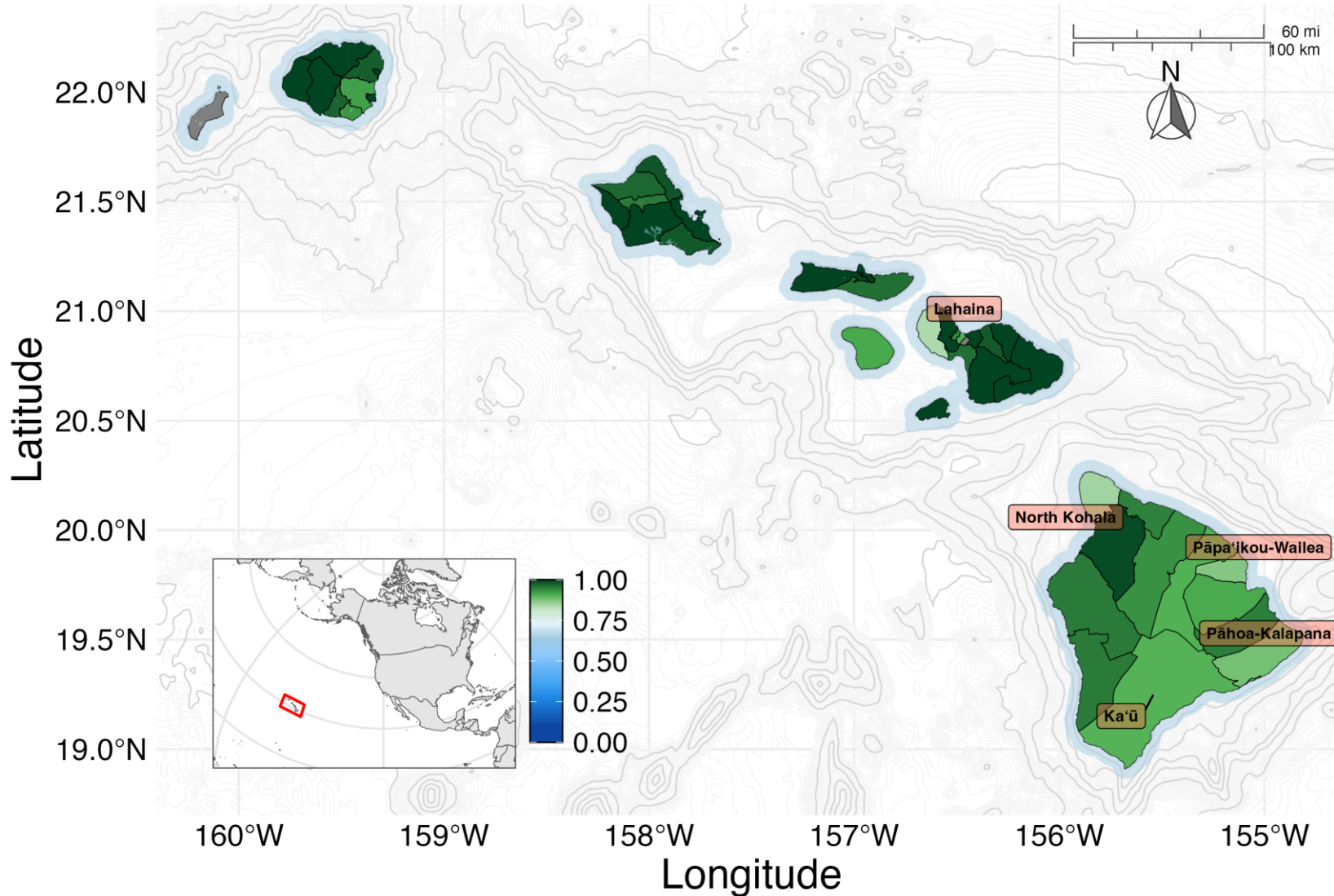


SENSITIVITY



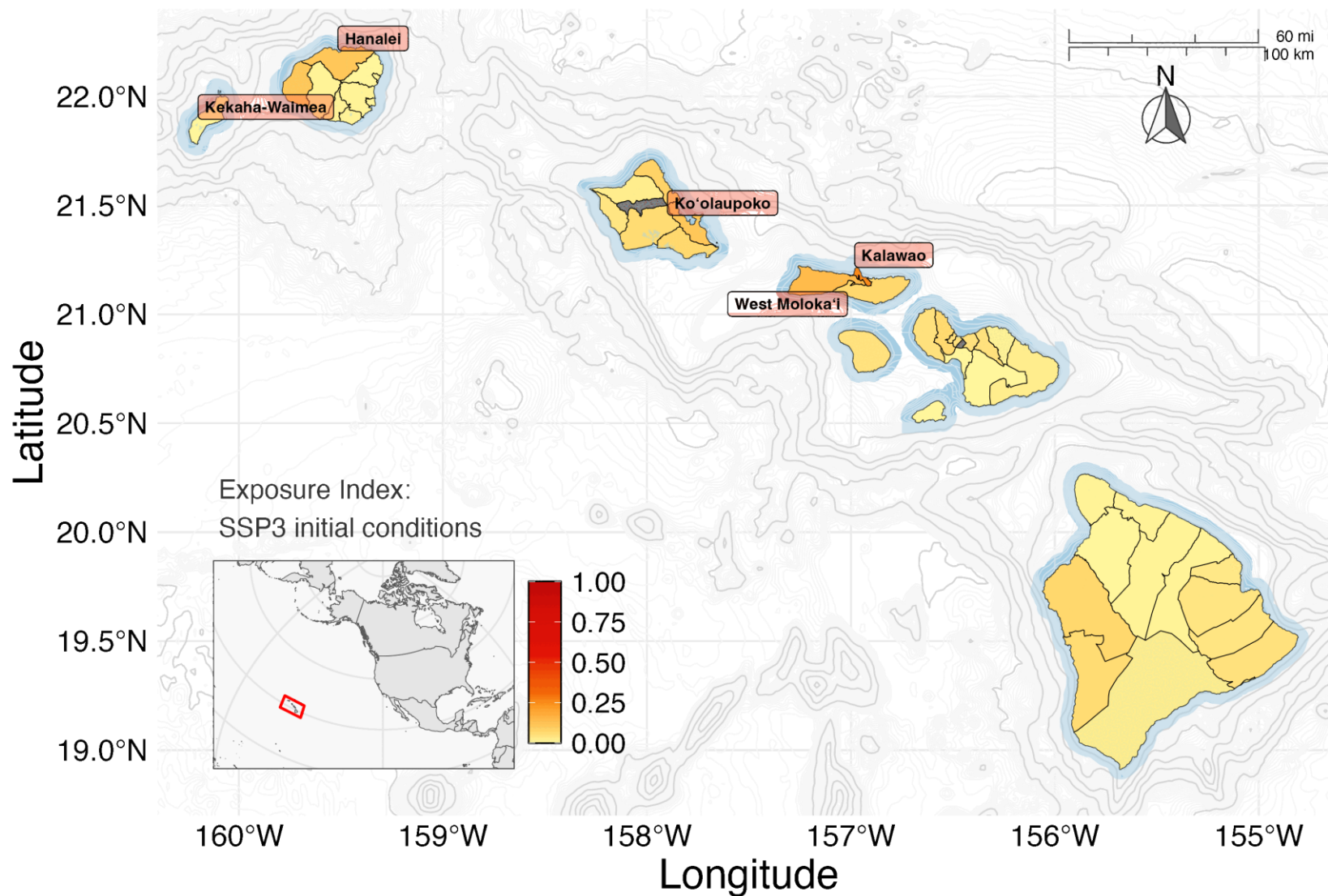
- Spatial variation across and within islands
- Oahu: commercial fishery engagement, recreational popularity
- Other islands: recreational fishery engagement

ADAPTIVE CAPACITY



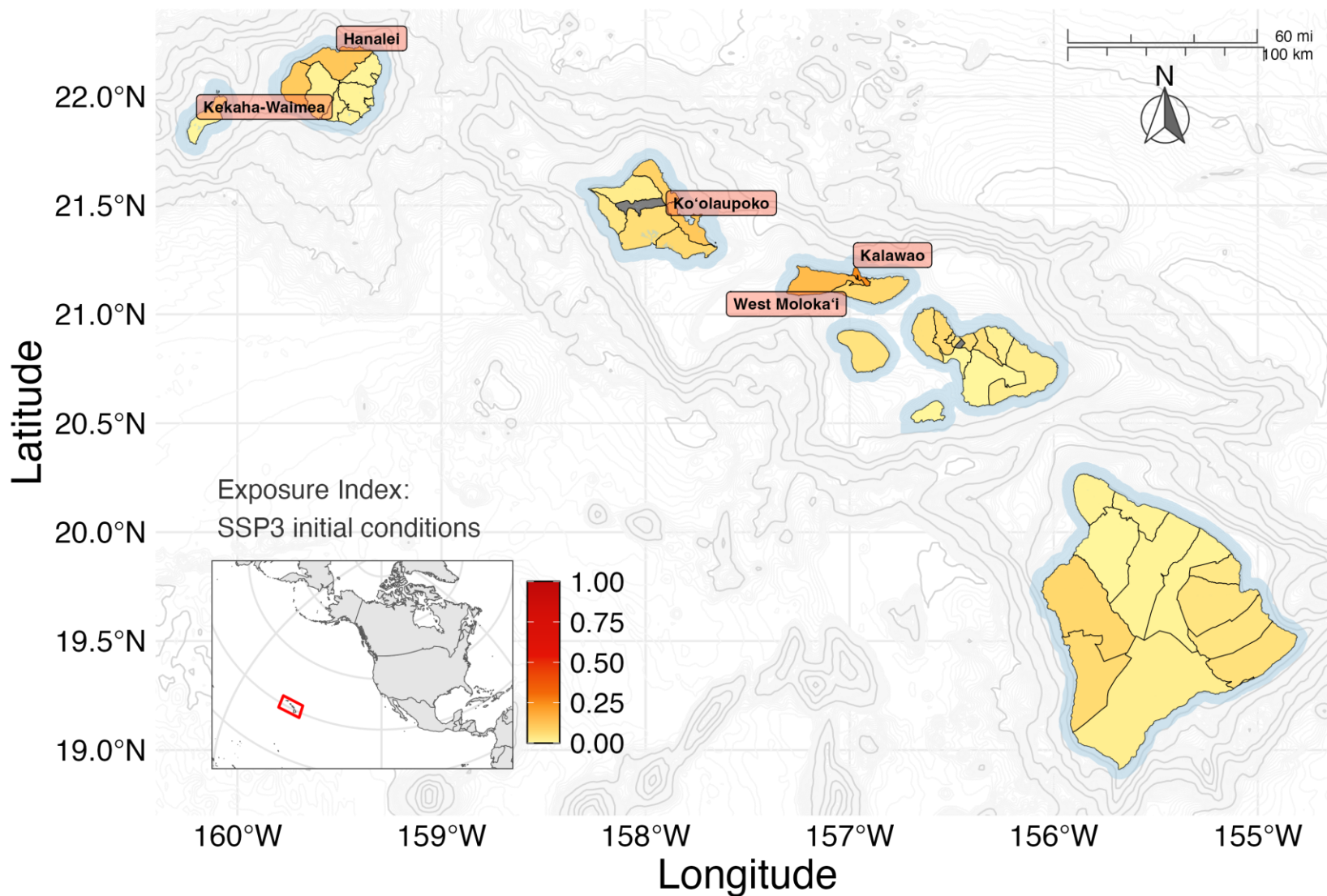
- Relatively high AC across MHI (0.83 – 1)
- Lower range AC largely on Hawai'i Island
- Low values mostly in assets, learning, agency

EXPOSURE



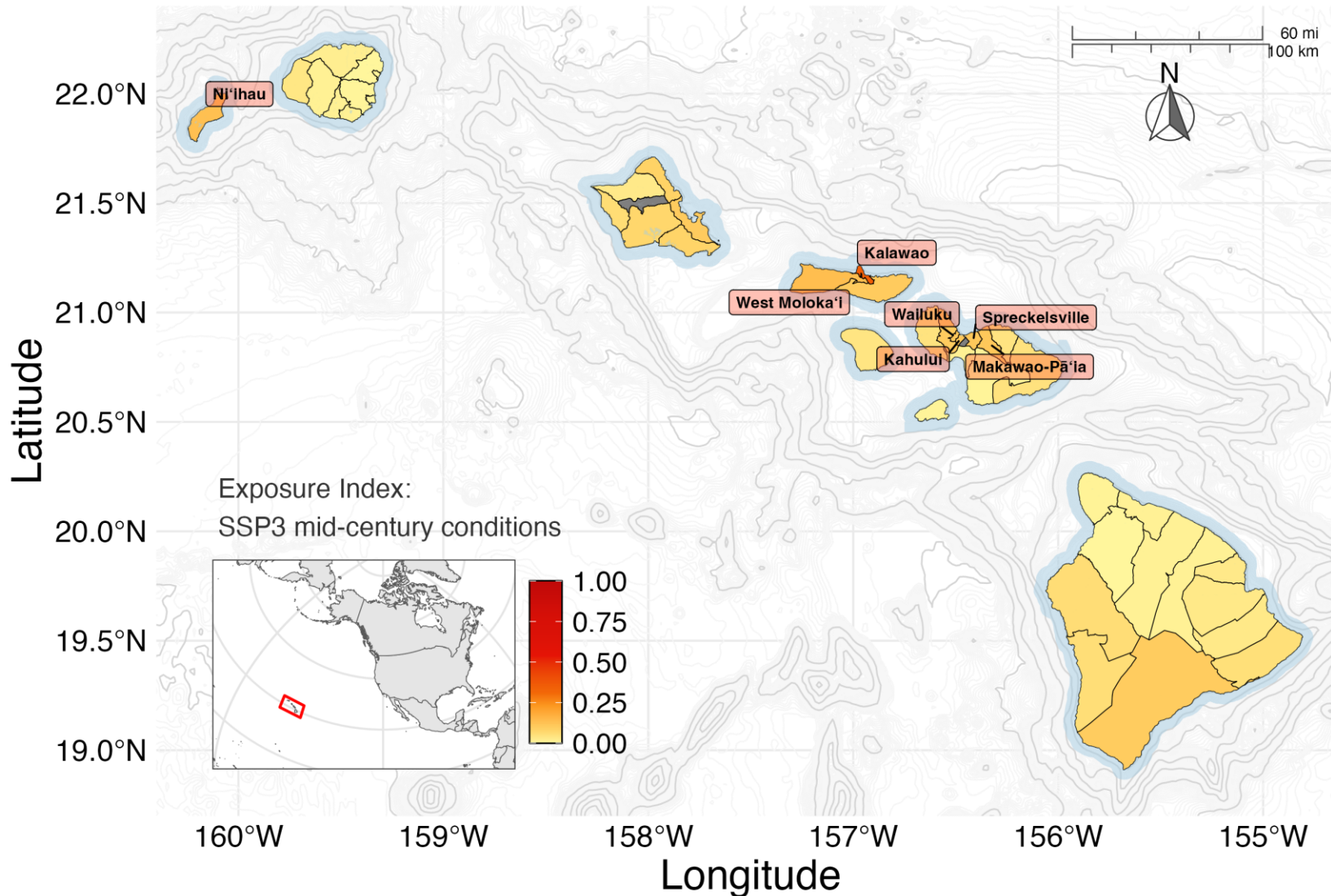
- SSP3 (high-emission) exposure index

EXPOSURE



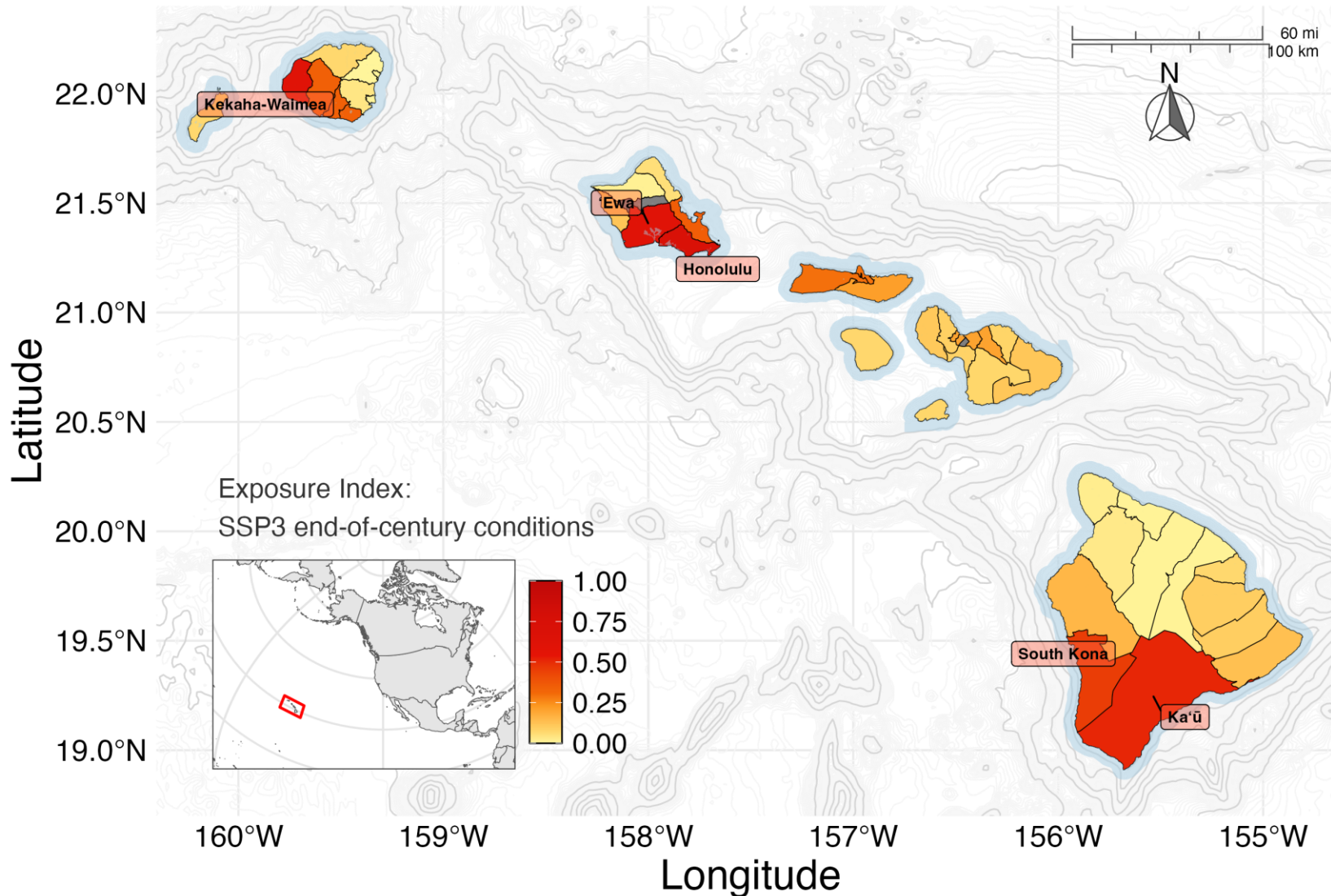
- SSP3 (high-emission) exposure index
- Initial: low exposure across MHI

EXPOSURE



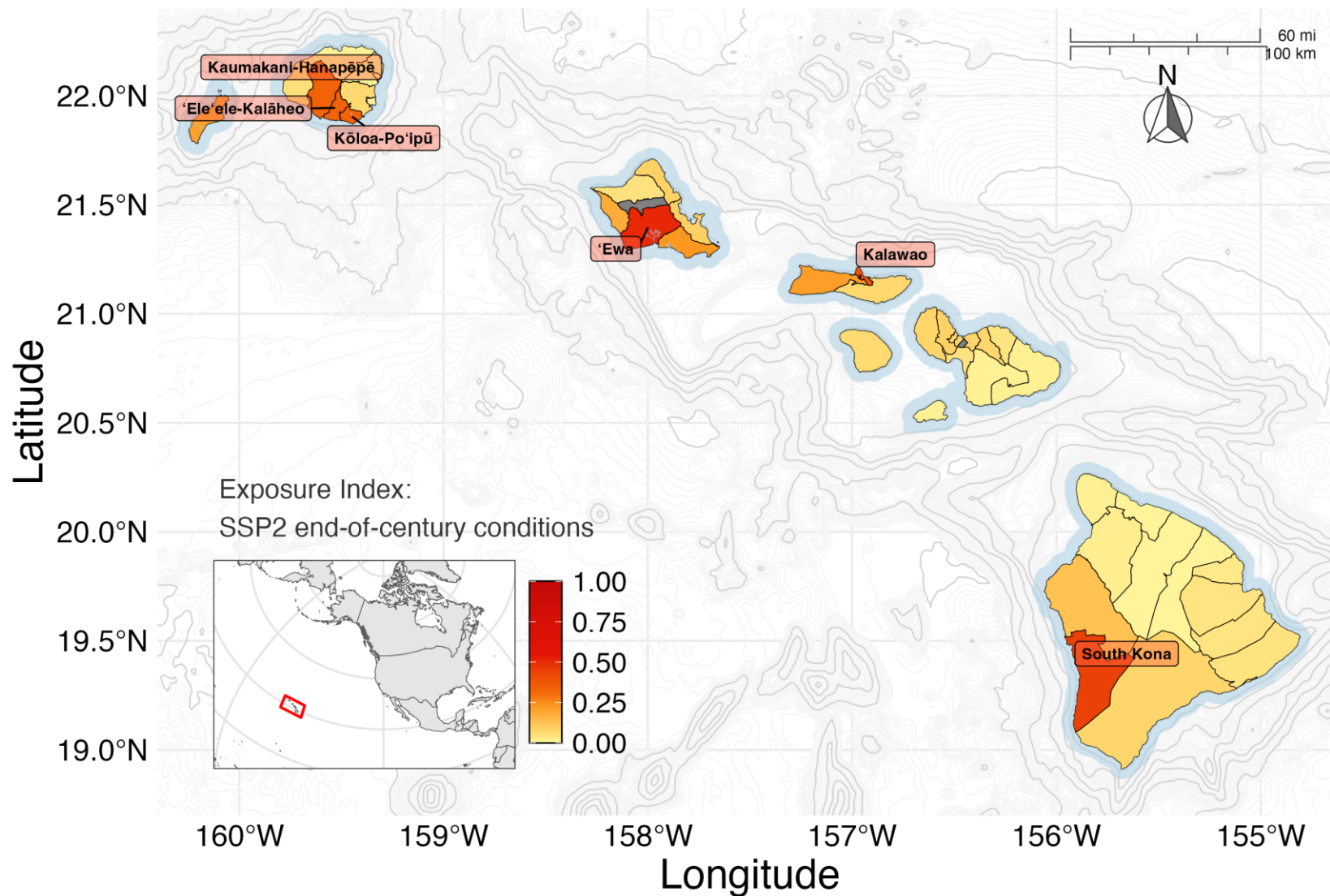
- SSP3 (high-emission) exposure index
- Initial: low exposure across MHI
- Mid-century: increasing exposure in Maui County islands

EXPOSURE



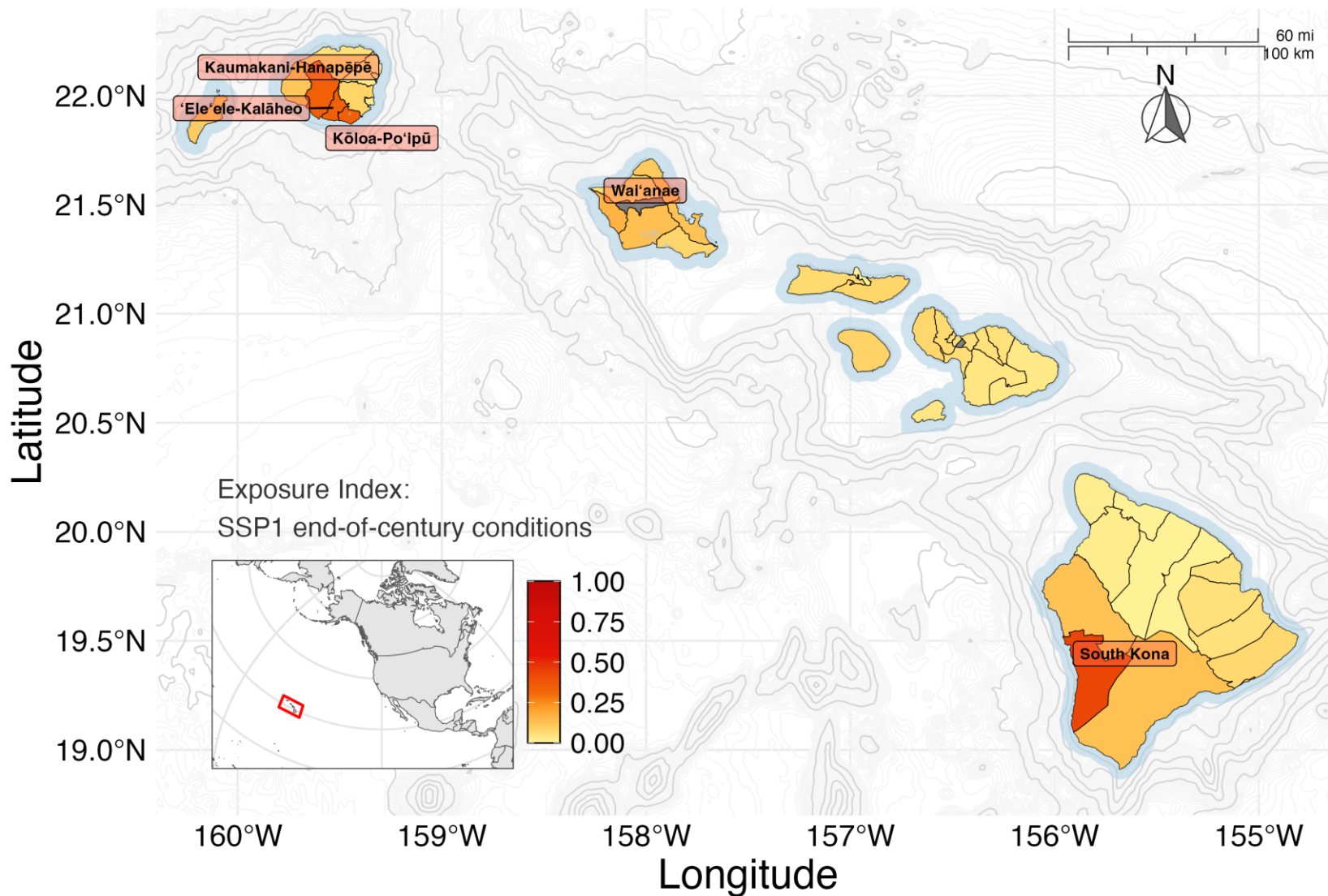
- SSP3 (high-emission) exposure index
- Initial: low exposure across MHI
- Mid-century: increasing exposure in Maui County islands
- End-of-century: high exposure everywhere except Maui County

EXPOSURE



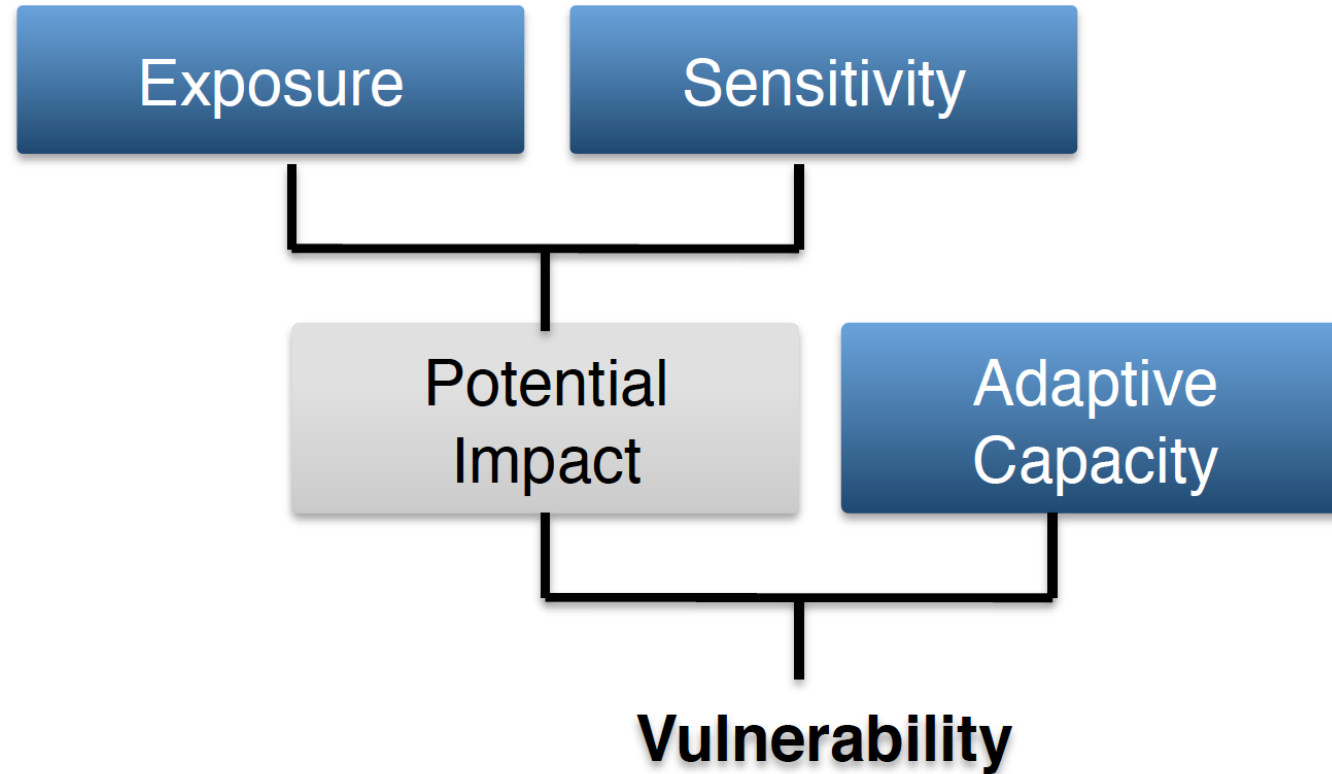
- Compare to SSP2
- Ewa & South Kona in 10% for SSP2 & SSP3

EXPOSURE



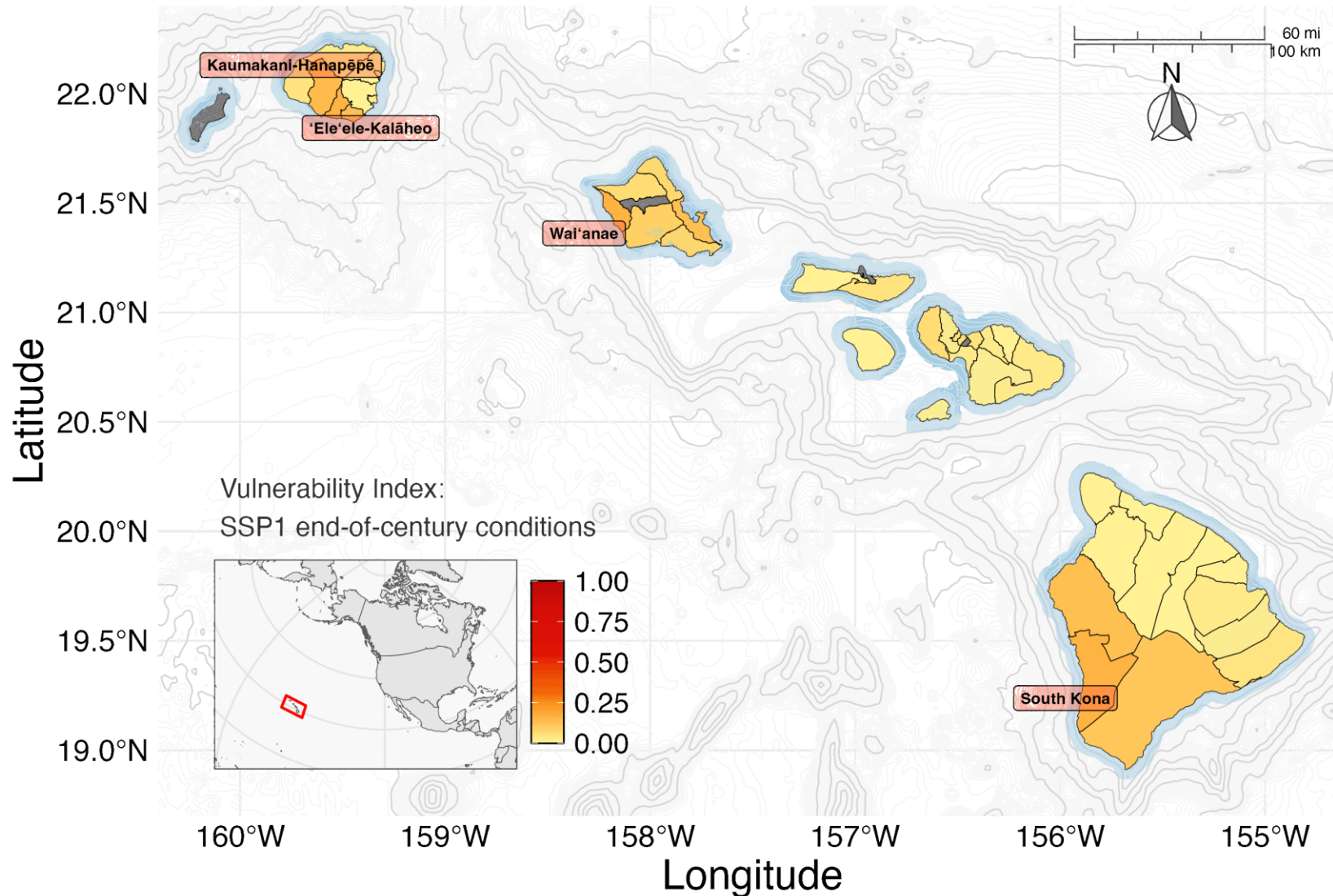
- Compare to SSP2
 - Ewa & South Kona in 10% for SSP2 & SSP3
- Compare to SSP1
 - South Kona in top 10% for all scenarios

VULNERABILITY



$$\text{Vulnerability} = \frac{\text{Exposure} \times \text{Sensitivity}}{\text{Adaptive Capacity}}$$

VULNERABILITY



- End-of-century vulnerability for all climate scenarios
- SSPs 1 & 2: South Kona and Wai'anae
- SSPs 2 & 3: Ewa and Honolulu



SUMMARY

- Sensitivity highest in O‘ahu, with some standout communities in other islands
- High AC range, but Hawai‘i Island in lower end of range
- Exposure increases over time, especially SSP3—Honolulu highest in SSP3 end-of-century
- 3 dimensions combine to assess vulnerability in a way that no one index could

SIGNIFICANCE

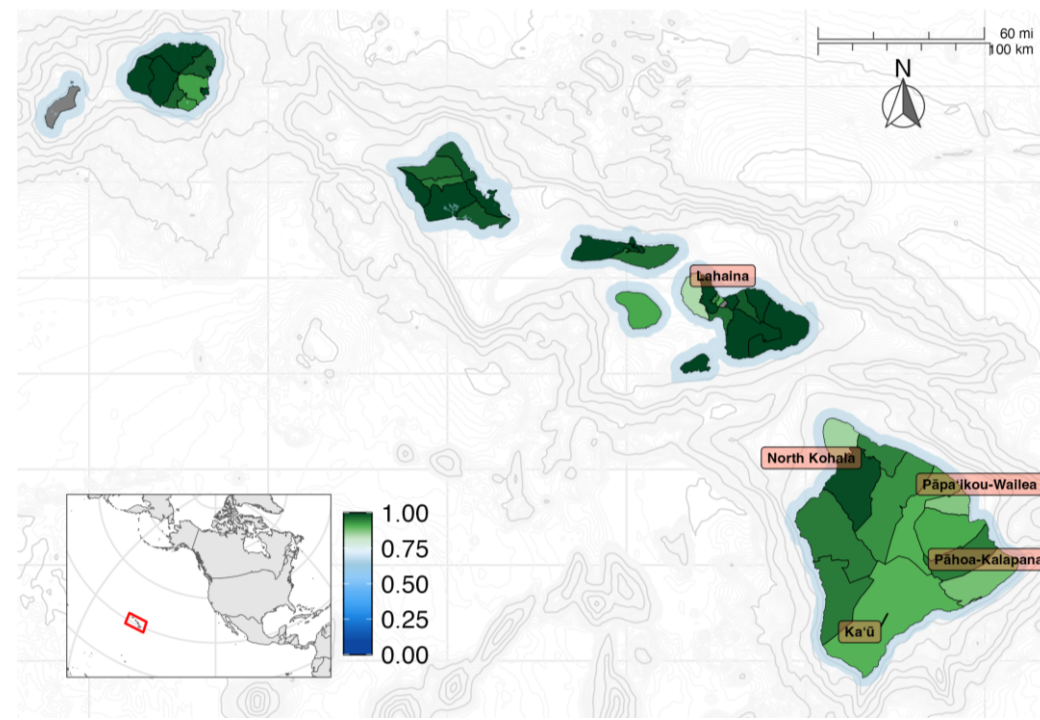
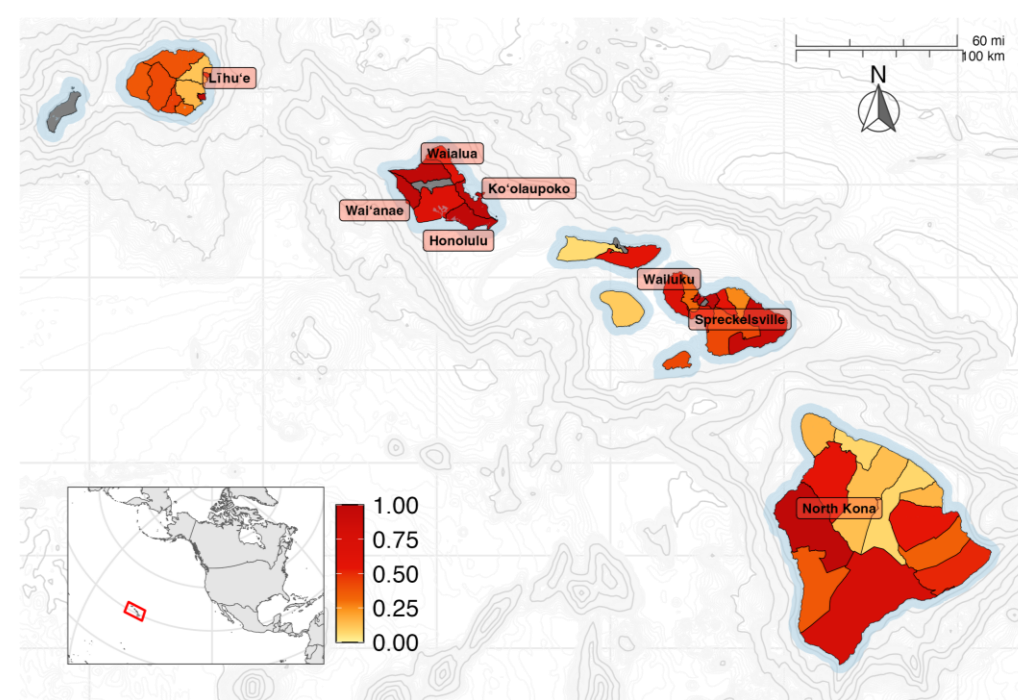
Urban communities
—higher sensitivity

Rural communities—
lower adaptive capacity

Spatial vulnerability varied with climate scenario

Spatially resolved indices inform targeted adaptation strategies

TAKEAWAYS



A large sea turtle is swimming towards the left in clear, turquoise water. Below it is a coral reef with several small, bright yellow fish and a few striped butterflyfish. The turtle's shell is brown and patterned, and its flippers are visible. A semi-transparent box with the text "Thank You!" is centered over the turtle's body.

Thank
You!

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NOAA-OAR-OAP-2020-2006333