# How much marsh restoration is enough to deliver coastal protection benefits?

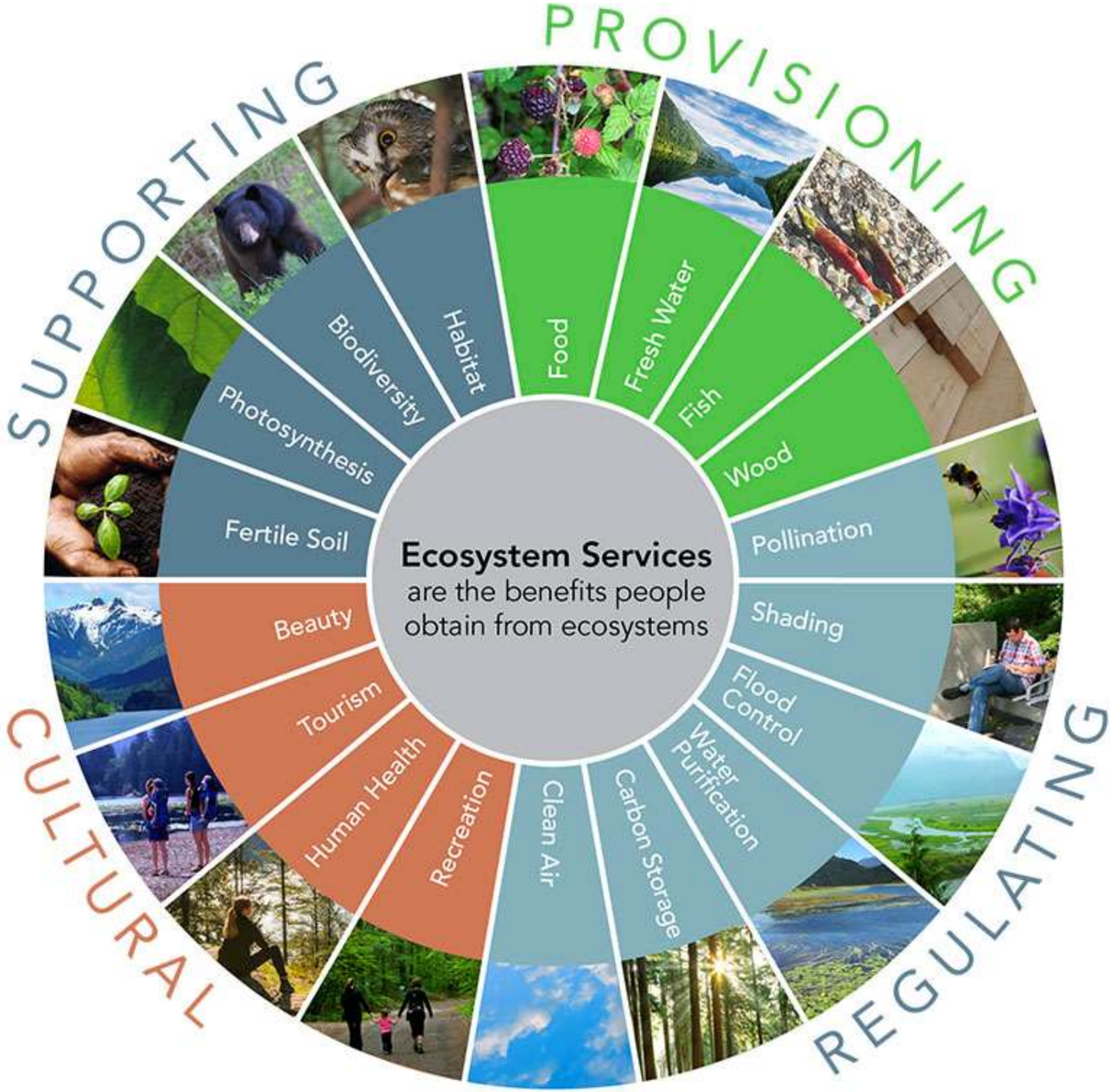
Herring River Estuary, Wellfleet, MA

**Katherine A. Castagno, Ph.D.**

Martha's Vineyard Coastal Conference

24 October 2022

# Salt marshes provide valuable ecosystem services



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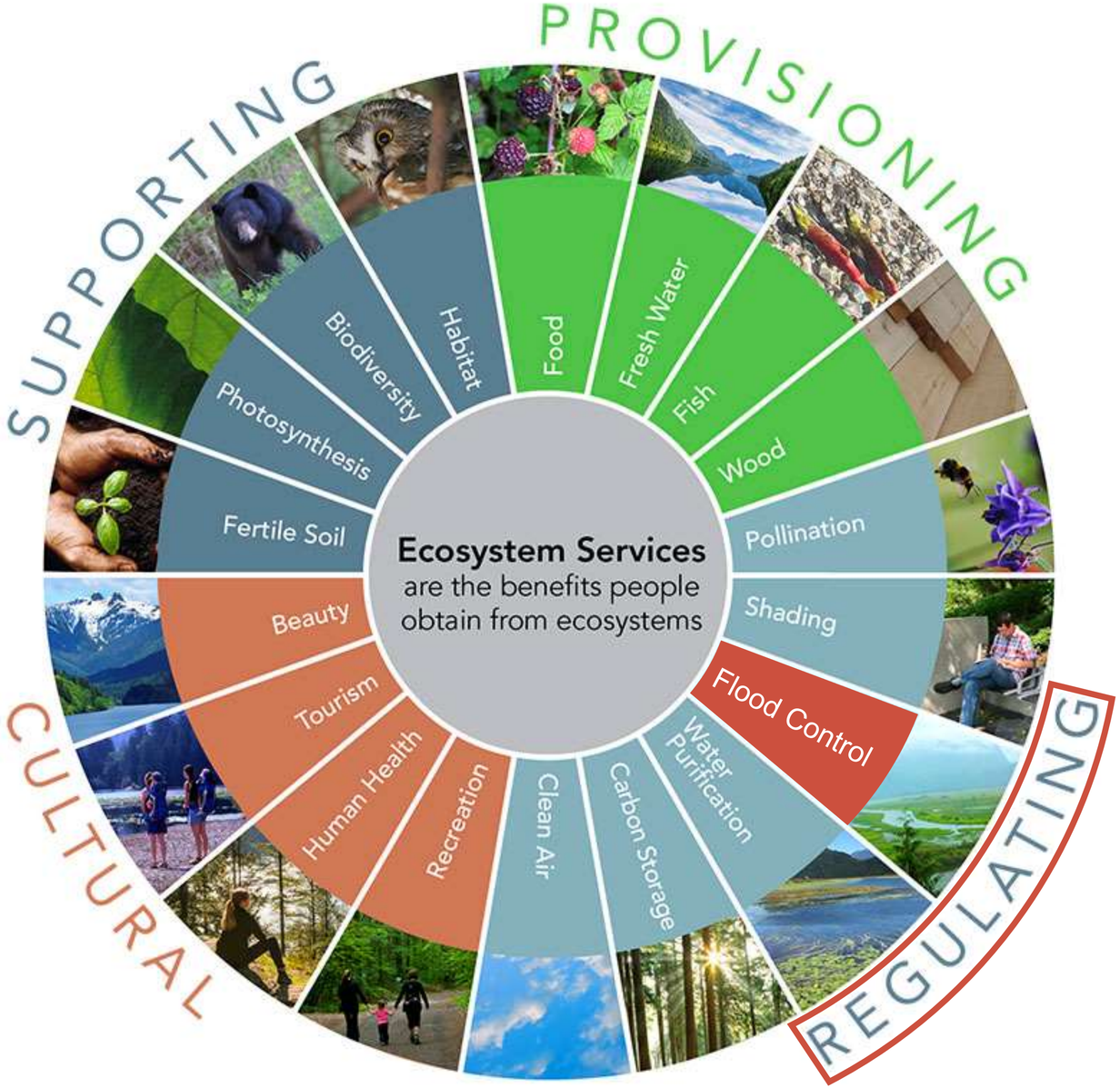


# Salt marshes have experienced centuries of *natural* alteration

Sopkin *et al.* (2014)

Fagherazzi *et al.* (2014)

Argow *et al.* (2011)

# Salt marshes have experienced centuries of *human* alteration

SCIENTIFIC AMERICAN

A WEEKLY JOURNAL OF PRACTICAL INFORMATION, ART, SCIENCE, MECHANICS, CHEMISTRY, AND MANUFACTURES

Vol. XIX.---No. 5. [NEW SERIES.] NEW YORK, JULY 29, 1868. $3 per Annum. [IN ADVANCE.]

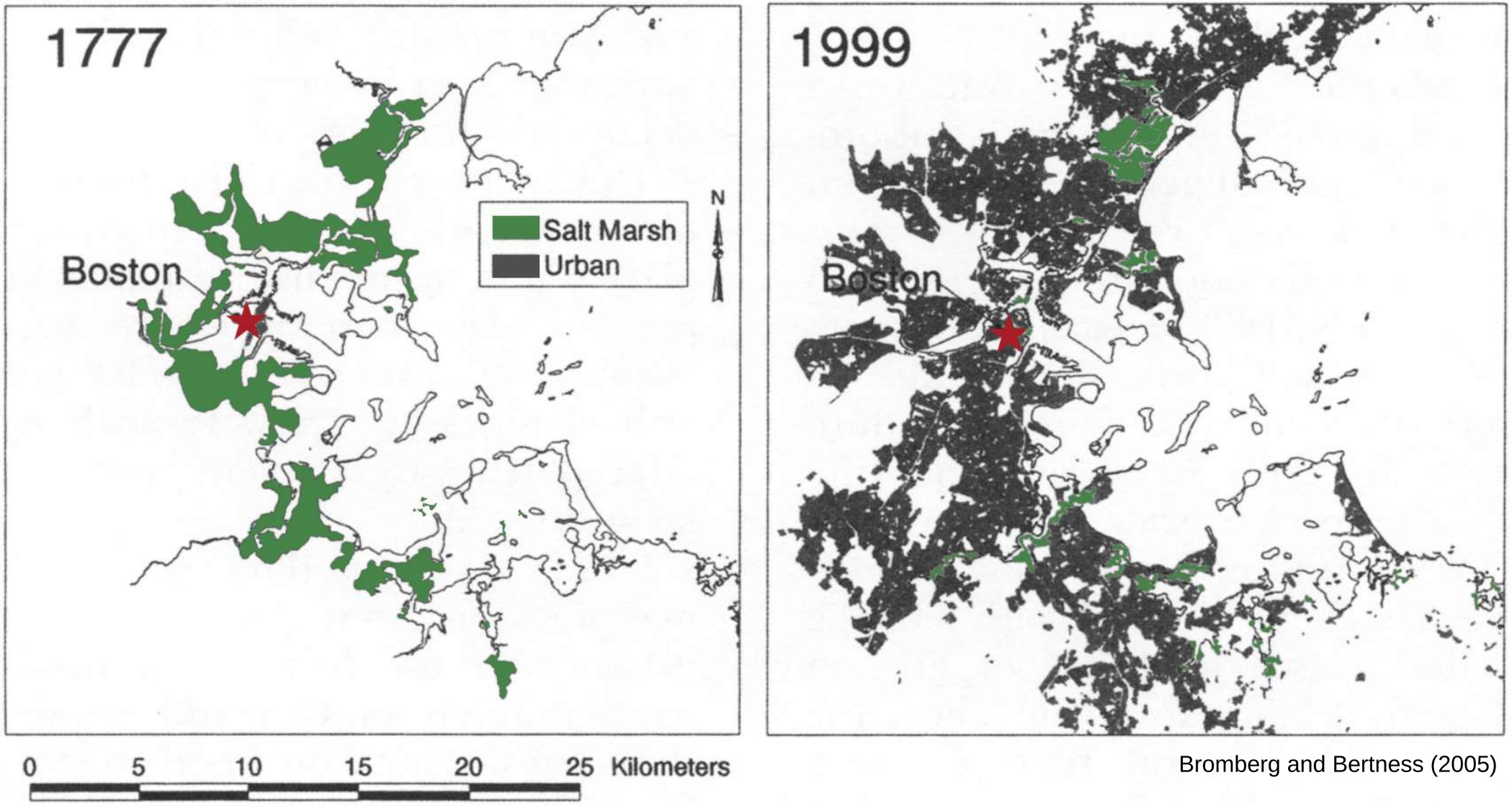
DIKING AND DRAINING THE NEW JERSEY MEADOWS.

Scientific American (1868)

DE Mosquito Control Section (~1930)

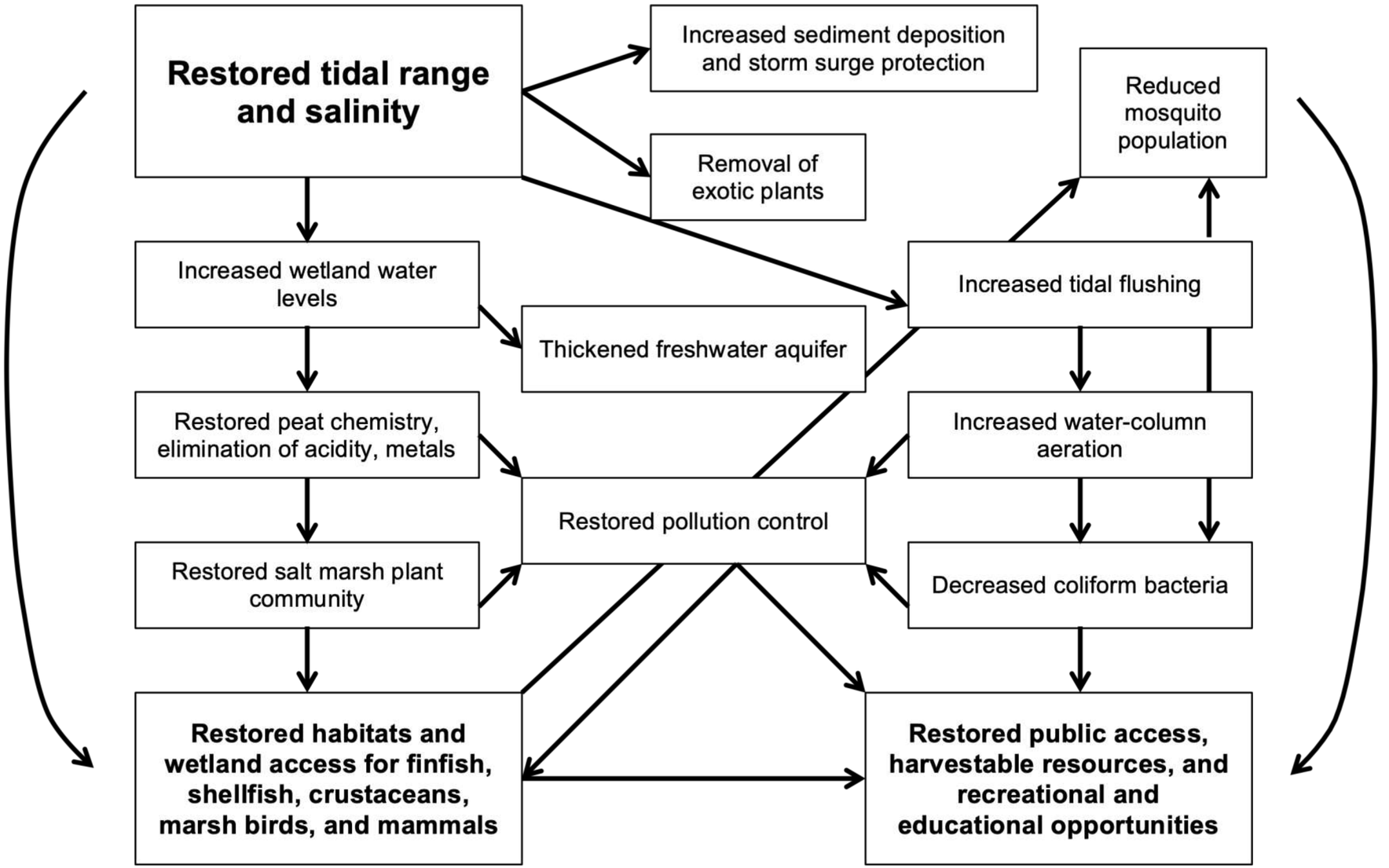
George Dexter (~1900)

# Marshes have been lost at an alarming rate




Bromberg and Bertness (2005)

# Salt marsh restoration seeks to restore ecosystem services



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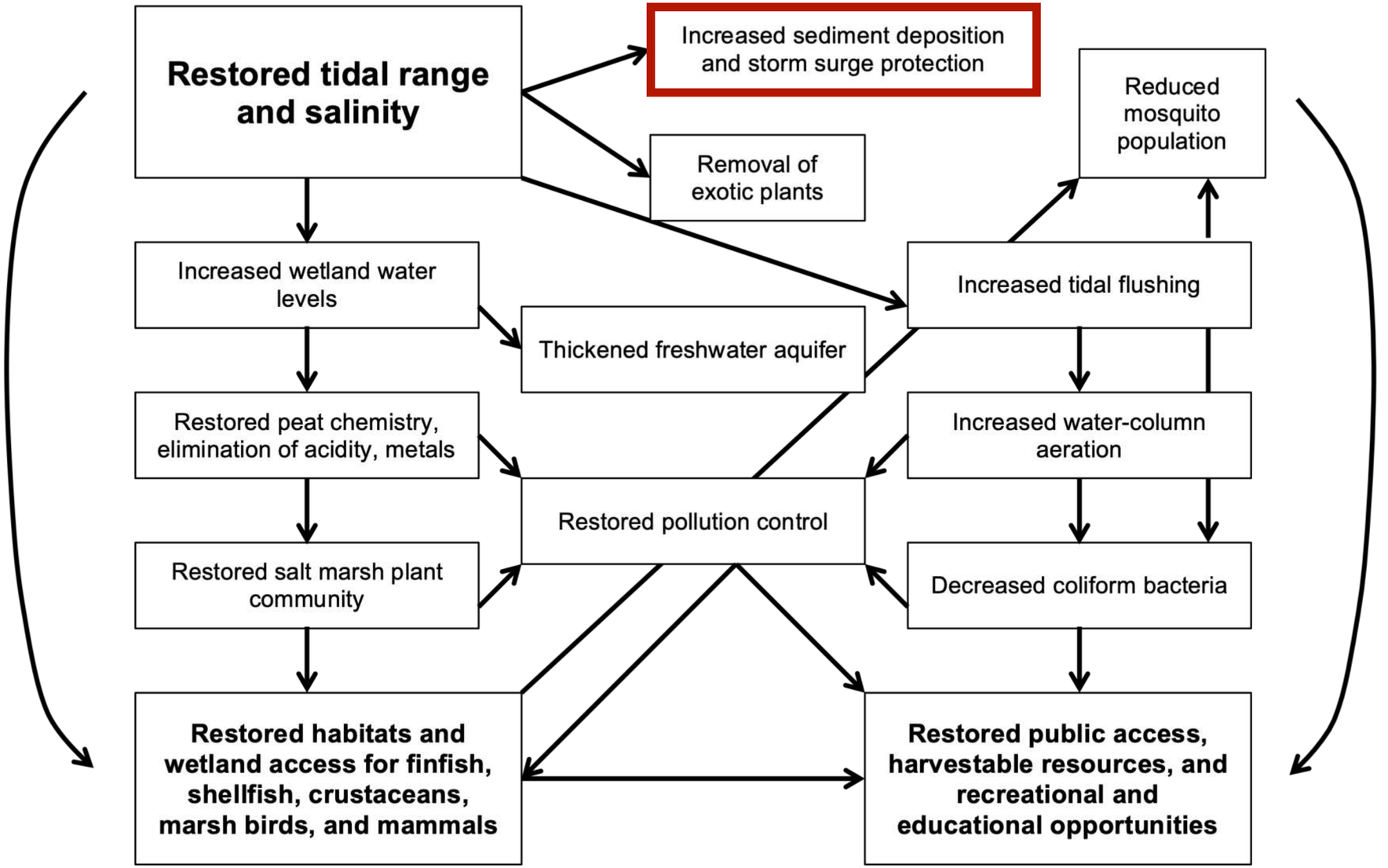
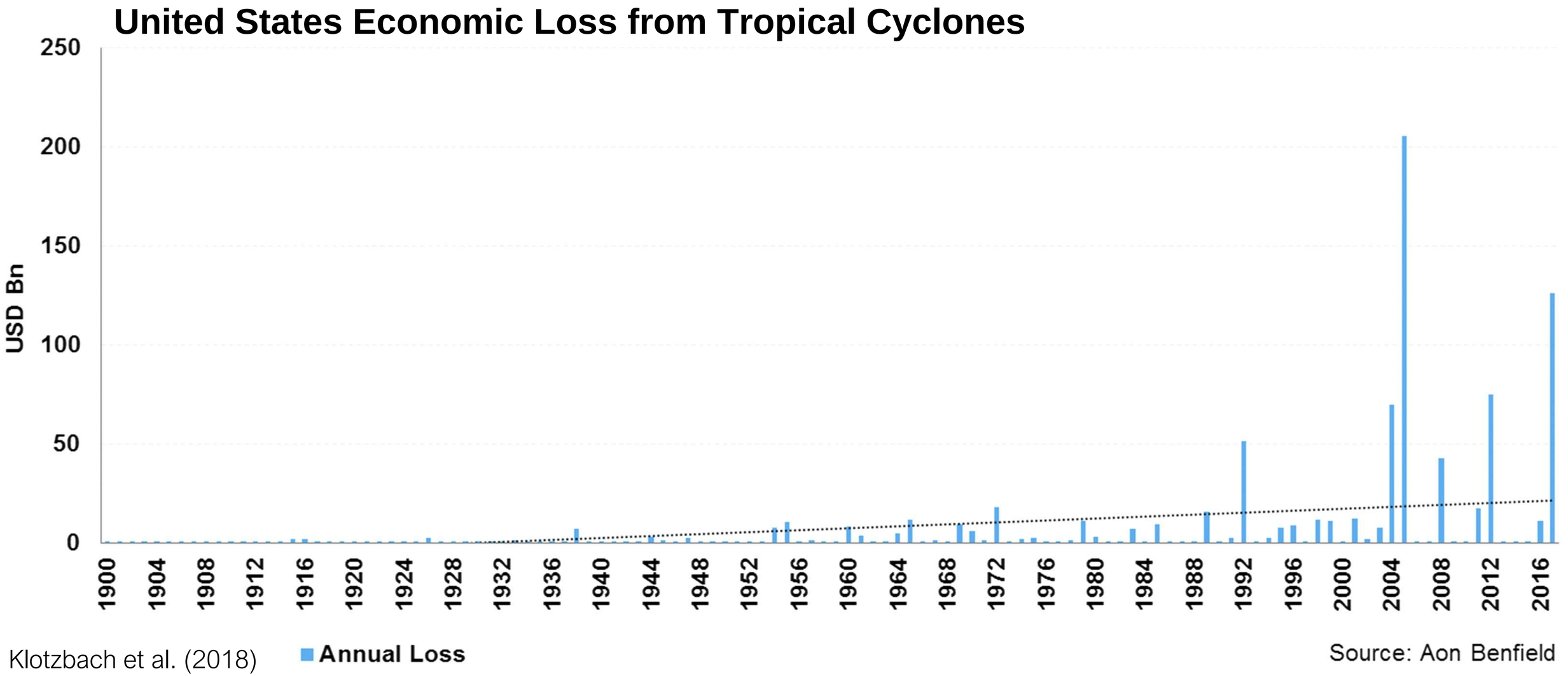


# Coastal communities are growing more vulnerable to storm impacts




Klotzbach et al. (2018)

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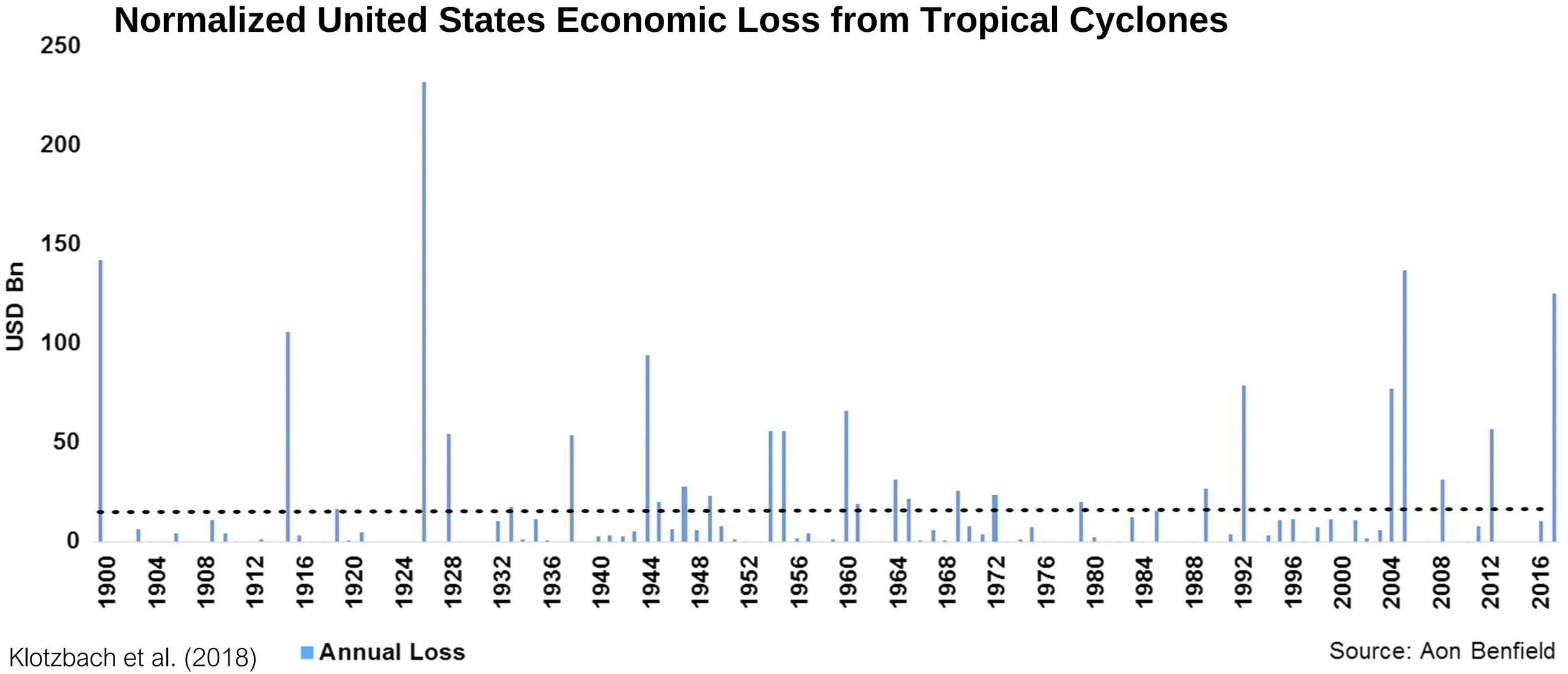
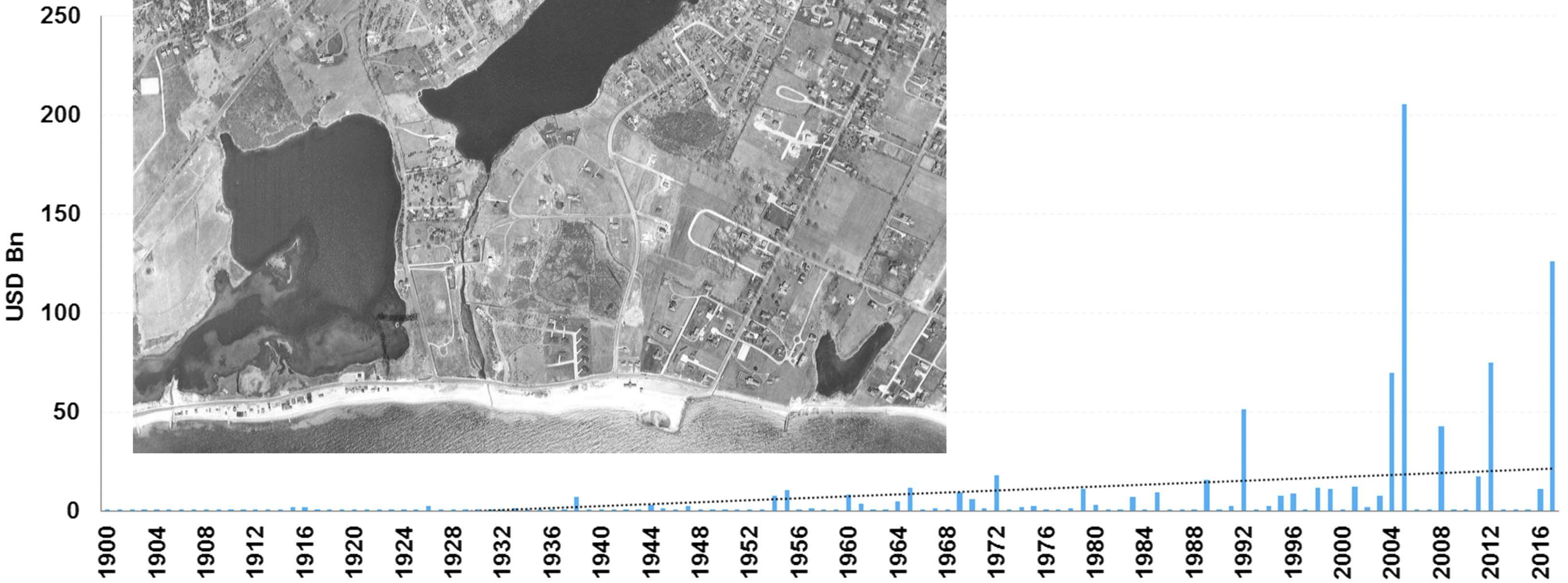



Klotzbach et al. (2018)

# Wealth is concentrated along vulnerable coastlines




Klotzbach et al. (2018)

Source: Aon Benfield

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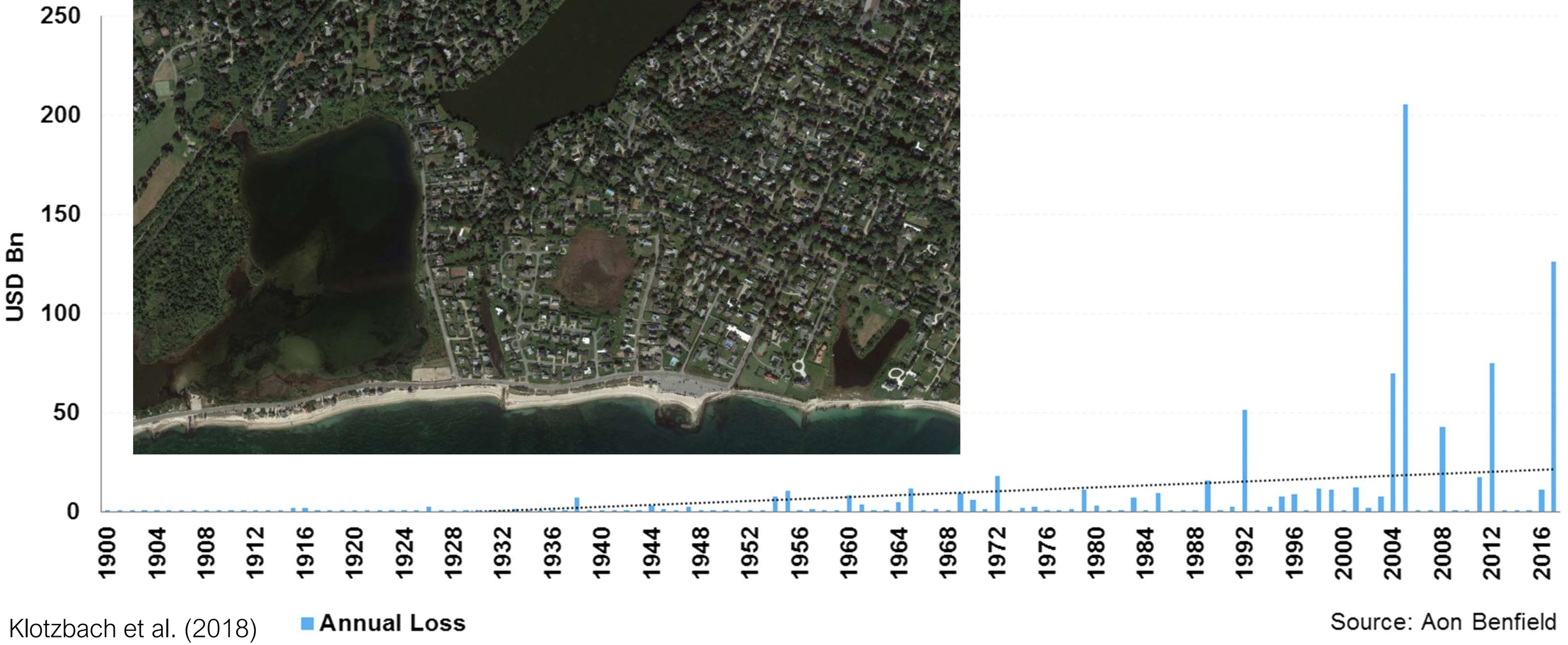


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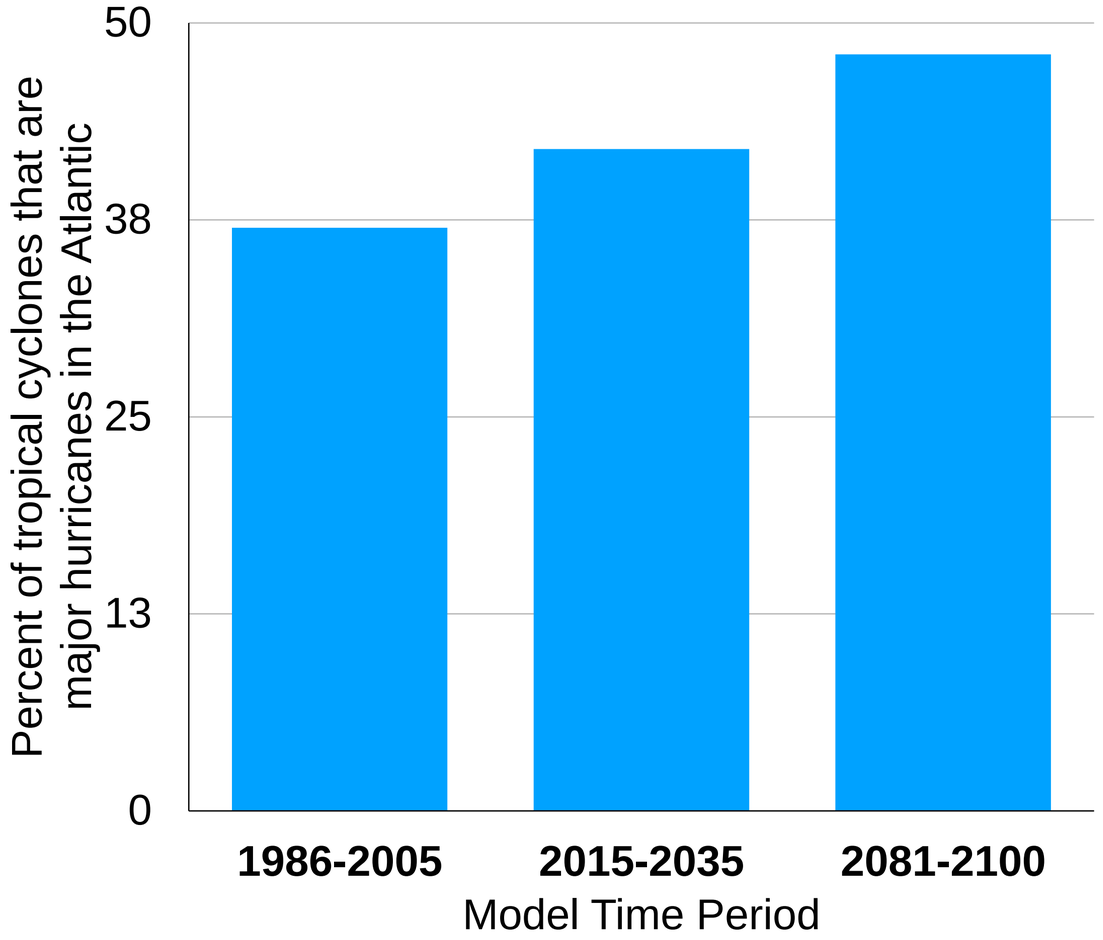
# Intense hurricanes are estimated to increase in frequency




Bhatia et al. (2018)

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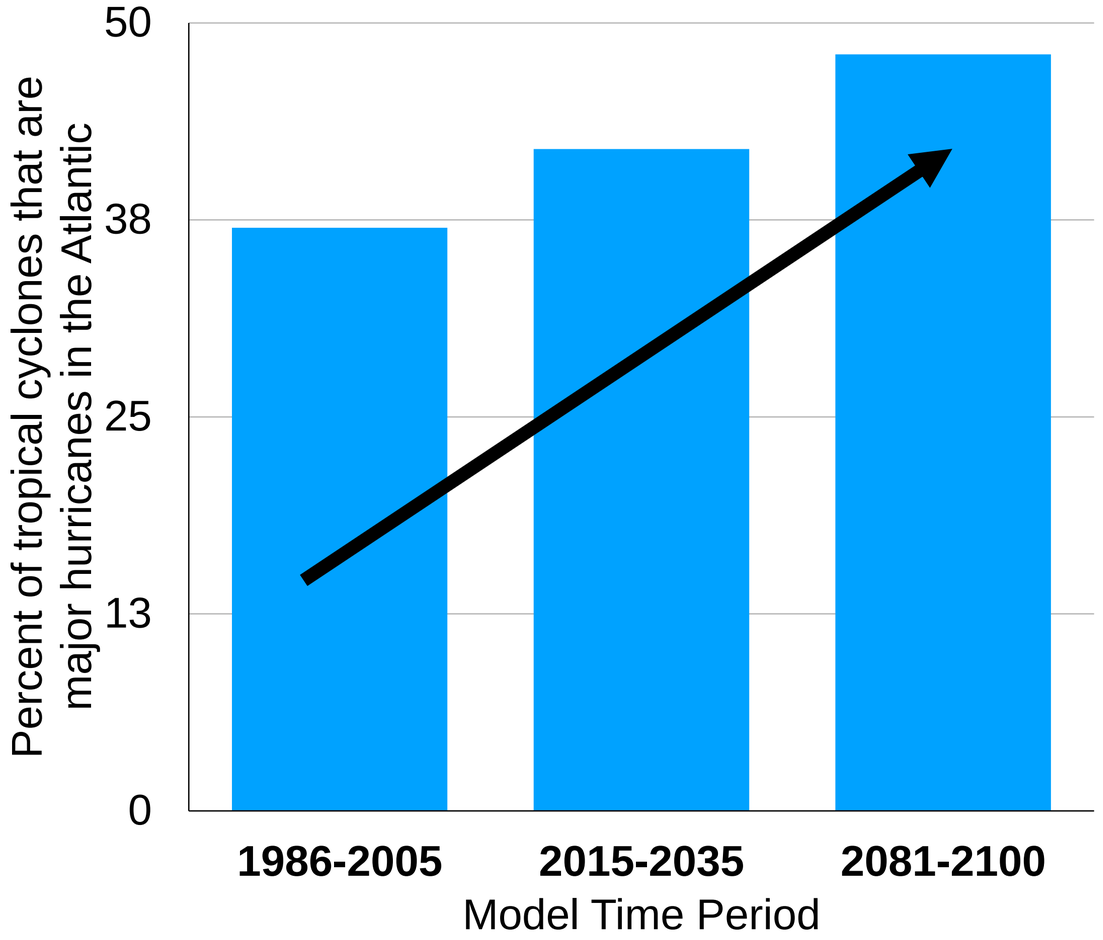


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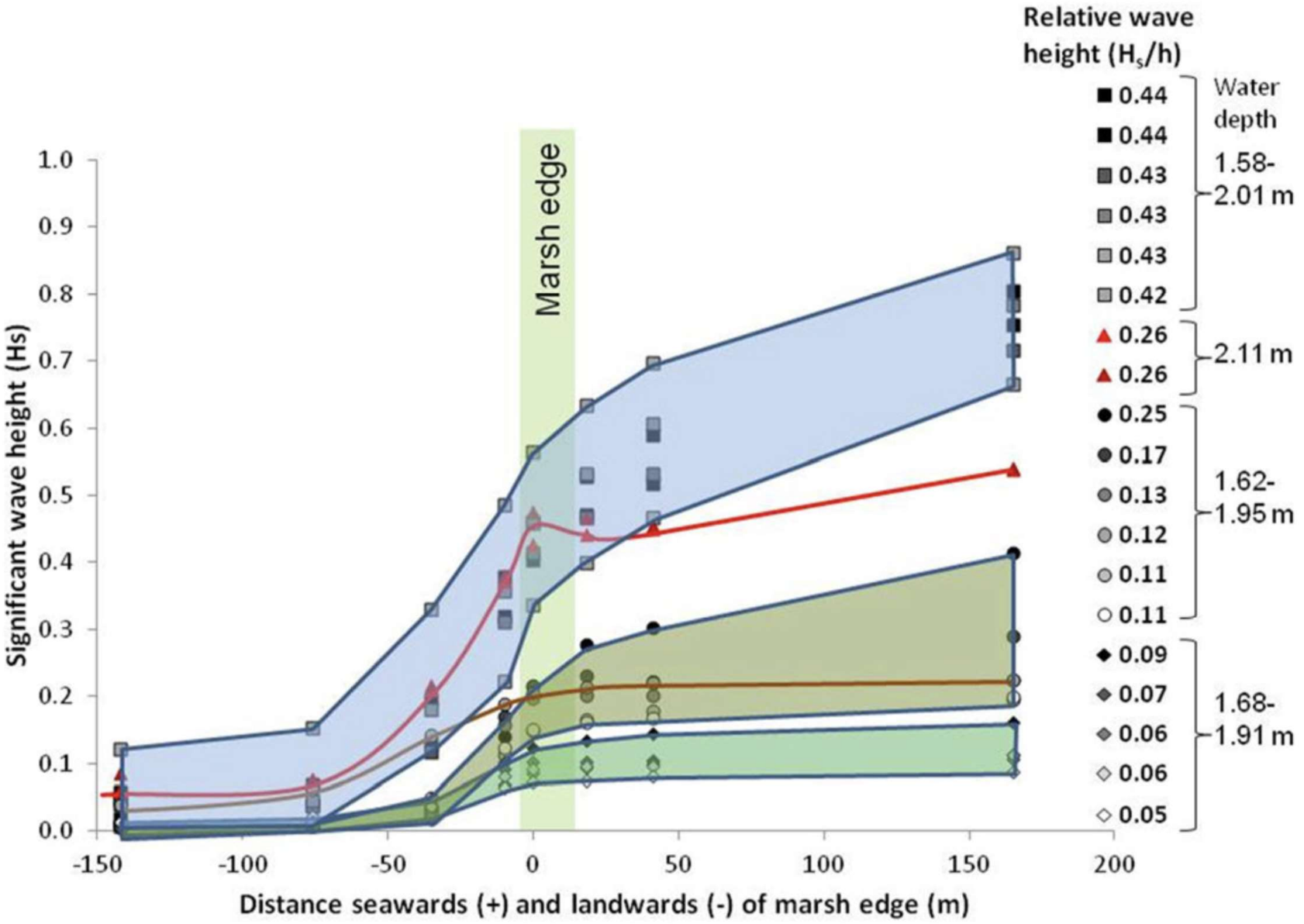
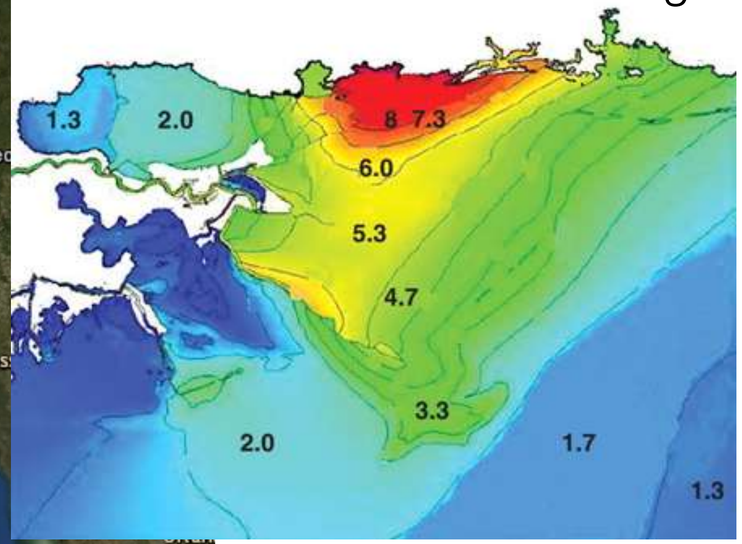
# Salt marshes contribute to coastal resilience as storm buffers

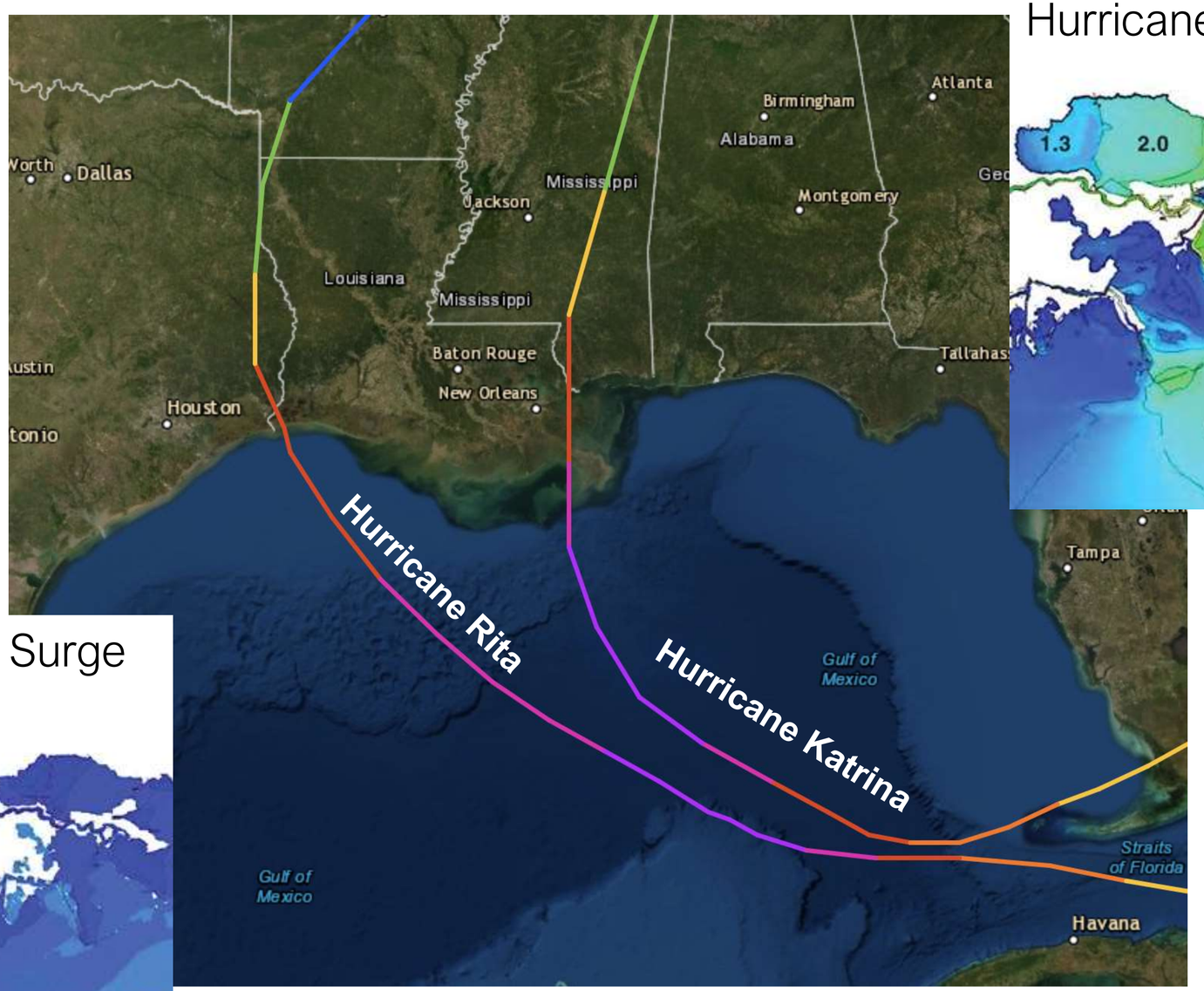



Möller (2012)

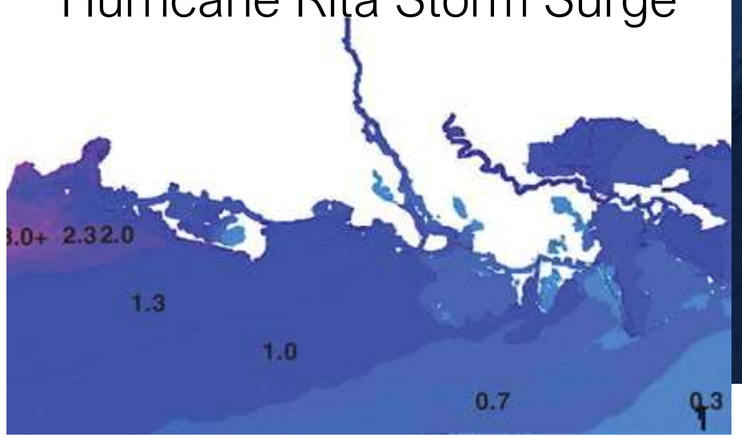
# Salt marshes contribute to coastal resilience as storm buffers

Hurricane Katrina Storm Surge



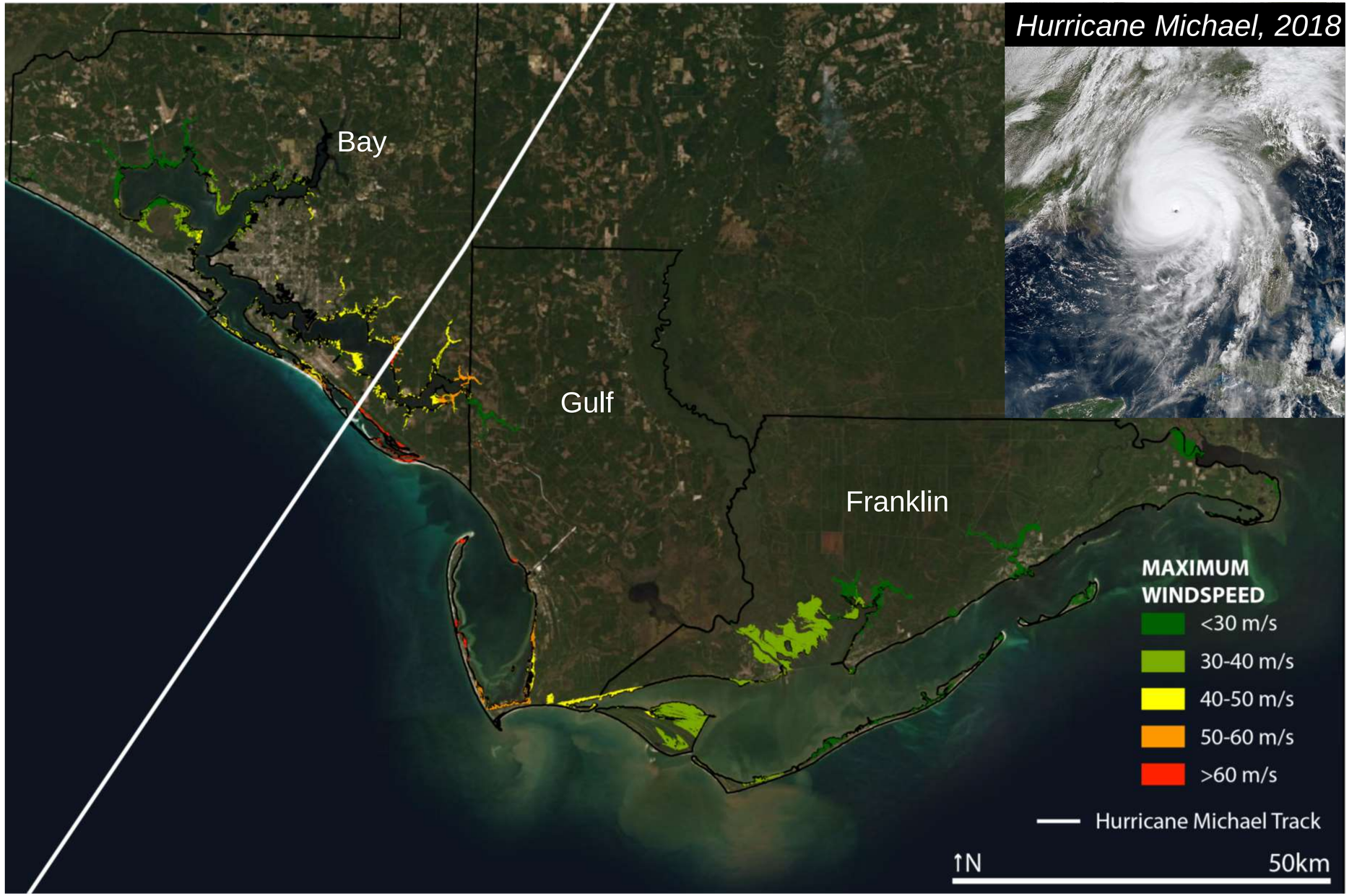



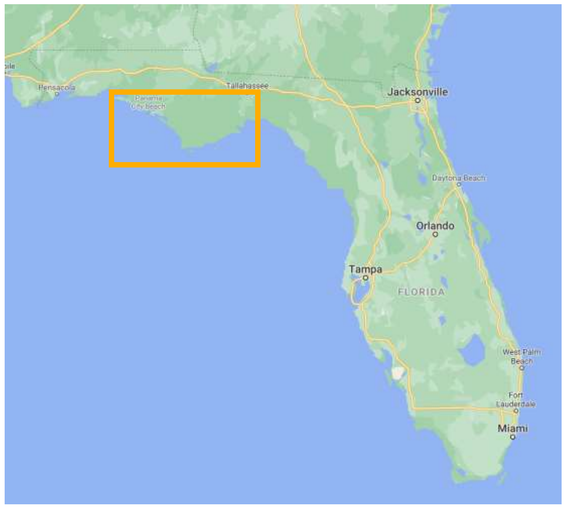

Hurricane Rita Storm Surge

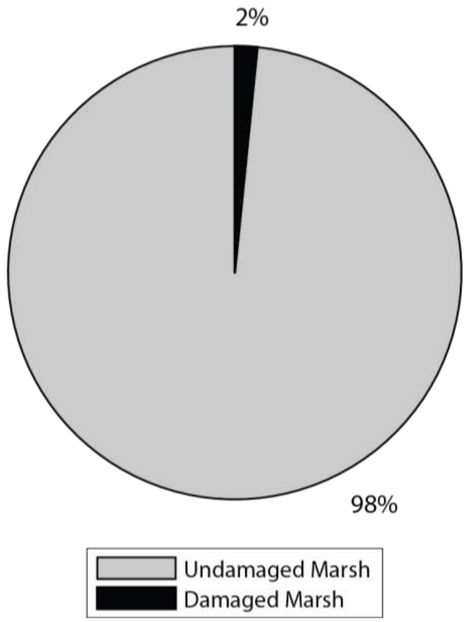



Day et al. (2007)

# Salt marshes are largely resistant to storm damage



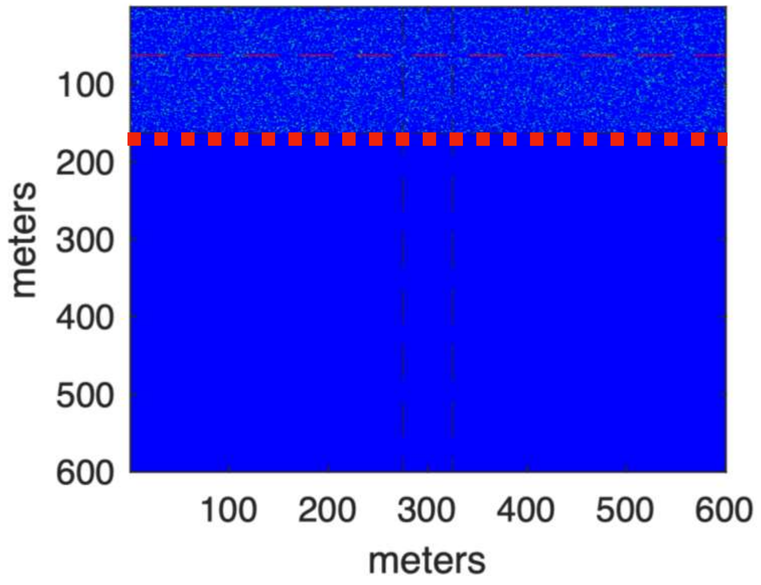

Castagno et al., 2021, Scientific Reports

# How much restoration is enough to deliver coastal protection?

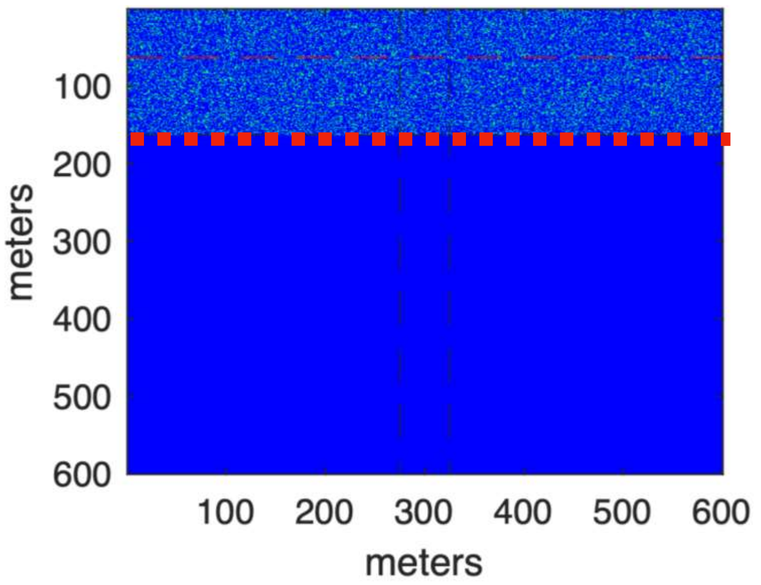
**Modeling to determine restoration benchmarks**

- SWAN (Simulating WAves Nearshore): “a state-of-the-art third-generation wave model which computes random, short-crested wind-generated waves in coastal regions and inland waters” (TU Delft)
- Analysis of percent change in wave energy at 100m from shore (first 40m of marsh reduces wave heights by at least 15%; Möller et al., 2014)

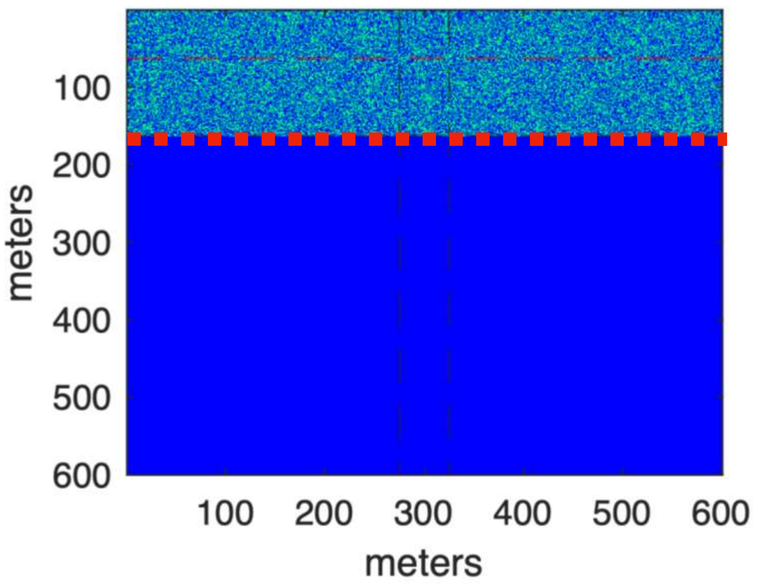
10% vegetated




30% vegetated




50% vegetated



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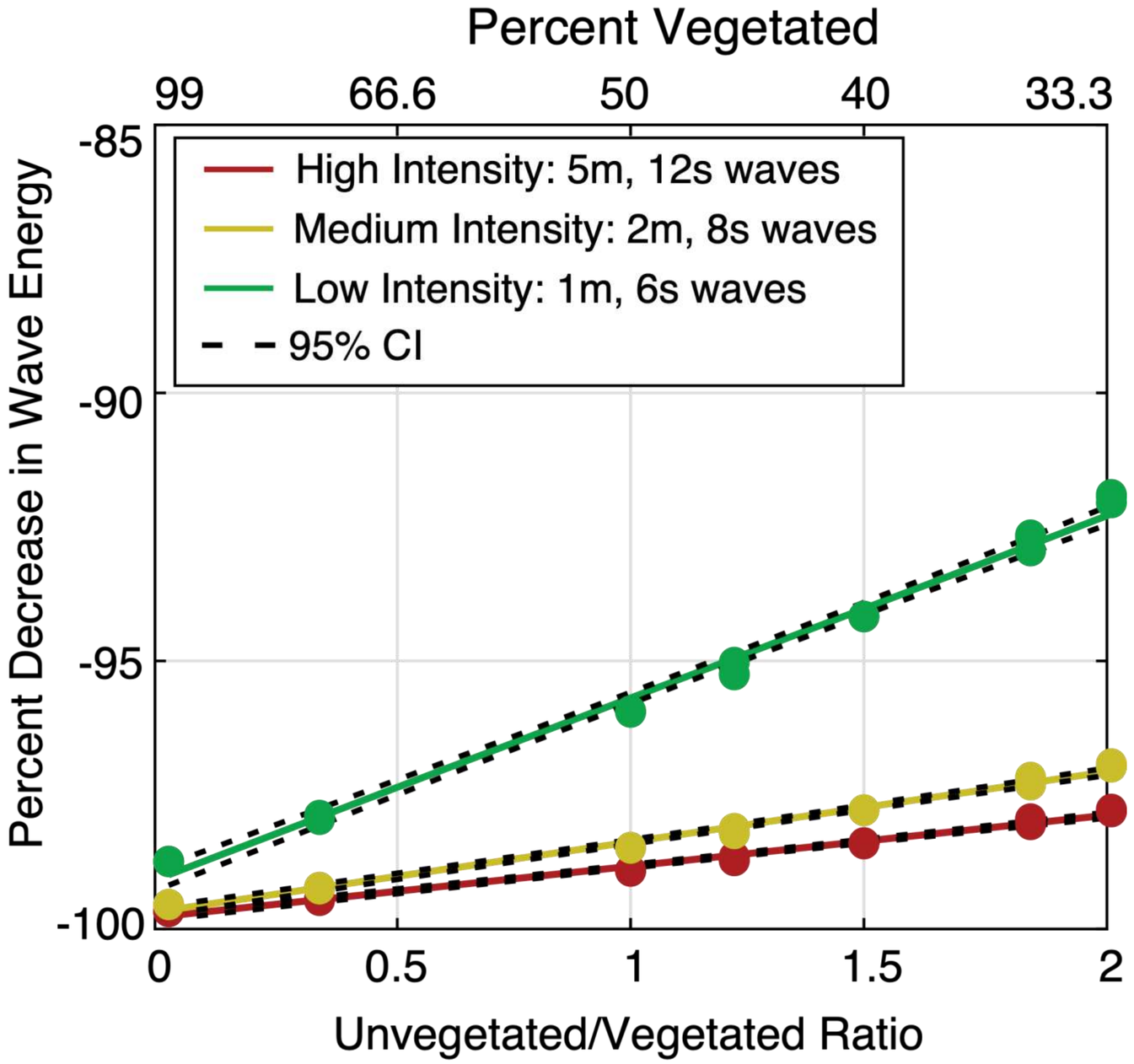


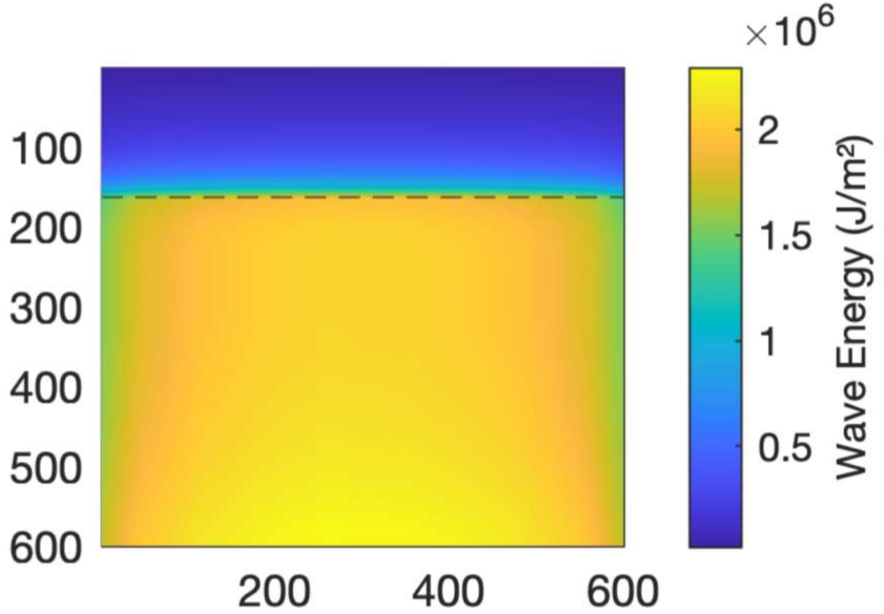


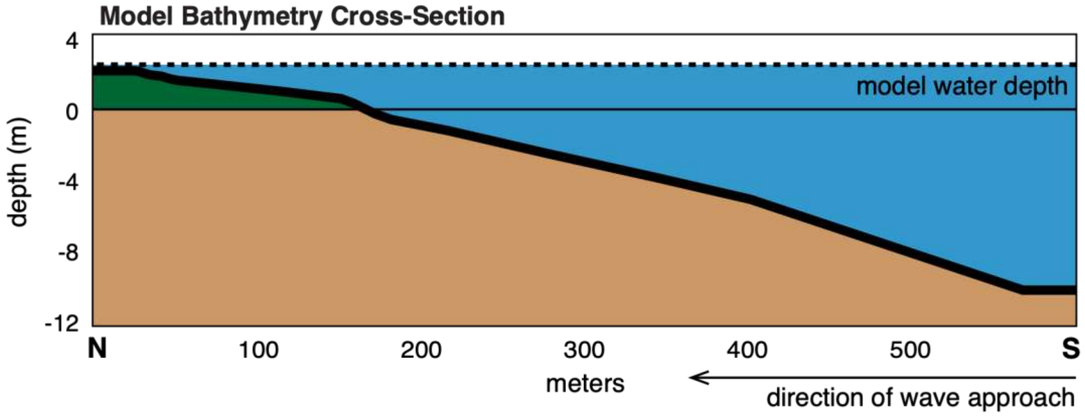

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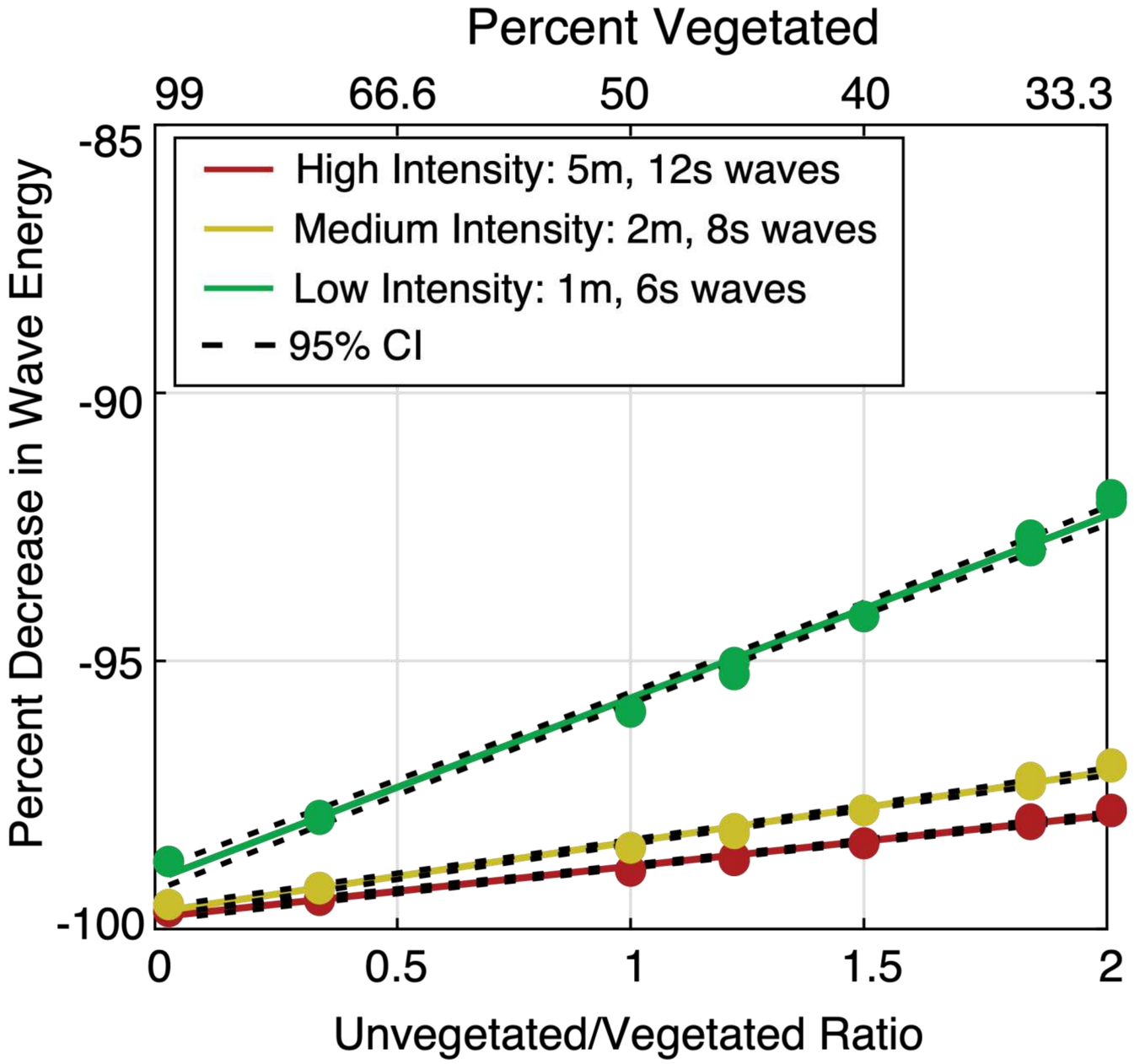


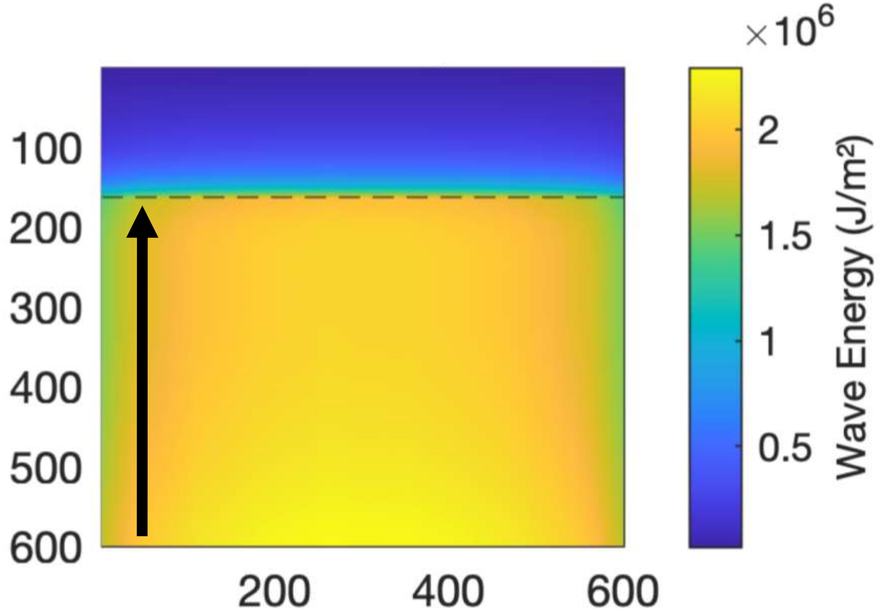


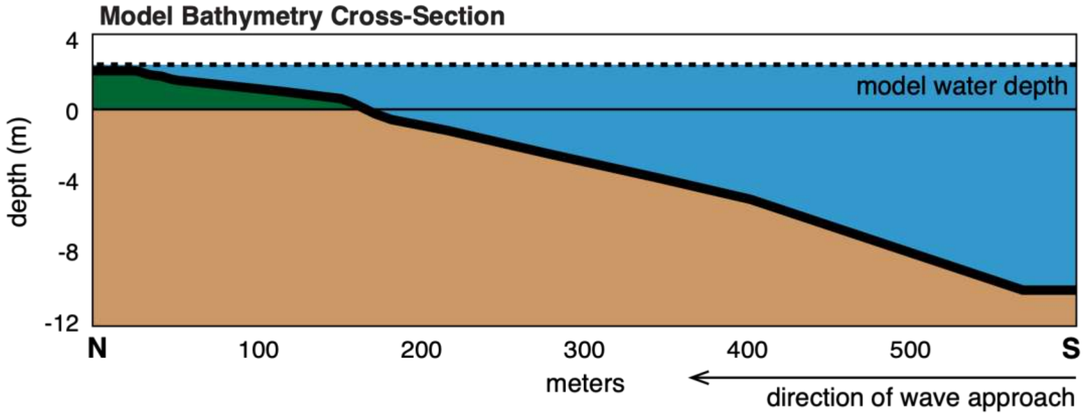

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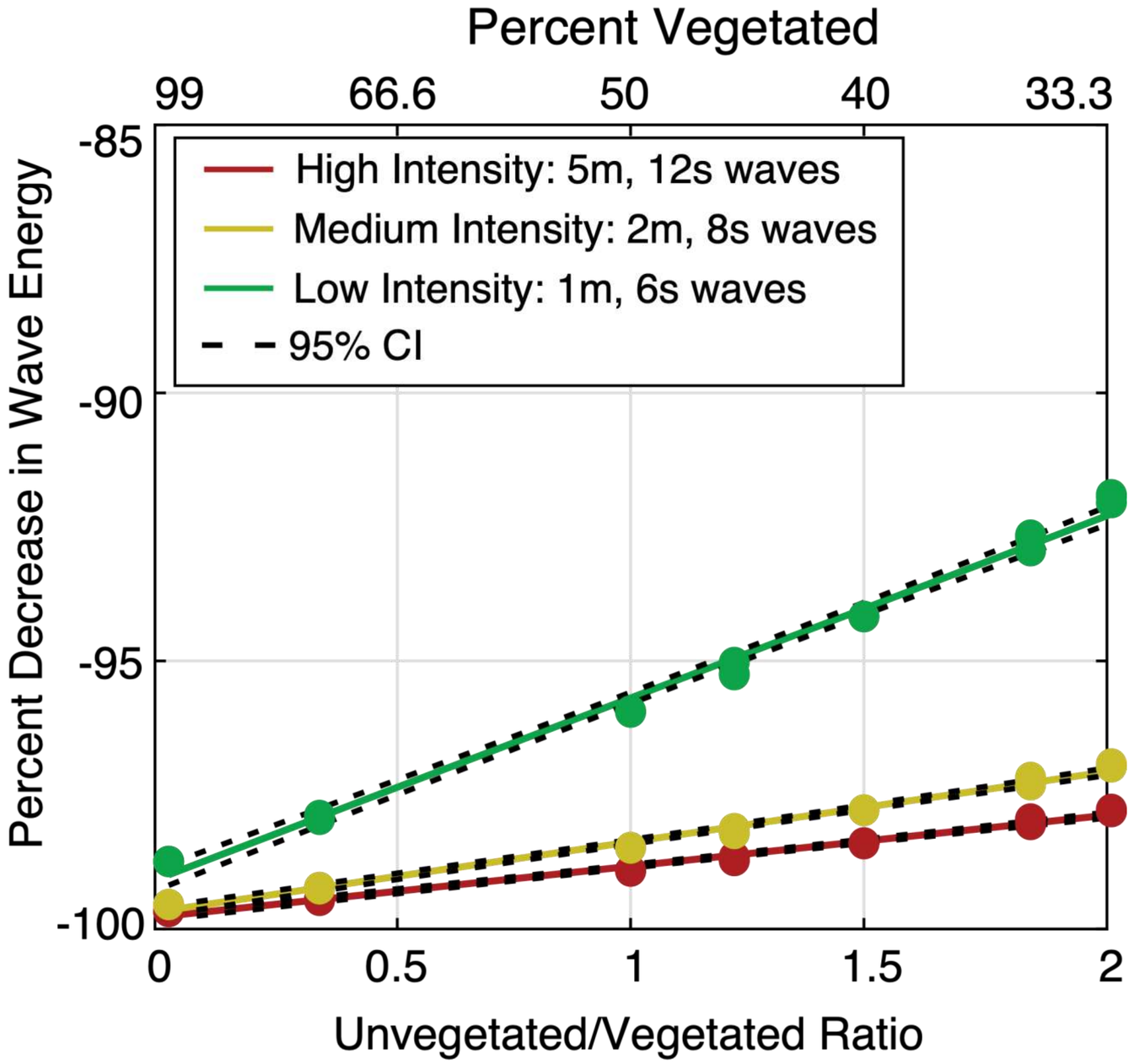


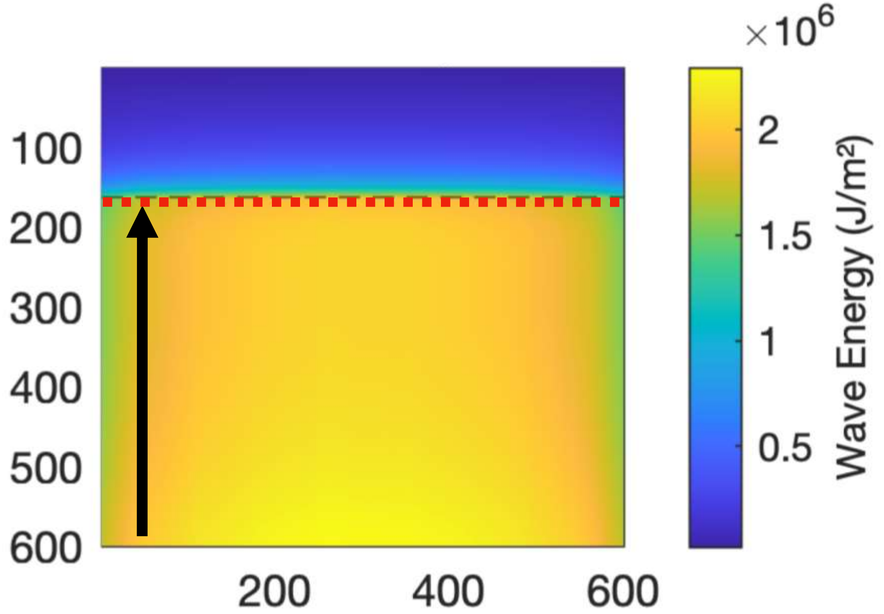


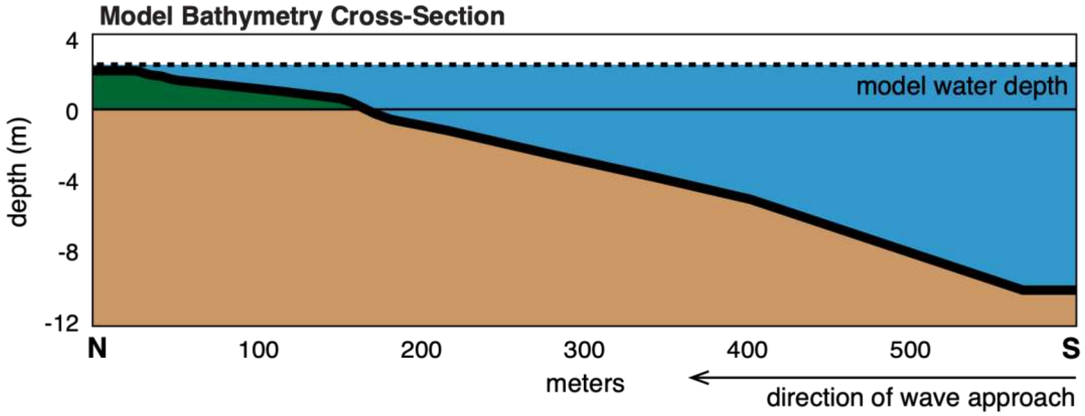

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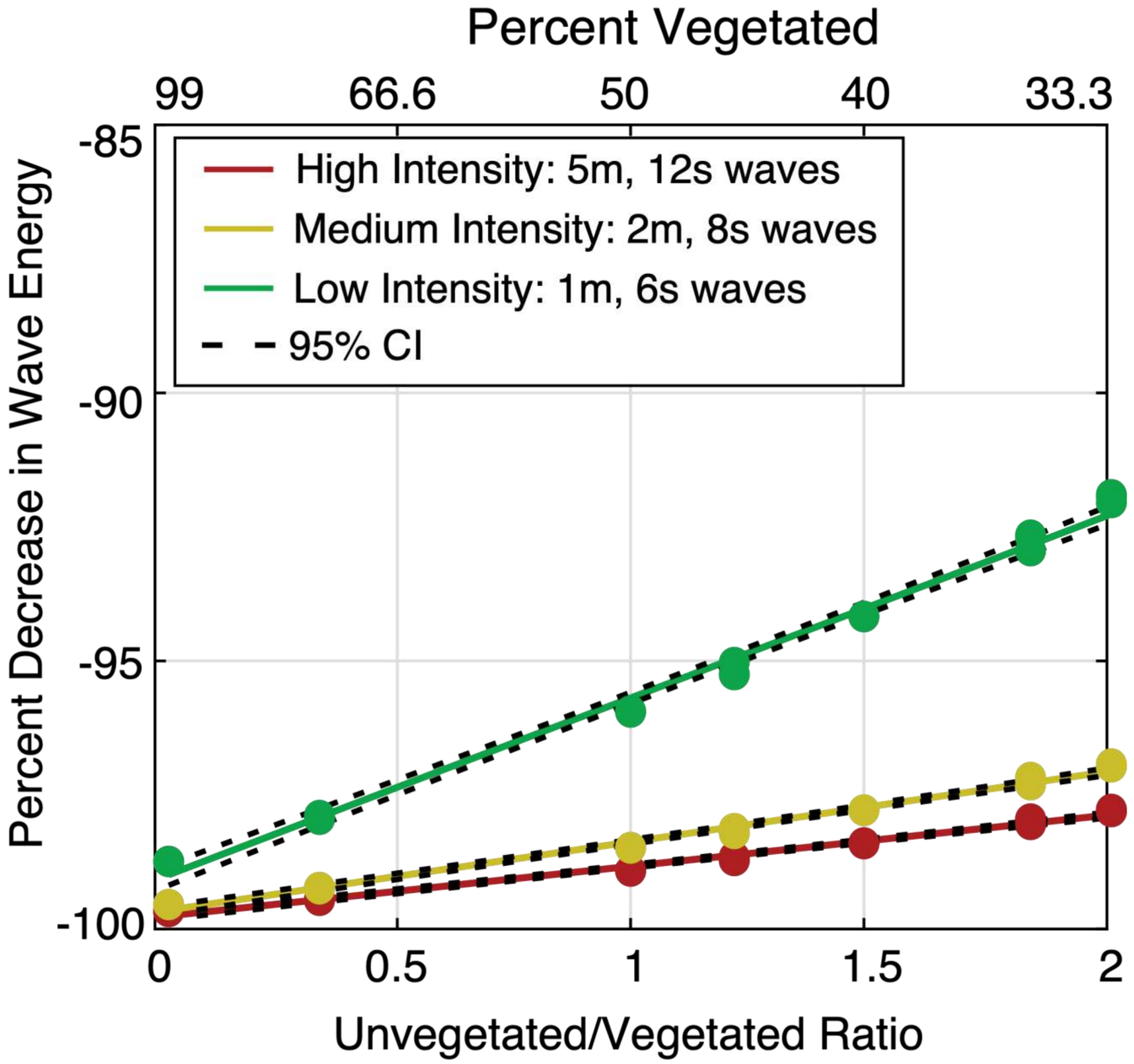


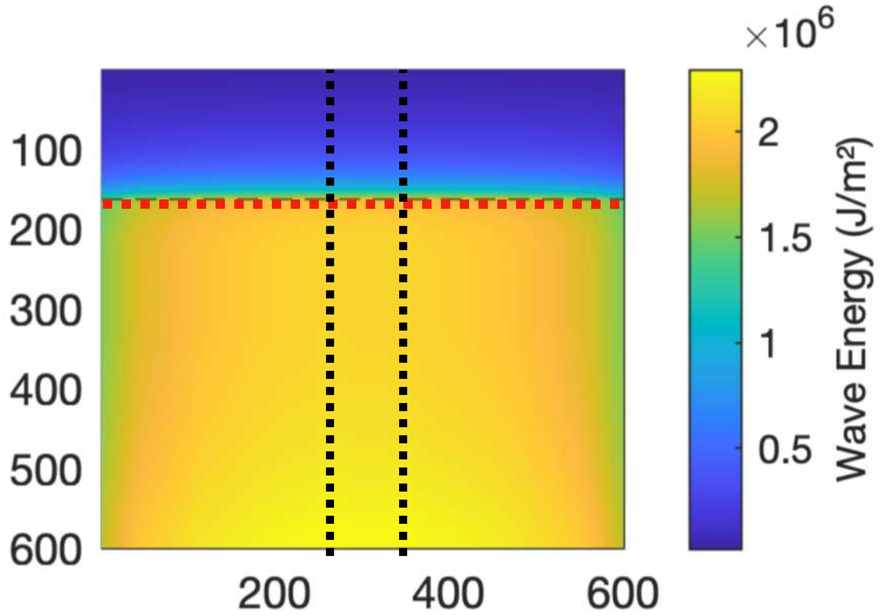


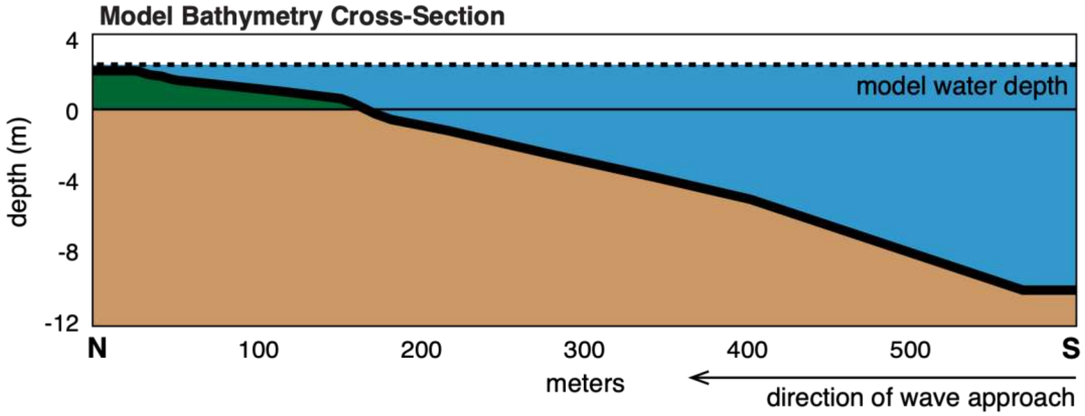

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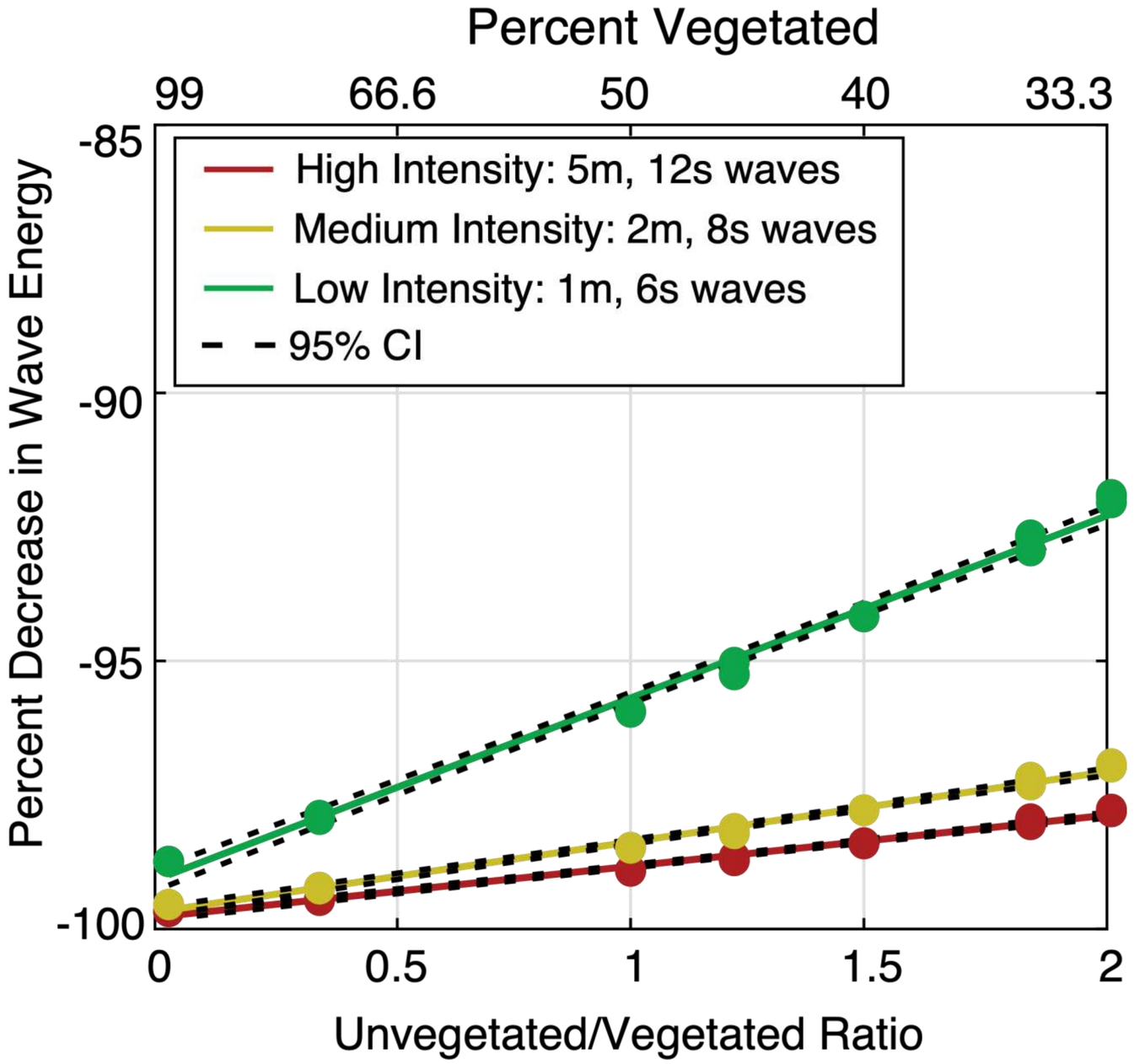


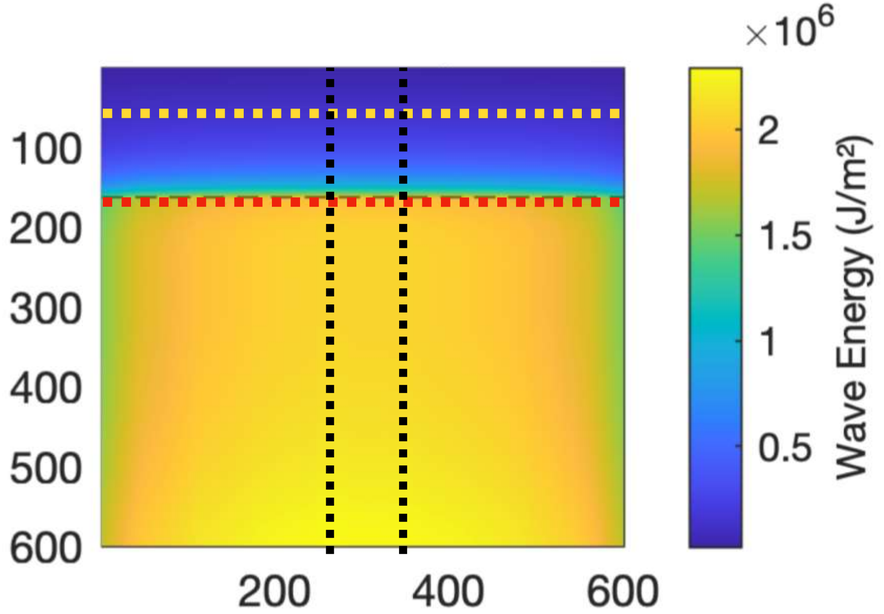


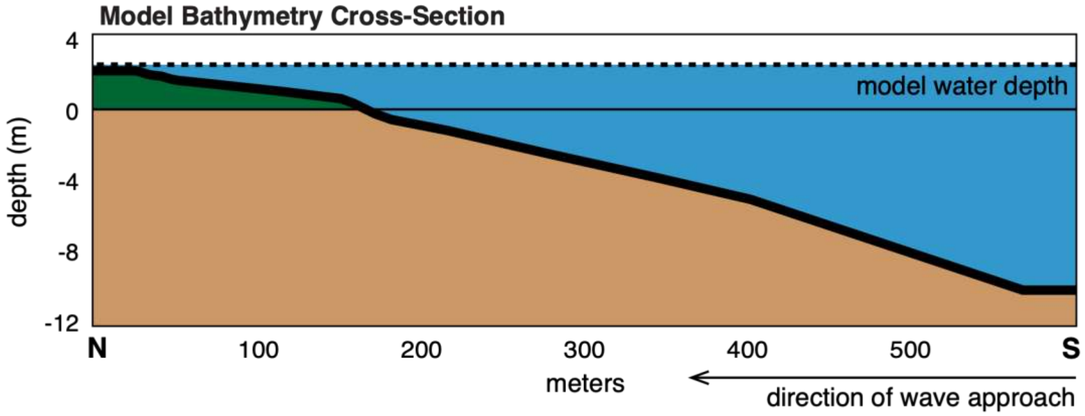

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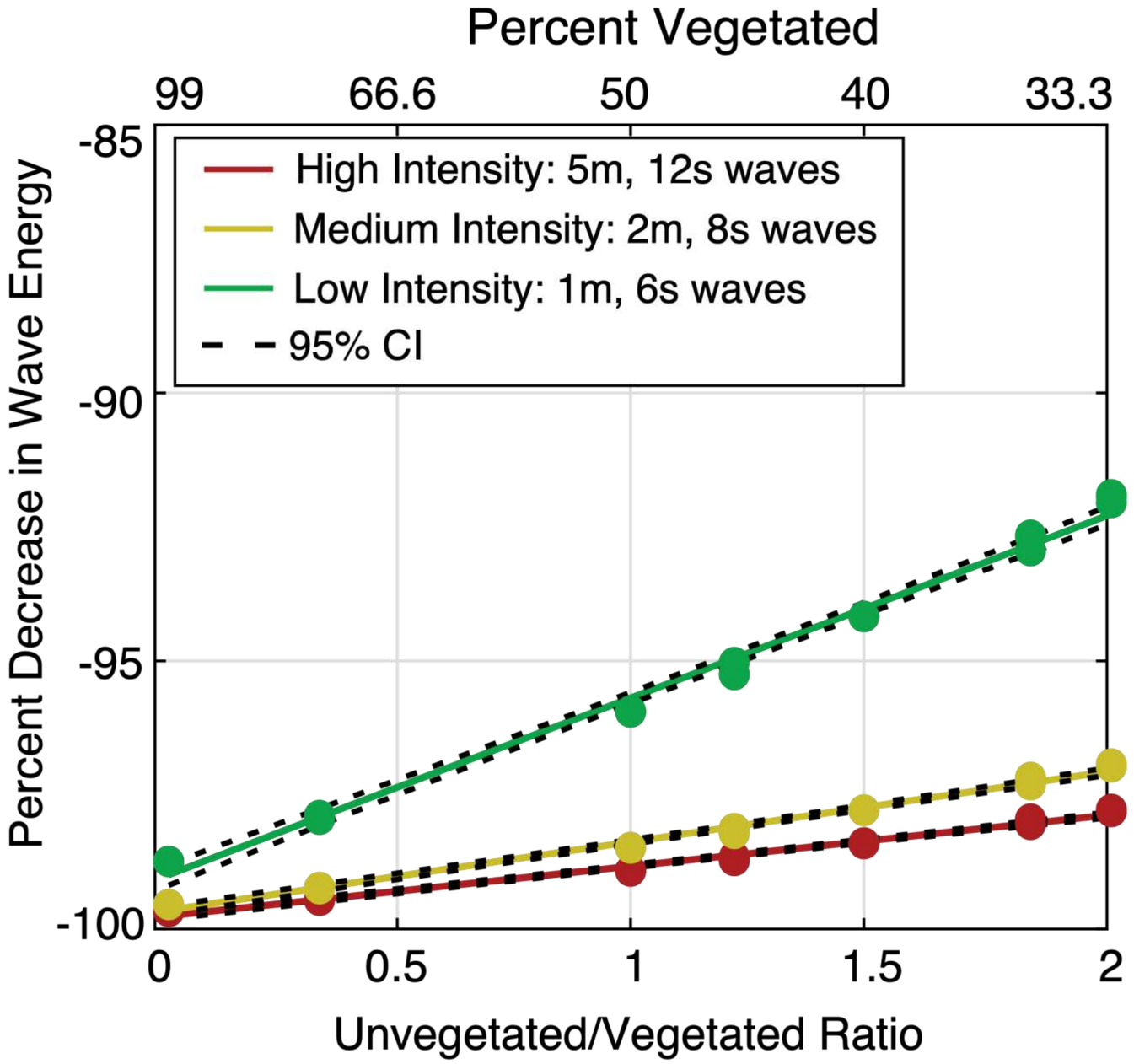


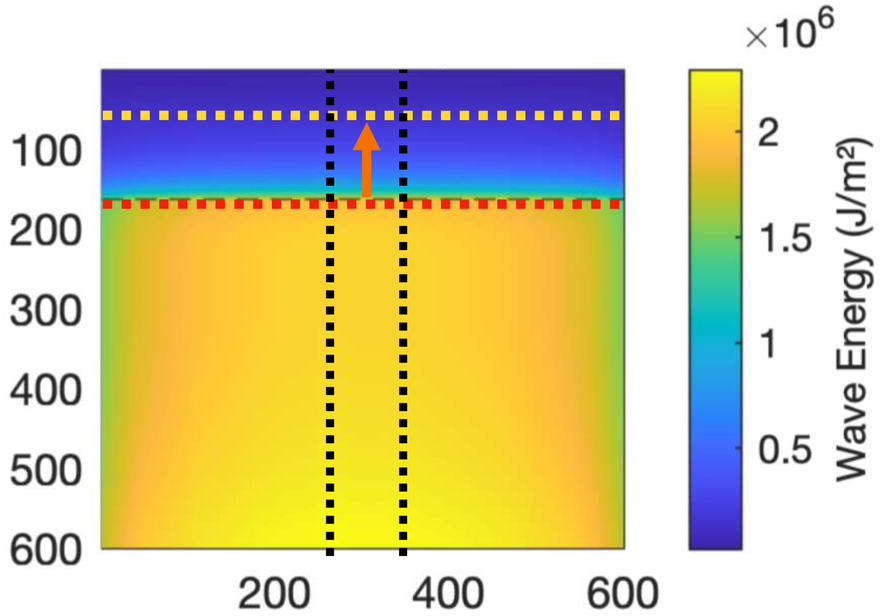


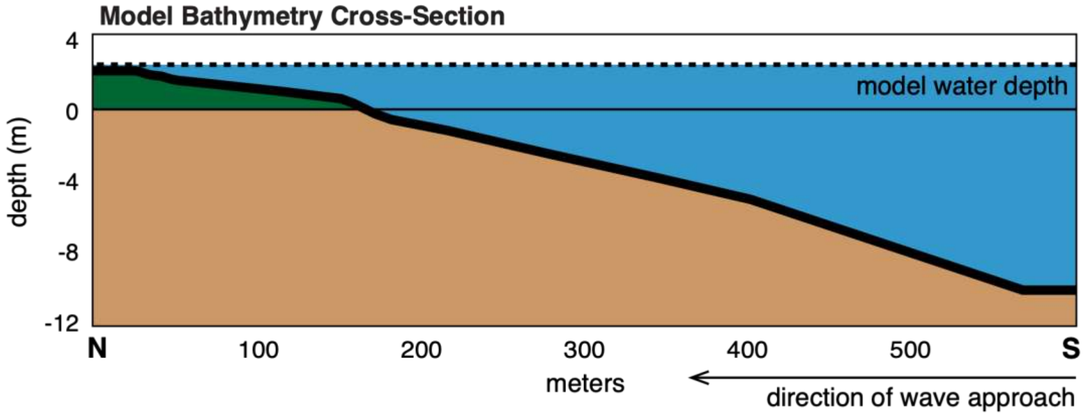

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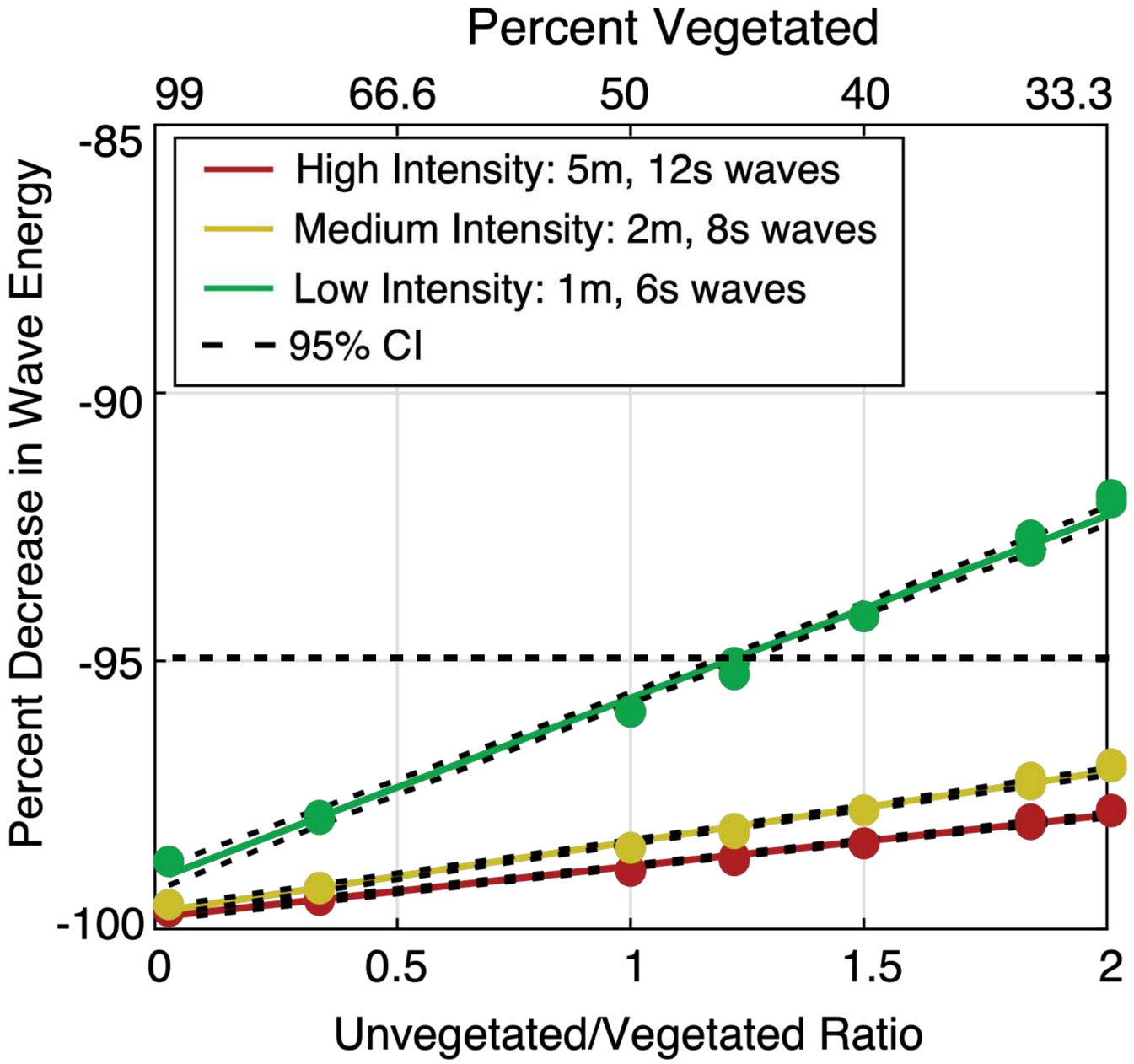


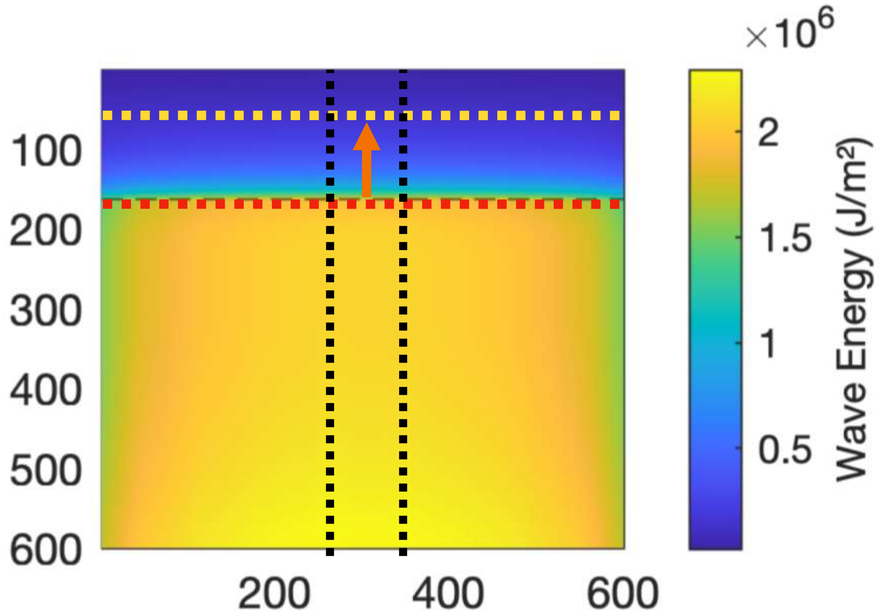


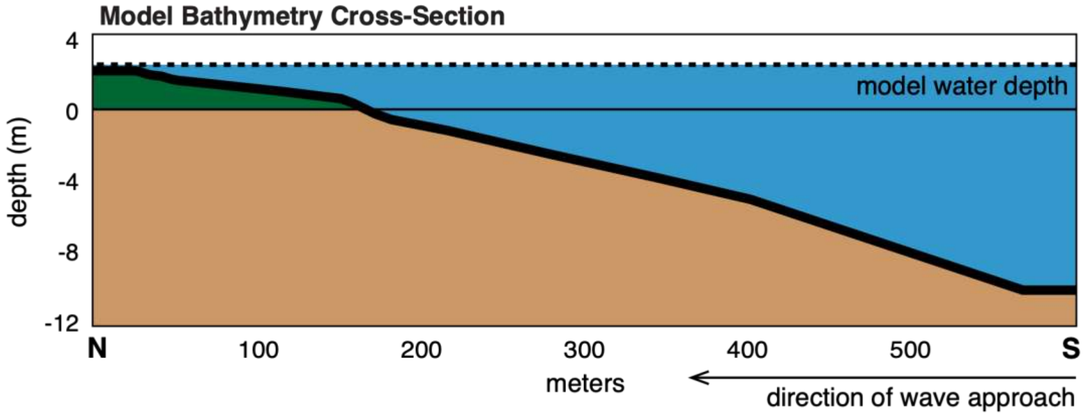

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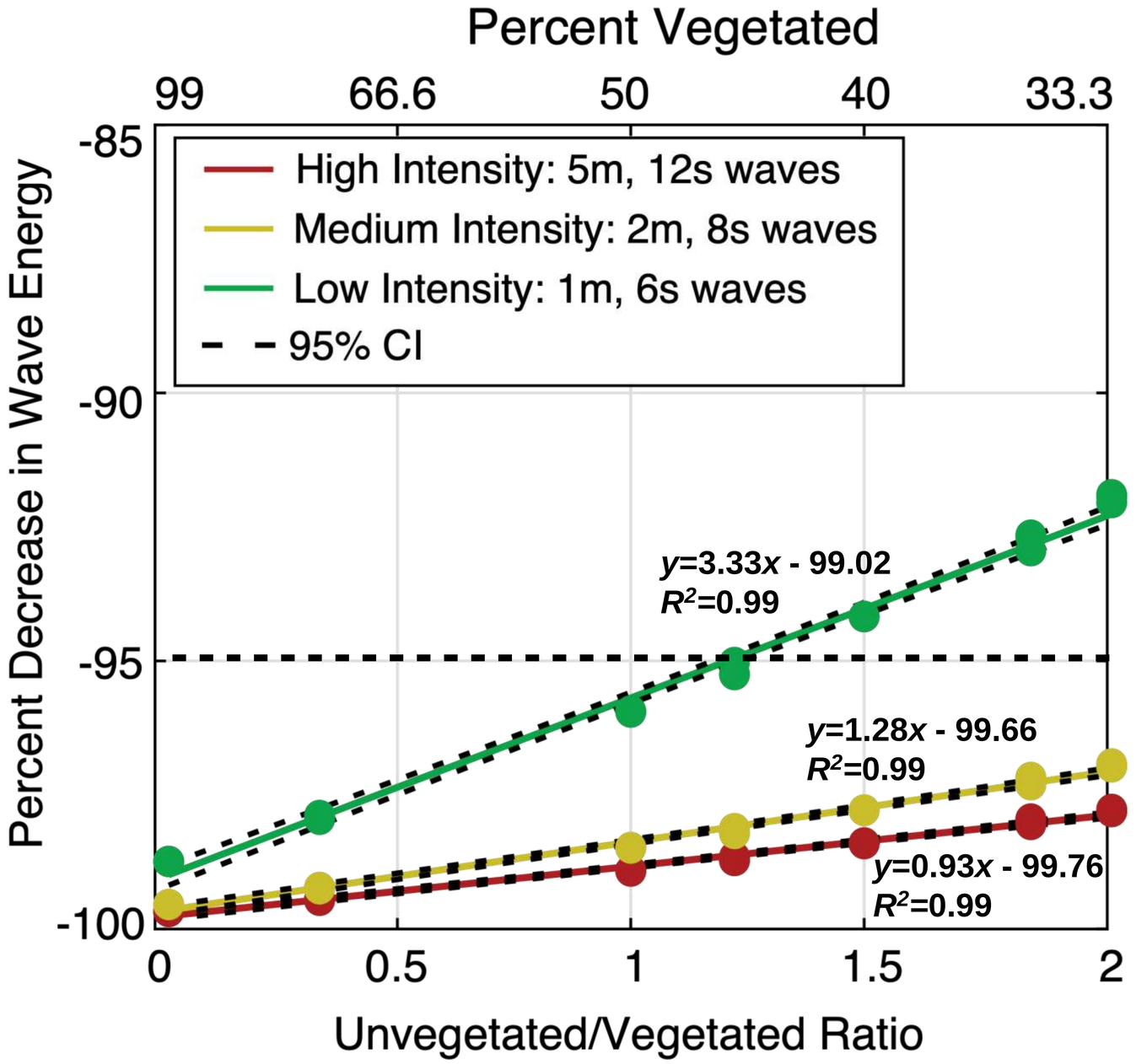


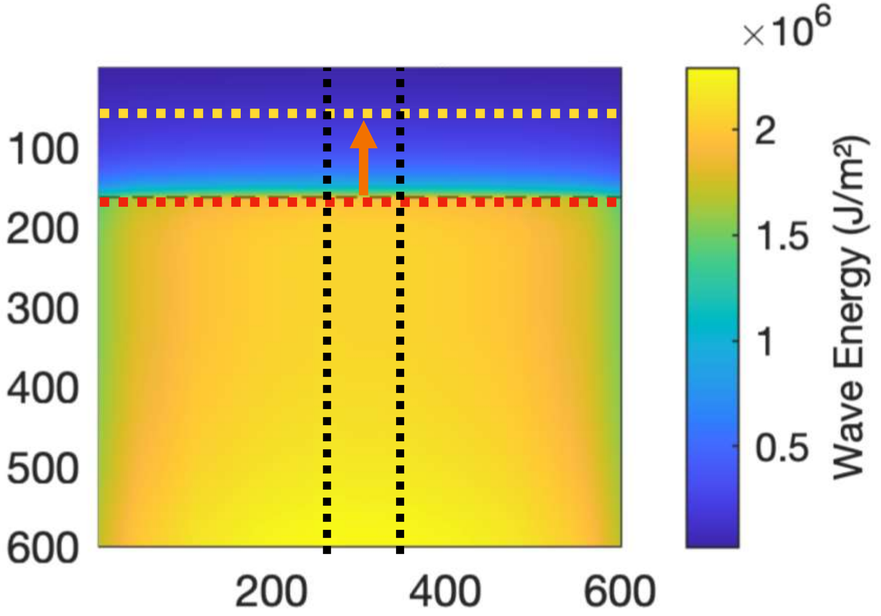


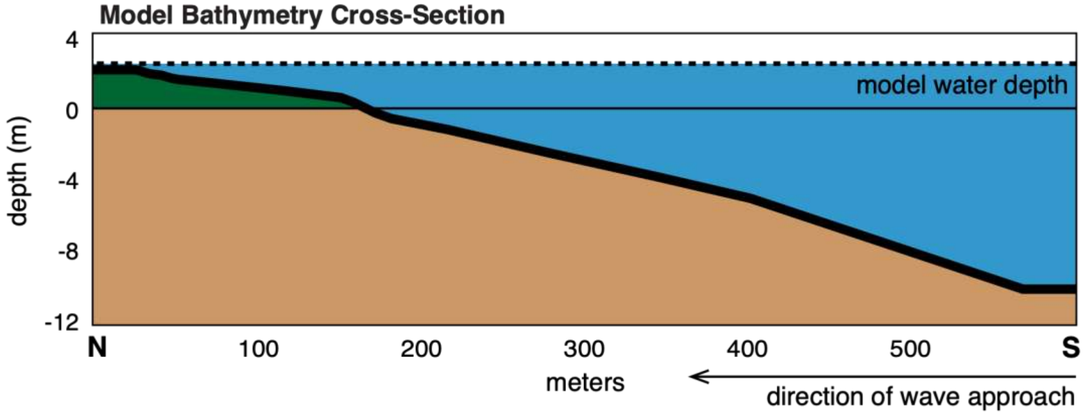

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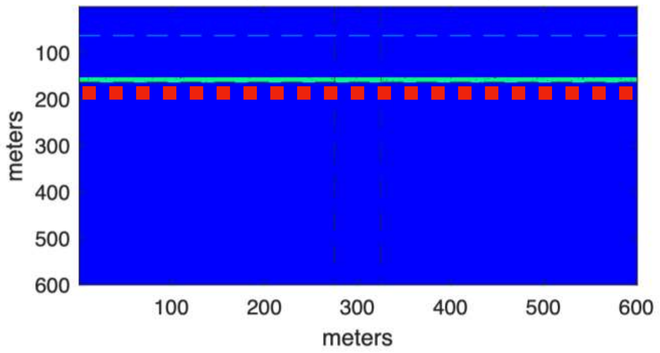
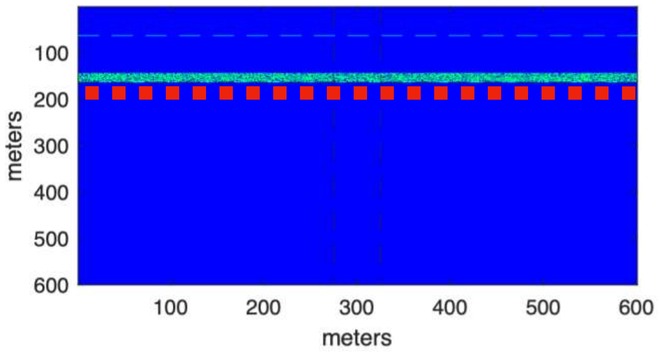
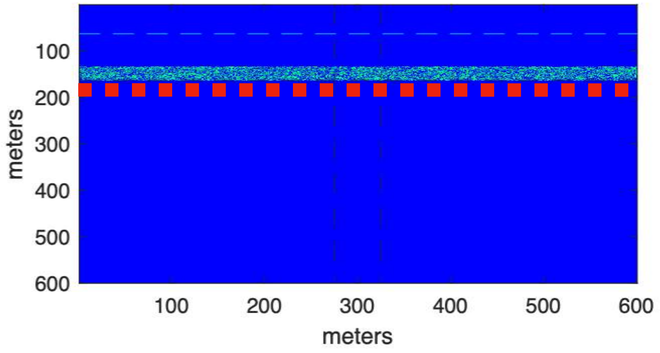
10m edge, 99% vegetated



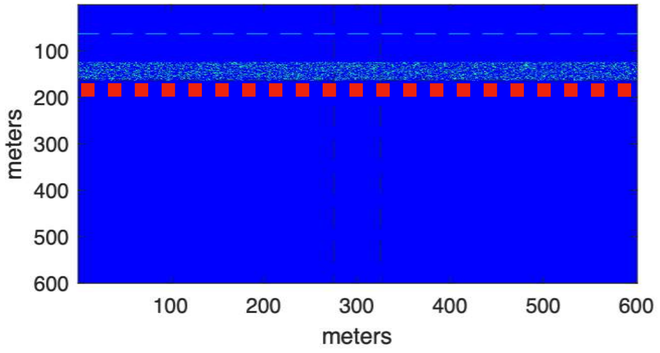

20m edge, 75% vegetated



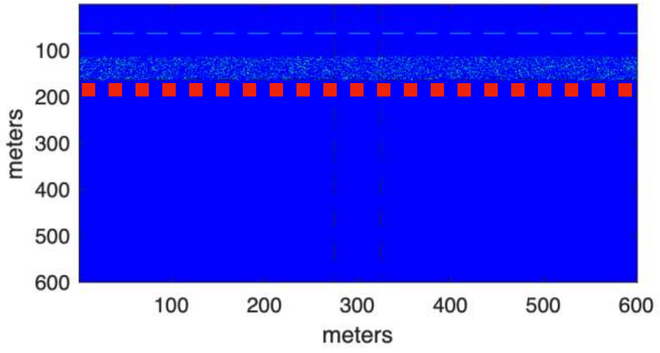

30m edge, 50% vegetated



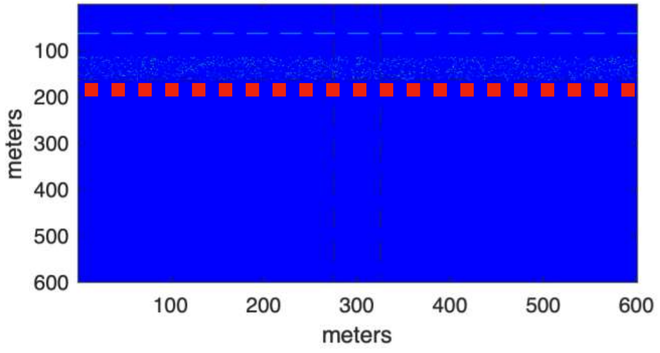

40m edge, 25% vegetated




50m edge, 15% vegetated




50m edge, 5% vegetated



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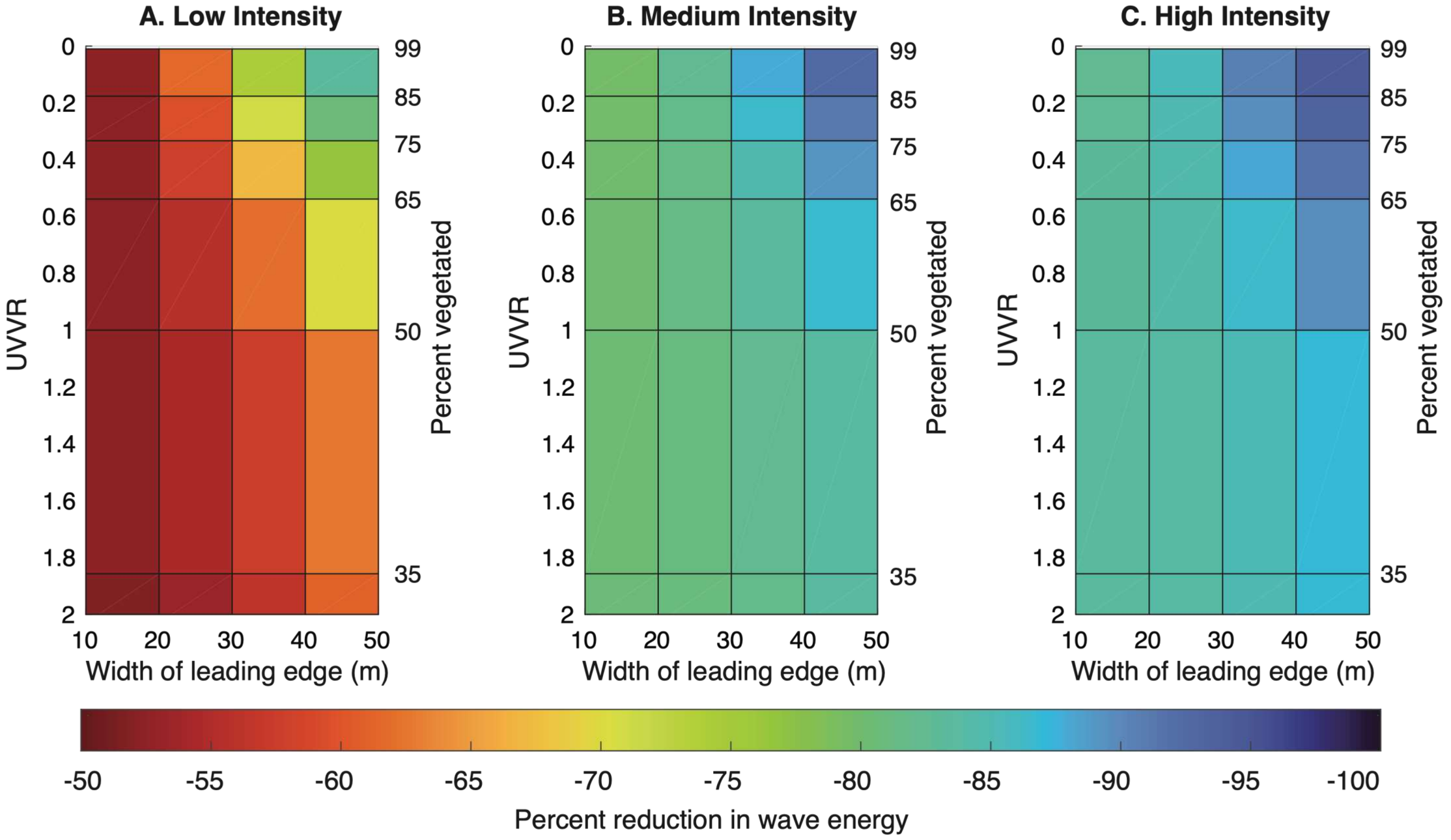

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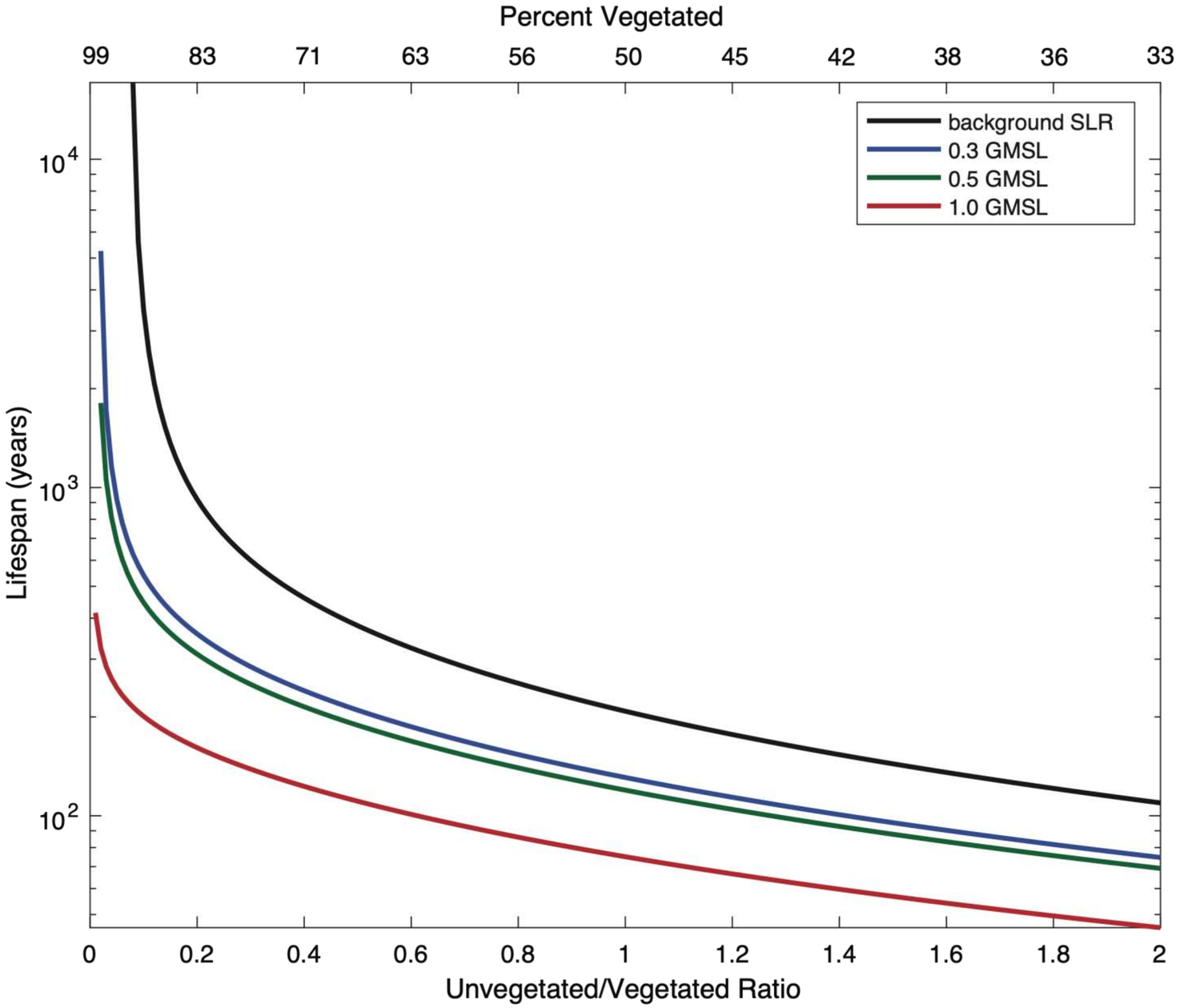


- **UVVR 1 (50% vegetated)**
  - *Background SLR:* 208 years
  - *0.3 m SLR by 2100:* 130 years
  - *0.5 m SLR by 2100:* 120 years
  - *1.0 m SLR by 2100:* 75 years
- **UVVR 0.1 (90% vegetated)**
  - *Background SLR:* 3,477 years
  - *0.3 m SLR by 2100:* 540 years
  - *0.5 m SLR by 2100:* 446 years
  - *1.0 m SLR by 2100:* 200 years

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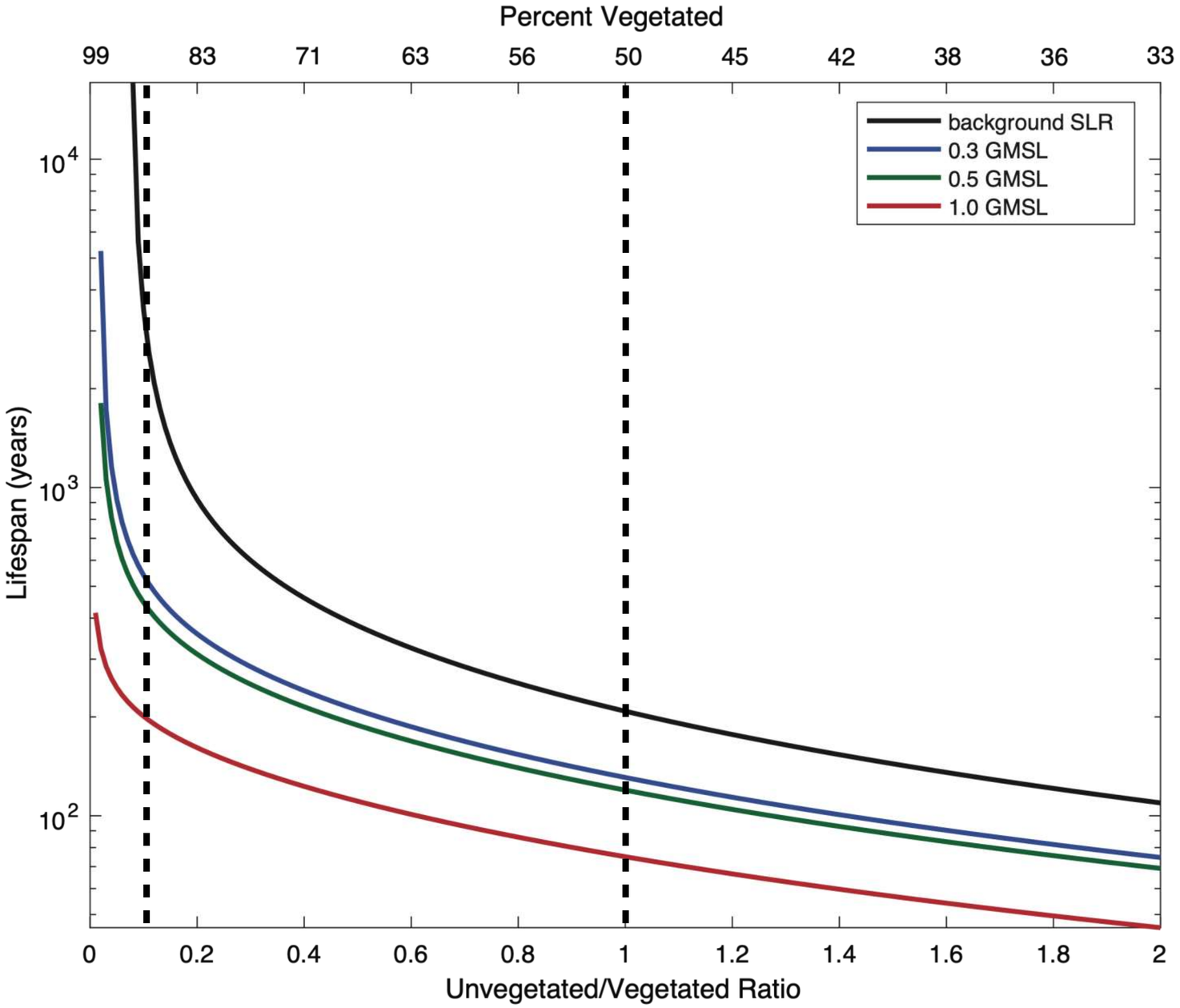


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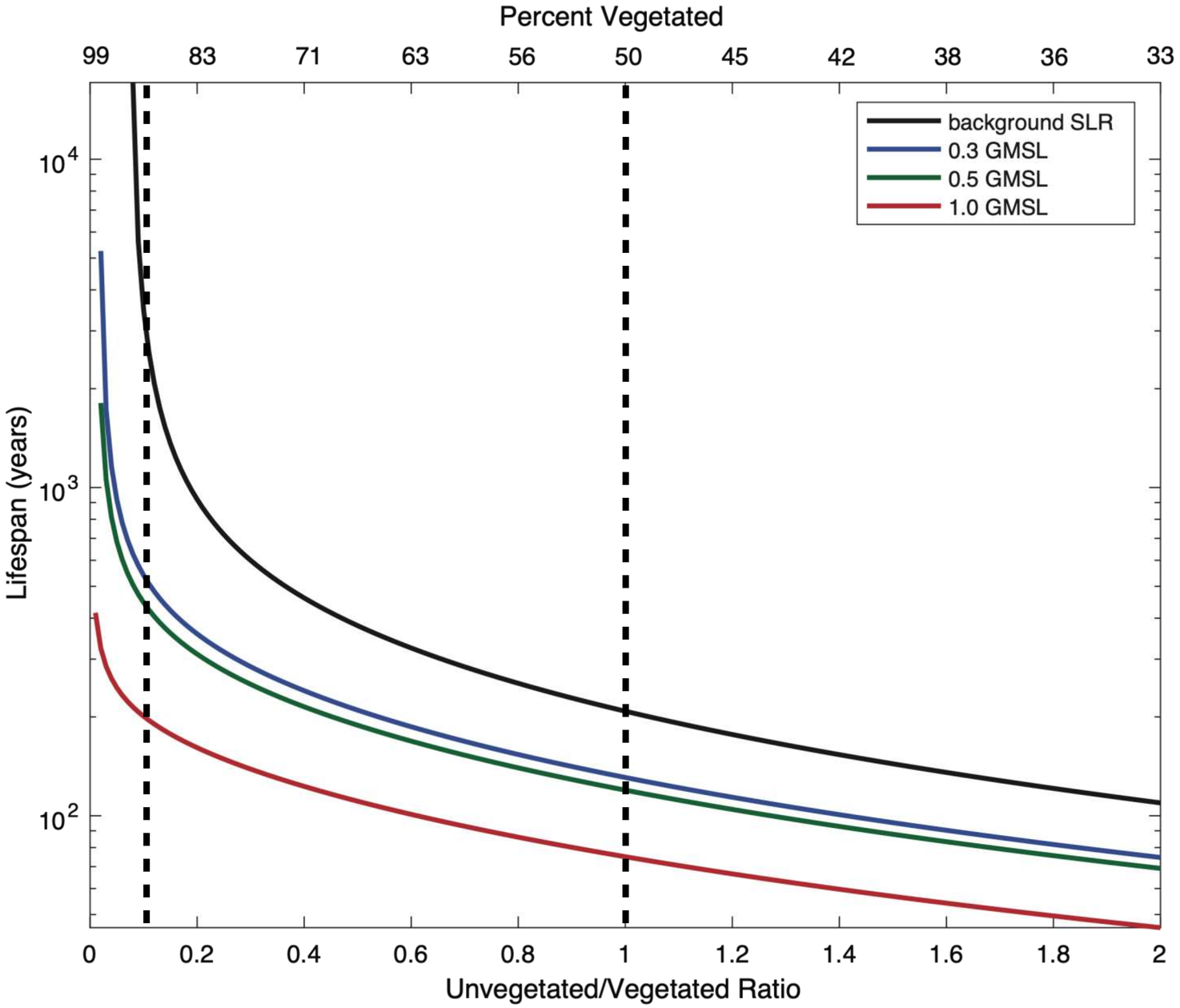


- **Back of the envelope calculation:**
  - $1.25 per 5-cm plug of *Spartina alterniflora*
  - 10 plugs/sq. meter
  - Moderate SLR (0.5 m by 2100)
- **Planting to 50% cover (UVVR 1):**
  - Cost: ~$614,000
  - Lifespan: 120 years
- **Planting to 90% cover (UVVR 0.1):**
  - Cost: ~$1,100,000
  - Lifespan: 446 years
- **Would you pay 2x for 4x the lifespan?**

# How much restoration is enough to deliver coastal protection?

- **We don’t need that much vegetation:**
  - Substantial wave attenuation evident at 30-40% vegetated cover, with significant attenuation (95% reduction in wave energy) by 50% cover
- **We don’t need that much marsh (if it is well vegetated):**
  - Up to 95% reduction in wave energy if a leading edge is 40-50m with 80% cover
  - Thinner leading edges (~10-20m) can still provide up to 80% reduction in wave energy
- **Potential to see storm protection ecosystem service benefits at year 0**
- **Must consider lifespan estimates in restoration benchmarks**

# How much restoration is enough to deliver coastal protection?

- Can apply on a wider scale using USGS datasets
  - Connection to unvegetated/vegetated ratio (UVVR)
  - 50% vegetated ~ UVVR 1
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- Knowledge sharing with practitioners re: metrics and performance goals (simple linear regressions)

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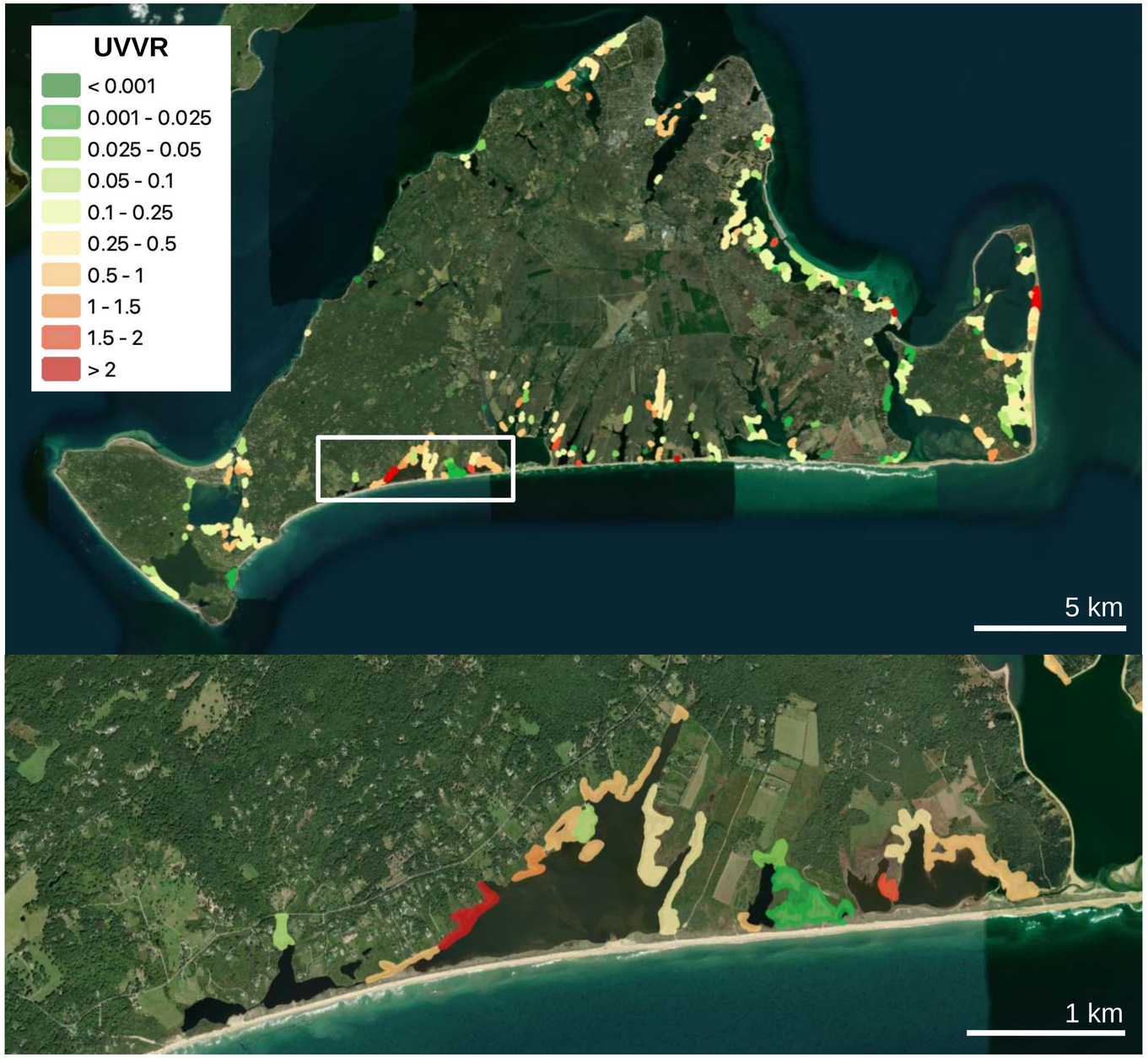

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