A Framework for Research on Recurrent Acute Disasters

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Leidos Civil Group

National Academies of Science, Engineering, and Medicine, 31 May 2022
Multi-Dimensional Aspects of Compounding and Cascading Extreme Events

SCIENCE ADVANCES | RESEARCH ARTICLE

APPLIED ECOLOGY

A framework for research on recurrent acute disasters

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Disaster science examines the causes, behaviors, and consequences of hazardous events, from hurricanes to wildfires, flooding, and major industrial accidents. Individual disasters are recurring more frequently and with greater intensity. Recurrent acute disasters (RADs) are sequential disasters that affect a specific locale over time. While disaster science has matured in recent years, understanding of the distinctive characteristics of RADs varies by discipline and lacks predictive power. A theoretical framework is presented by borrowing in part from mathematical topology and disturbance ecology. The recurrent disasters affecting Puerto Rico 2017–2020 are examined as a case example to test the framework. A key variable is the complex characteristics of legacy conditions created by one disaster that influence the effects of subsequent disasters. Substantial improvements in disaster response, recovery, and preparedness can be gained by adopting a RAD-based approach.

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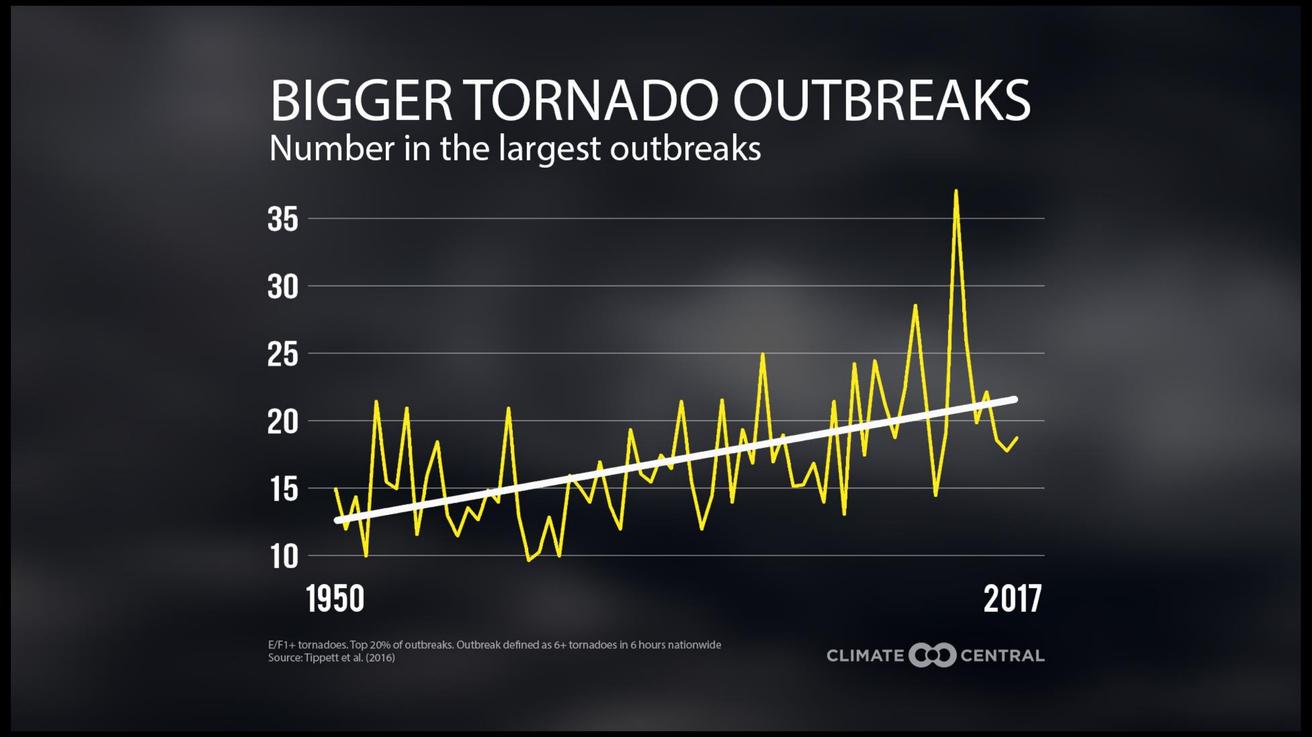
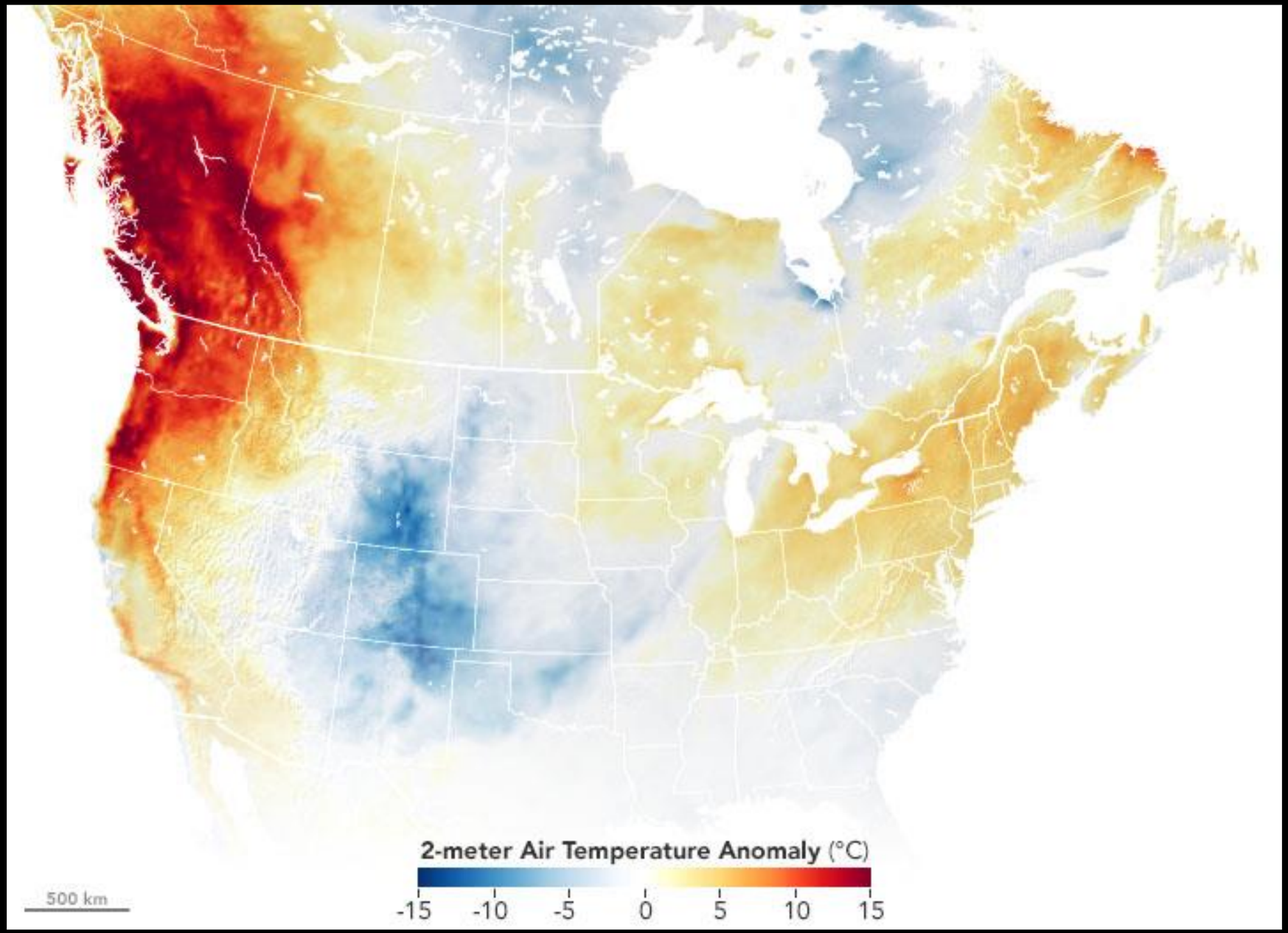
Relevant Increasing Trends

- intensity
- variability
- frequency
- vulnerability
- economic and social costs

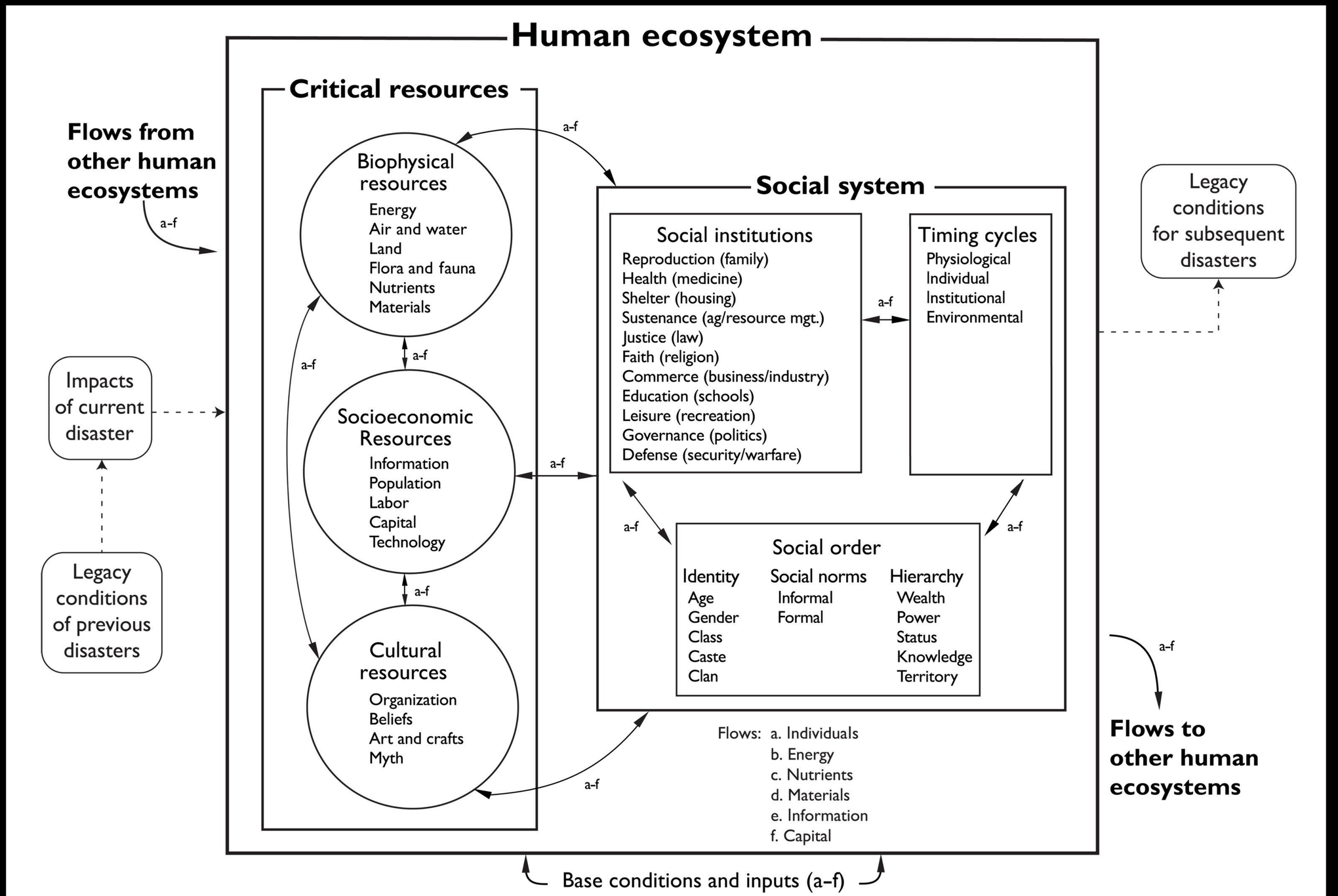


Recurrent acute disasters (RADs) are individual major hazard events that occur in a specific locale and create legacy conditions that impact future disasters in that locale.


2-meter Air Temperature Anomaly (°C)
-15
-10
-5
0
5
10
15
500 km

Applied Research Questions

- Is there a distinctive signature to recurring acute disasters and their impacts upon human ecosystems?
- If so, what are the key legacy conditions that create these distinctive signatures, and can a theory be developed that could predict them?
- If so, what policies, programs, and actions can be undertaken to mitigate the harmful effects of recurring acute disasters, and support safety, protection of human life, and community resilience in the face of these recurring events?

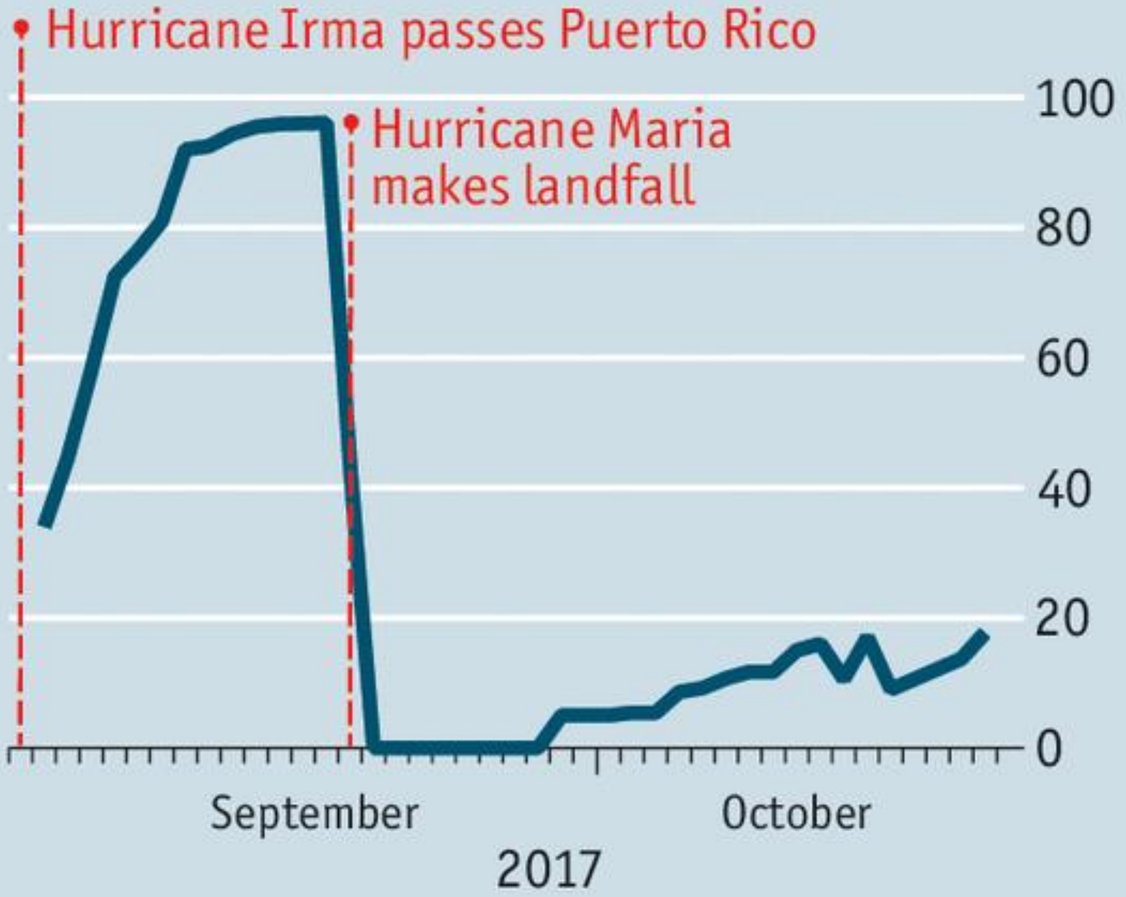

Human ecosystem
Critical resources
Flows from other human ecosystems
a–f
Biophysical resources
Energy
Air and water
Land
Flora and fauna
Nutrients
Materials
Socioeconomic Resources
Information
Population
Labor
Capital
Technology
Cultural resources
Organization
Beliefs
Art and crafts
Myth
Social system
Social institutions
Reproduction (family)
Health (medicine)
Shelter (housing)
Sustenance (ag/resource mgt.)
Justice (law)
Faith (religion)
Commerce (business/industry)
Education (schools)
Leisure (recreation)
Governance (politics)
Defense (security/warfare)
Timing cycles
Physiological
Individual
Institutional
Environmental
Social order
Identity
Age
Gender
Class
Caste
Clan
Social norms
Informal
Formal
Hierarchy
Wealth
Power
Status
Knowledge
Territory
Impacts of current disaster
Legacy conditions of previous disasters
Legacy conditions for subsequent disasters
Flows: a. Individuals
b. Energy
c. Nutrients
d. Materials
e. Information
f. Capital
Flows to other human ecosystems
Base conditions and inputs (a–f)

A Case Study:
Puerto Rico 2017-2020

- Hurricane Irma, 7 September 2017
- Hurricane Maria, 20 September 2017
- Island-wide drought, 11 February – 5 November 2019
- Earthquake series, 5-6 January 2020

Lights out

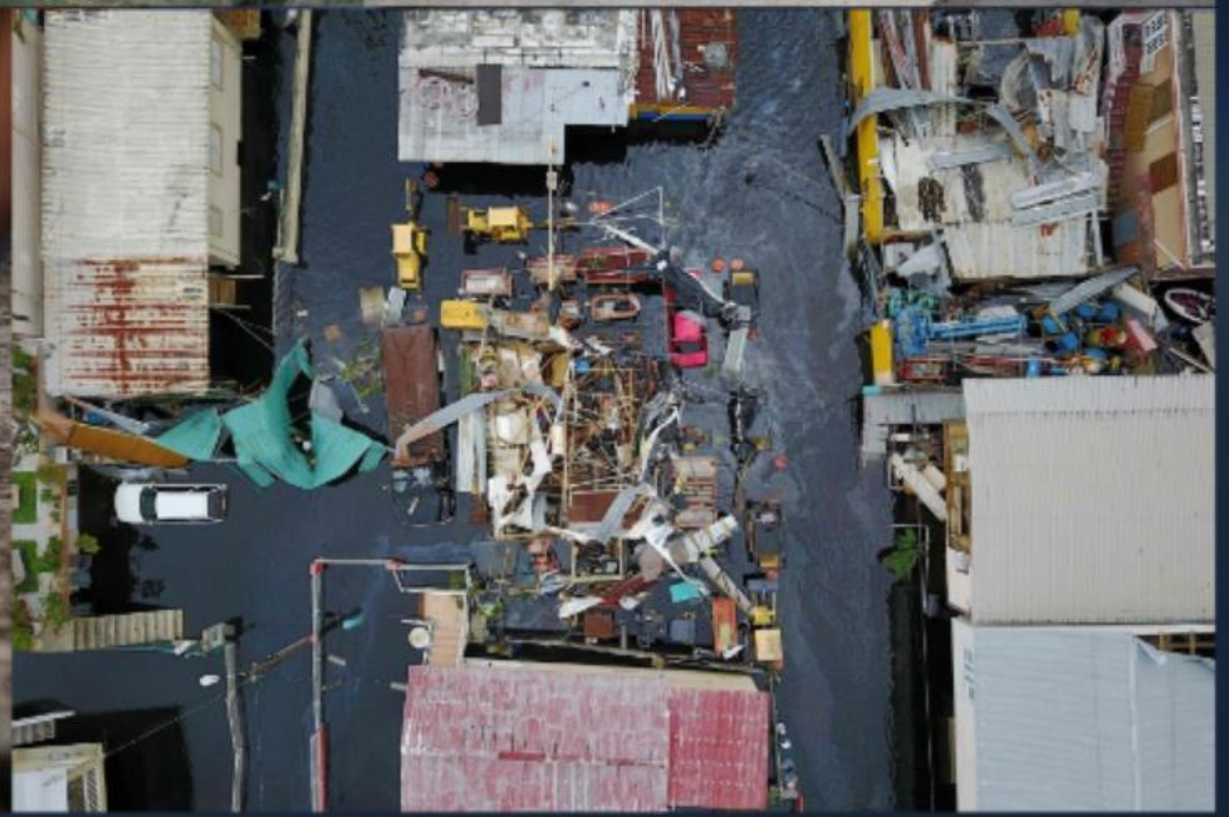
Puerto Rico, inhabitants with electricity, %



Source: Department of Energy

Economist.com

Legacy Conditions…



- $ 90 billion dollars in damages
- -15% loss in GDP
- +4,645 lives lost
- Migration of +200,000 persons
- Emotional Impact: unknown

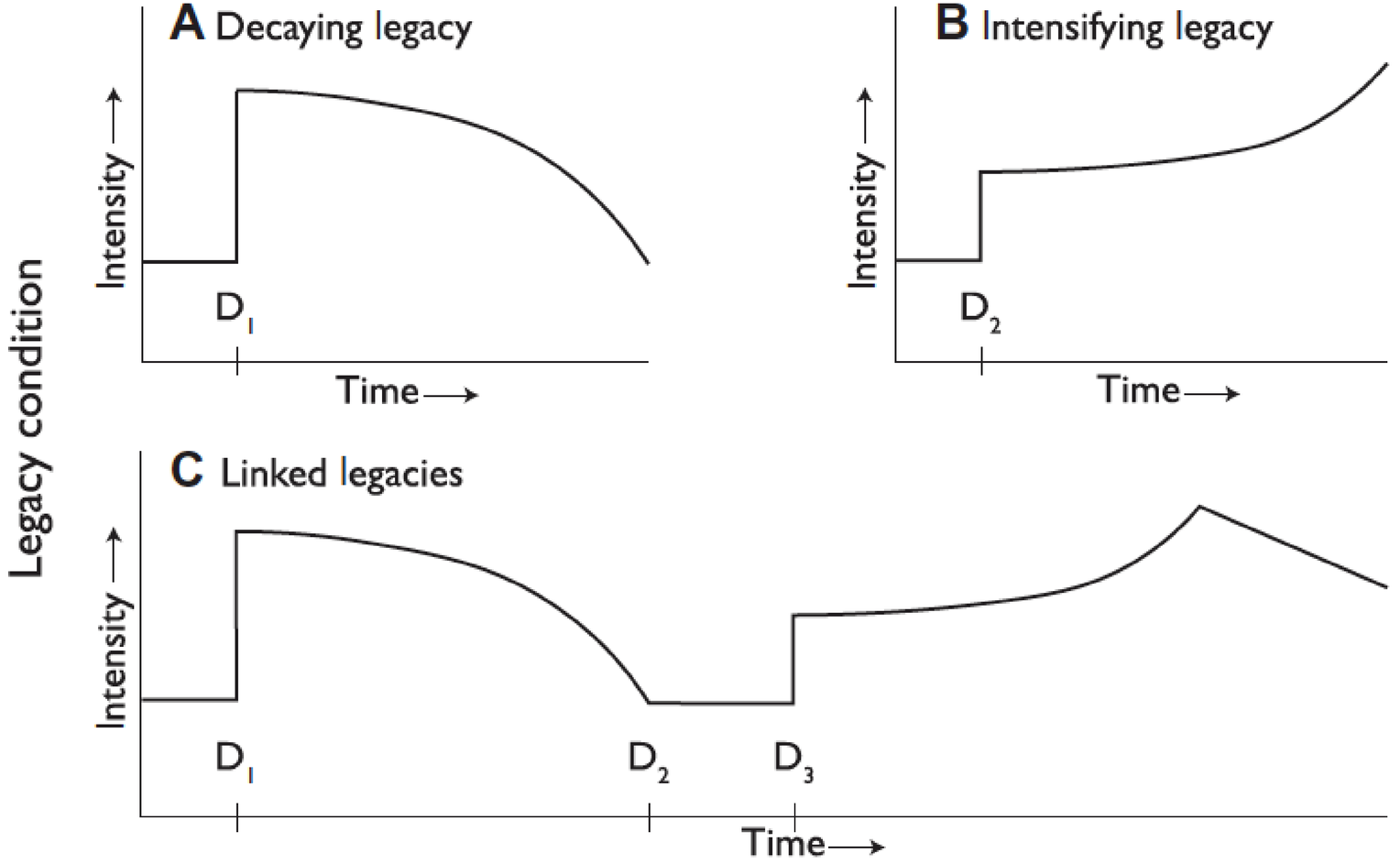


Fig. 3. A general schema of several categories of legacy conditions. (**A** to **C**) D_1 to D_3 represent RADs.

Food Nutrition vs Food Safety...

National Aeronautics and Space Administration

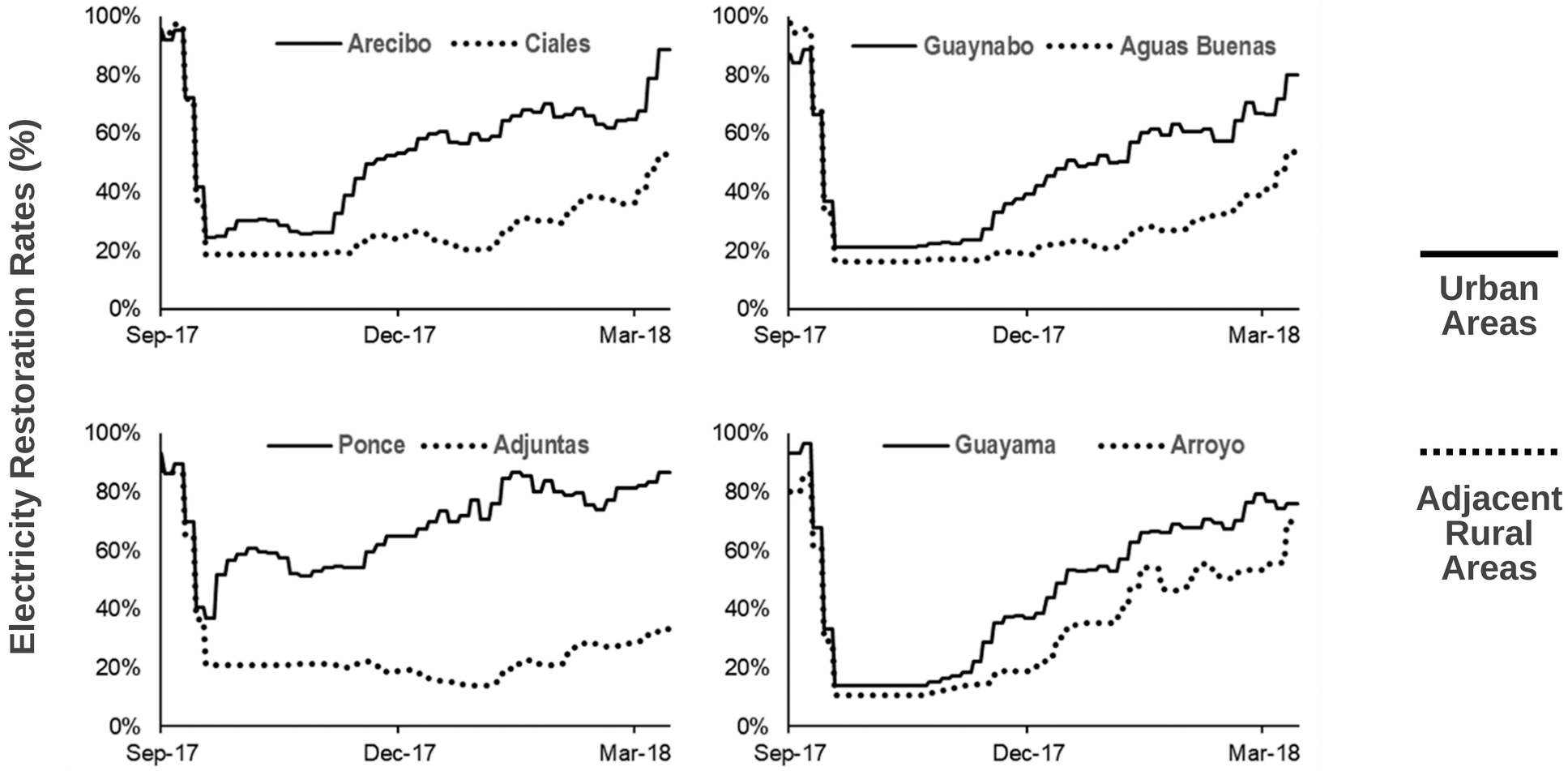
NASA

Earth at Night

EXPLORE EARTH

Román et al., (2018)
https://blackmarble.gsfc.nasa.gov/

Inhabitants with Electricity (%) after Hurricanes Irma and Maria



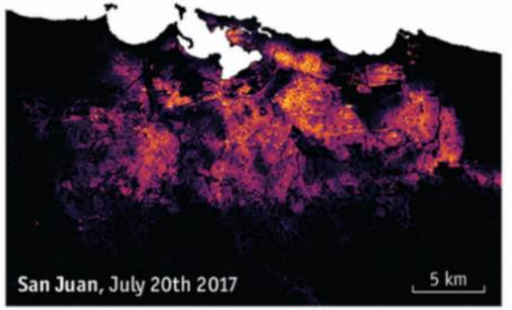
Román et al., (2019)

The Economist April 14th 2018

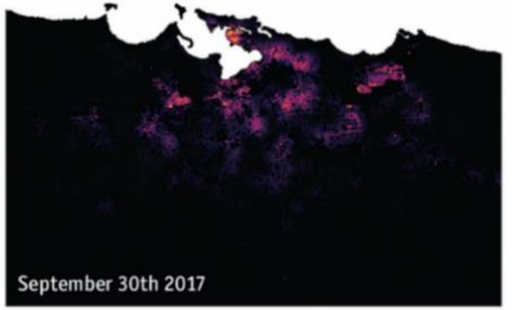
Illuminating

Night-light intensity in San Juan

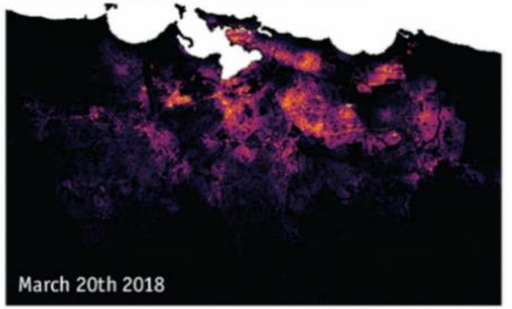
Before Hurricane Maria makes landfall



Immediate aftermath of Hurricane Maria

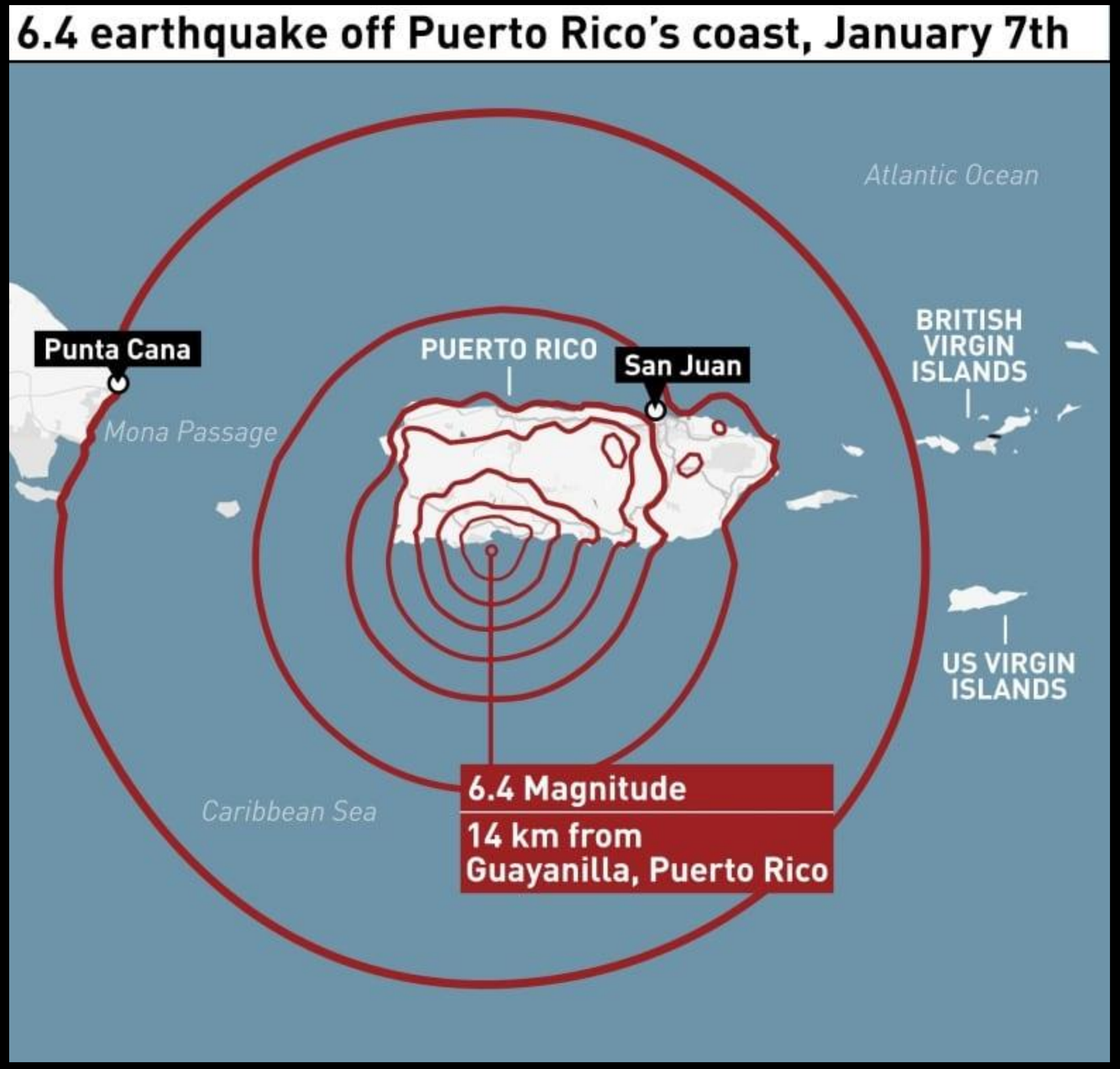


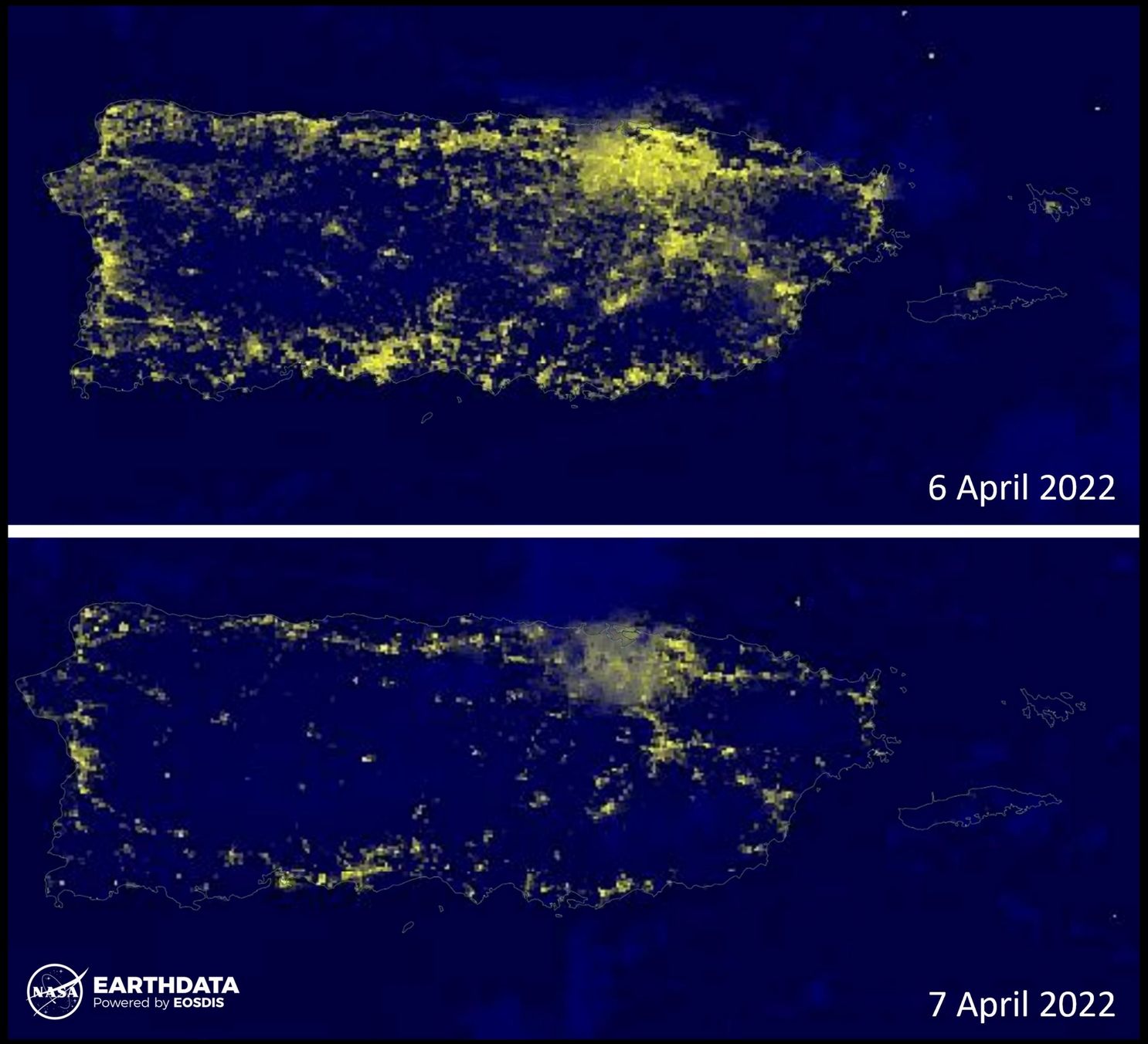
Six months after Hurricane Maria



Source: Suomi NPP VIIRS data from Miguel Román, NASA Disasters Programme

Economist.com


6.4 earthquake off Puerto Rico's coast, January 7th
Atlantic Ocean
Punta Cana
PUERTO RICO
San Juan
BRITISH VIRGIN ISLANDS
Mona Passage
US VIRGIN ISLANDS
Caribbean Sea
6.4 Magnitude
14 km from Guayanilla, Puerto Rico


6 April 2022
7 April 2022
NASA
EARTHDATA
Powered by EOSDIS

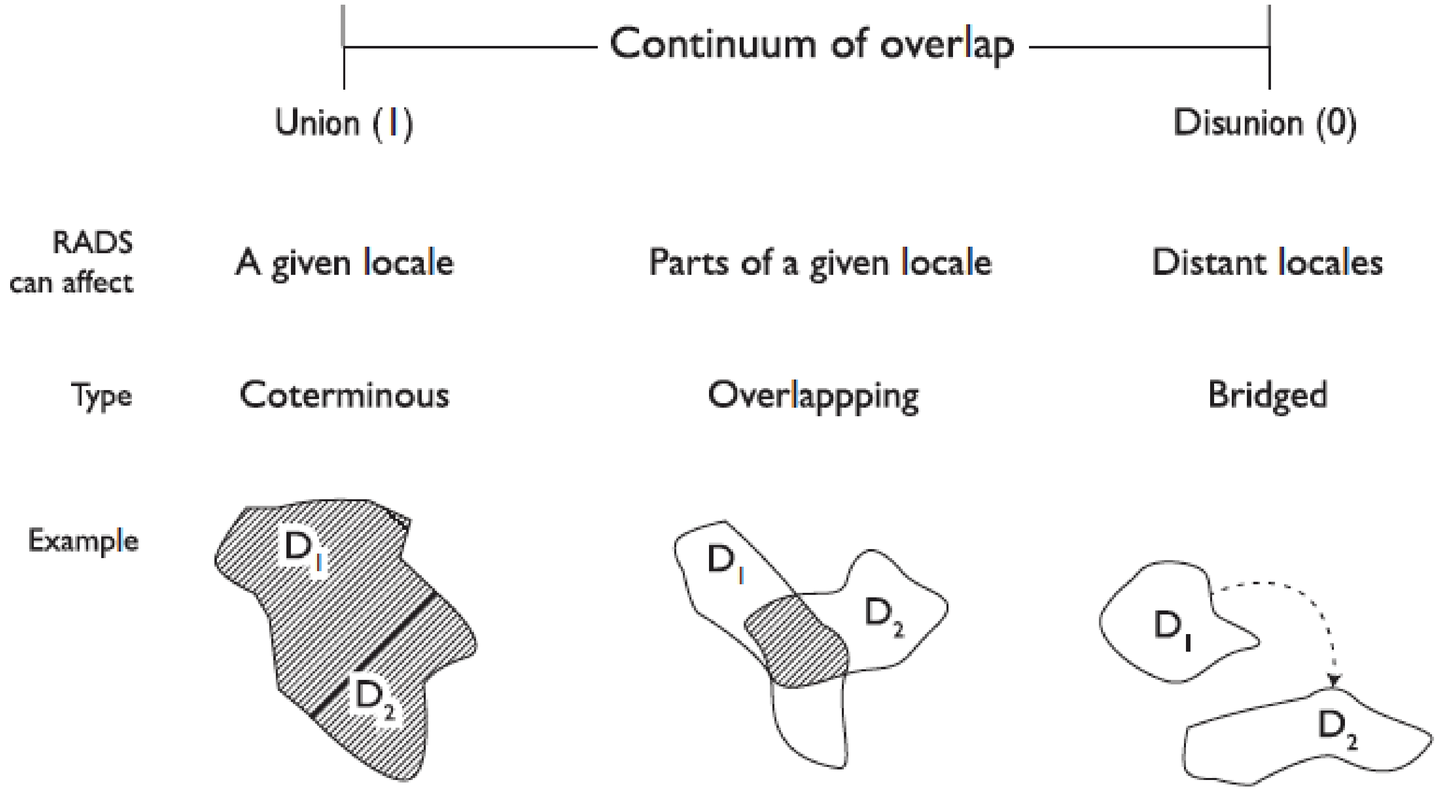
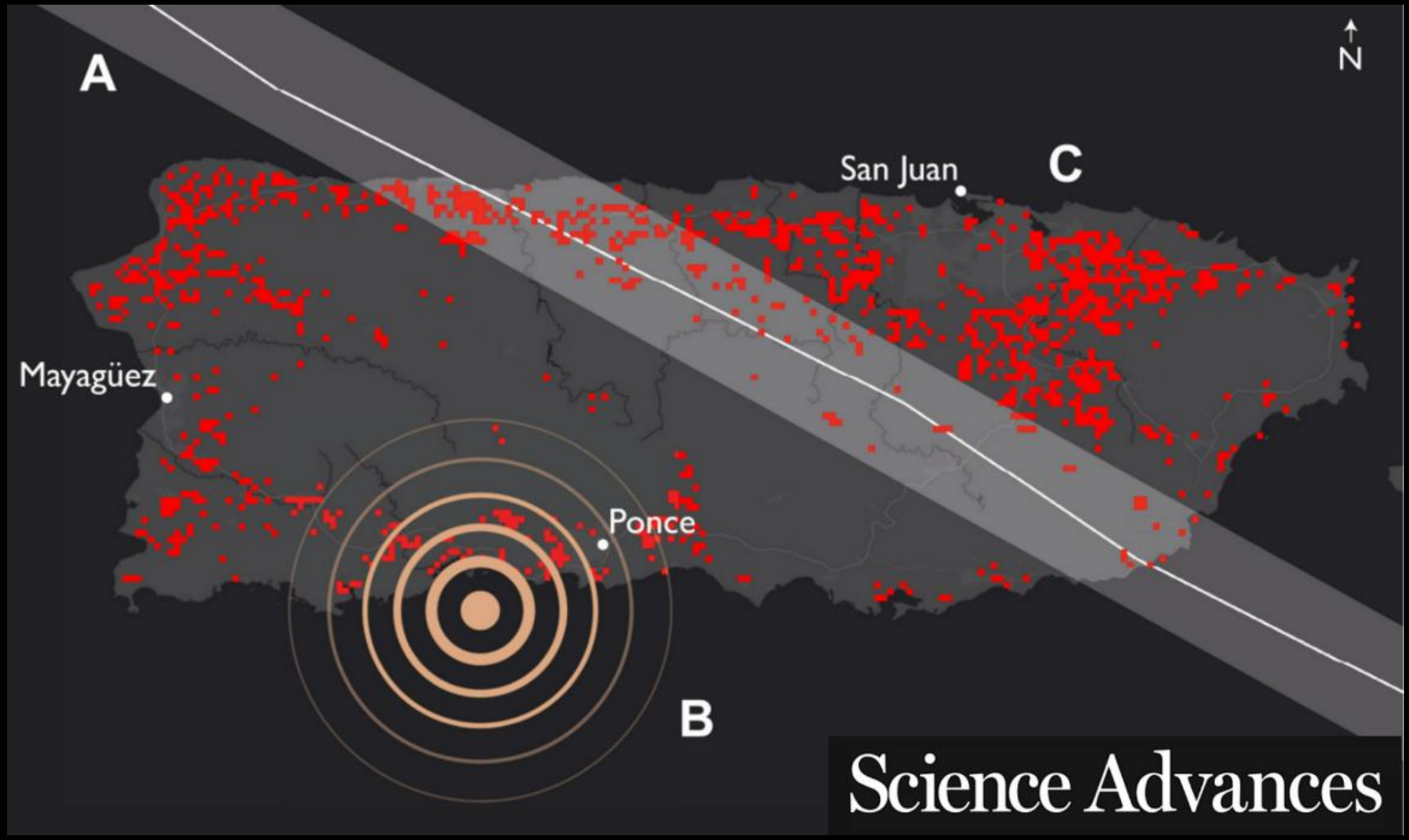


Fig. 1. A continuum of RAD spatial relationships. D_1 and D_2 represent RADs. Note that complete union (perfect spatial overlap of disasters) is improbable and disunion can vary by the spatial distance between bridged events.

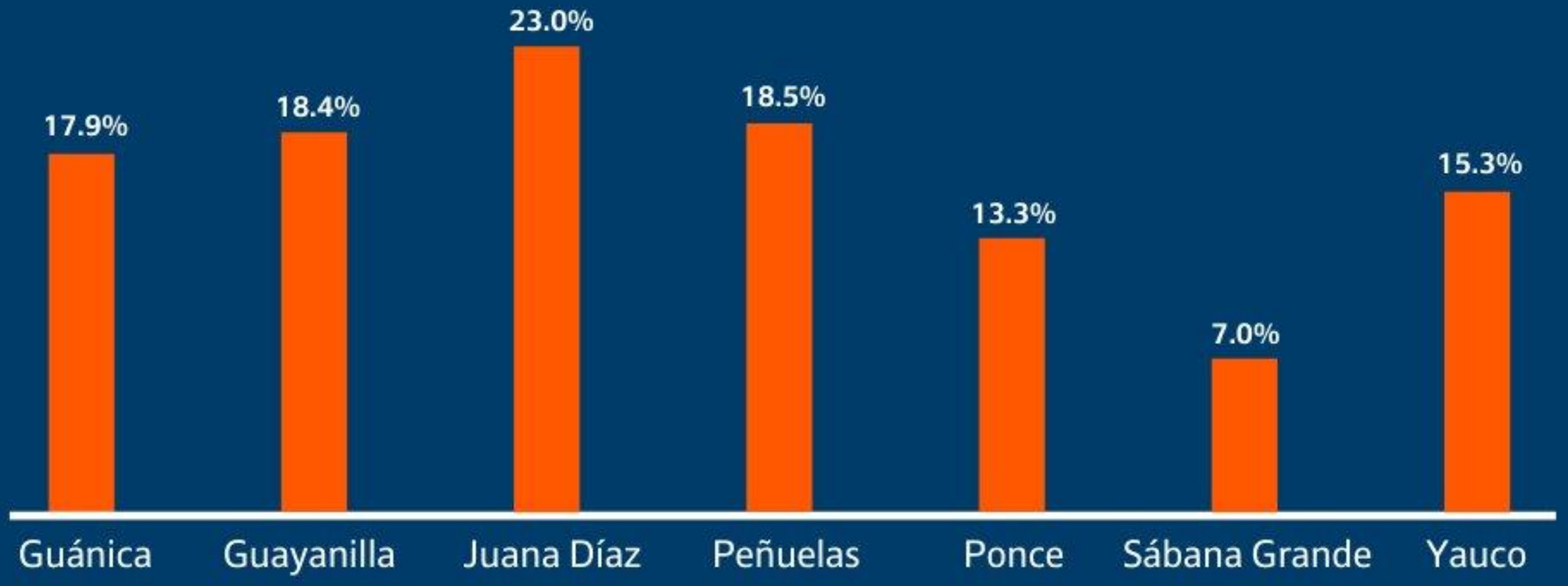
Map of the main island of Puerto Rico showing two bridged RADs.



Agripina Seda School, Guánica PR.

Percent of Occupied Housing Units Damaged or Destroyed by Hurricane María

CNE
Puerto Rico's Think Tank



Source: FEMA Individual Assistance Data for Hurricane María; US Census Bureau & CNE Analysis

RAD Policy Implications

- *Improved scientific understanding of RADS and their legacy conditions*
- *Damage and needs assessments, incident response plans, building codes, public health regulations, insurance premiums, emergency communications, prepositioning of resources, community preparedness training*
- *Potential to advance disaster science, improve disaster response, build resilience to future disasters, and save lives*

TRIPLE-S ADVANTAGE
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CERRADO

“Increasing our understanding of Recurrent Acute Disasters (RADs) has the potential to advance disaster science, improve disaster response, build resilience to future disasters, and save lives.”

RAD Project Concept Paper, 2021.p.9