



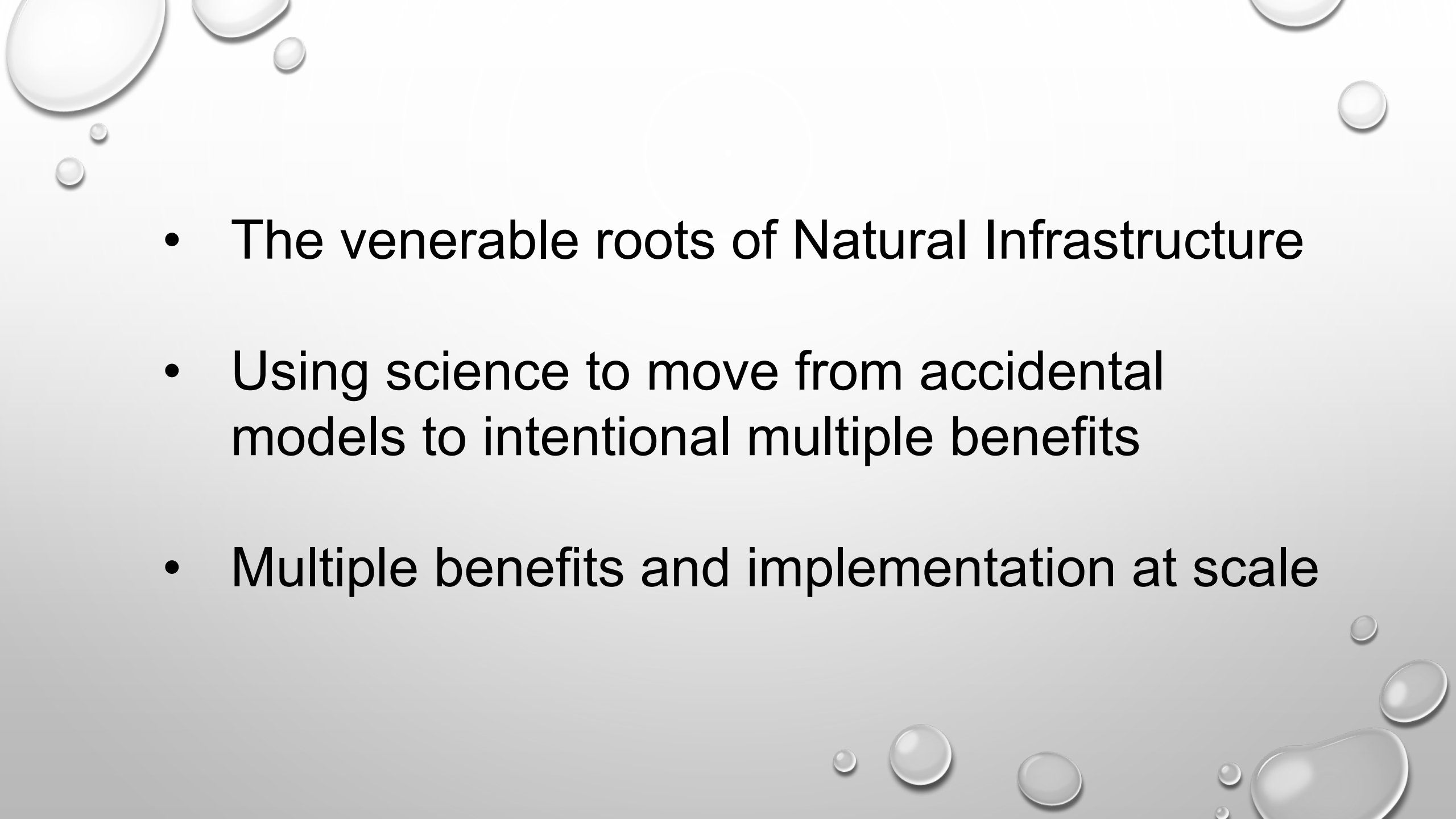
Natural infrastructure: from accidental models to implementation at scale

Jeff Opperman, WWF

NAS

Benefits, Applications, and Opportunities
of Natural Infrastructure

University of Georgia; May 10, 2022

- 
- The venerable roots of Natural Infrastructure
 - Using science to move from accidental models to intentional multiple benefits
 - Multiple benefits and implementation at scale

- Natural Infrastructure
- Green Infrastructure
- Ecosystem-based Adaptation
- Nature-based Solutions

Charles Ellet, Jr. (1810-1862)



H.B. Hall, engraver

Report on the Overflows of the Delta of the Mississippi

“levees...encourage a false security...The water is supplied by nature, but its *height* is increased by man. *This cause is the extension of the levees...* the water that was formerly allowed to spread over many thousand square miles of lowlands is becoming more and more confined to the immediate channel of the river...” (*italics in original*)

Charles Ellet, Jr. (1810-1862)



H.B. Hall, engraver

“Levees Only”

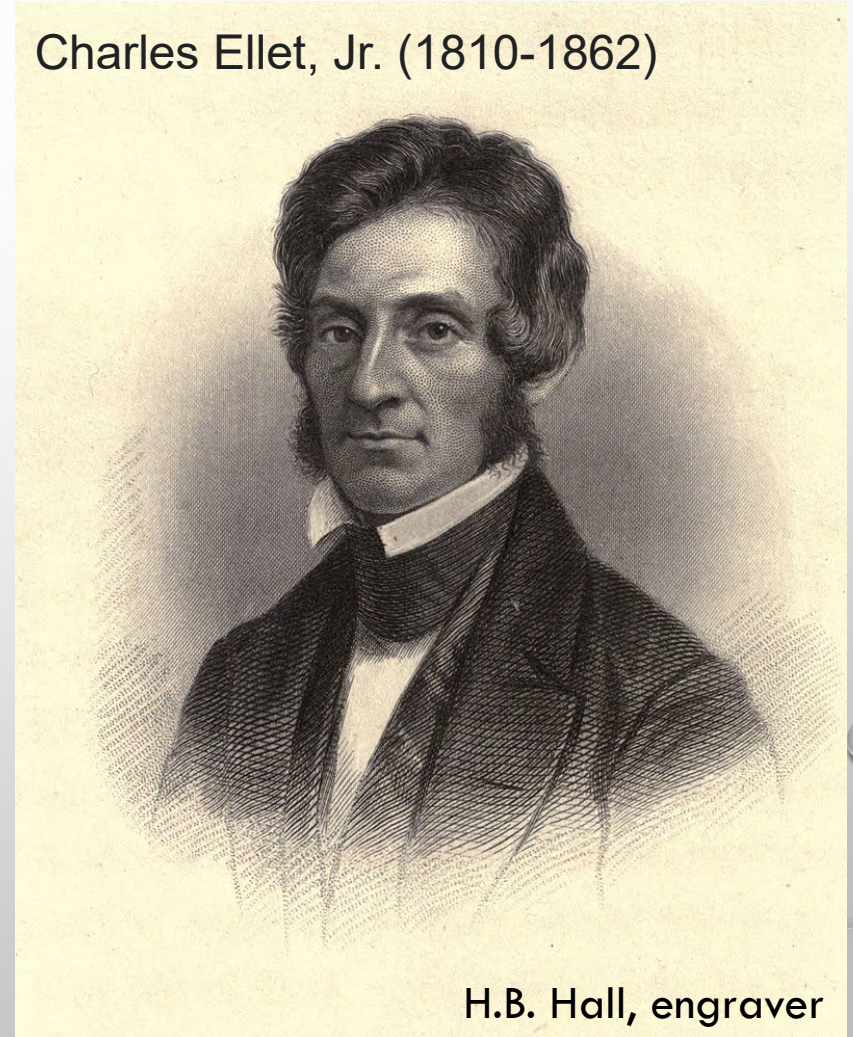
Major General Andrew Humphreys
(1810 – 1883)



M Brady

Diverse actions, including
maintaining and creating outlets
for floodwaters...

Charles Ellet, Jr. (1810-1862)



H.B. Hall, engraver

“Levees Only”

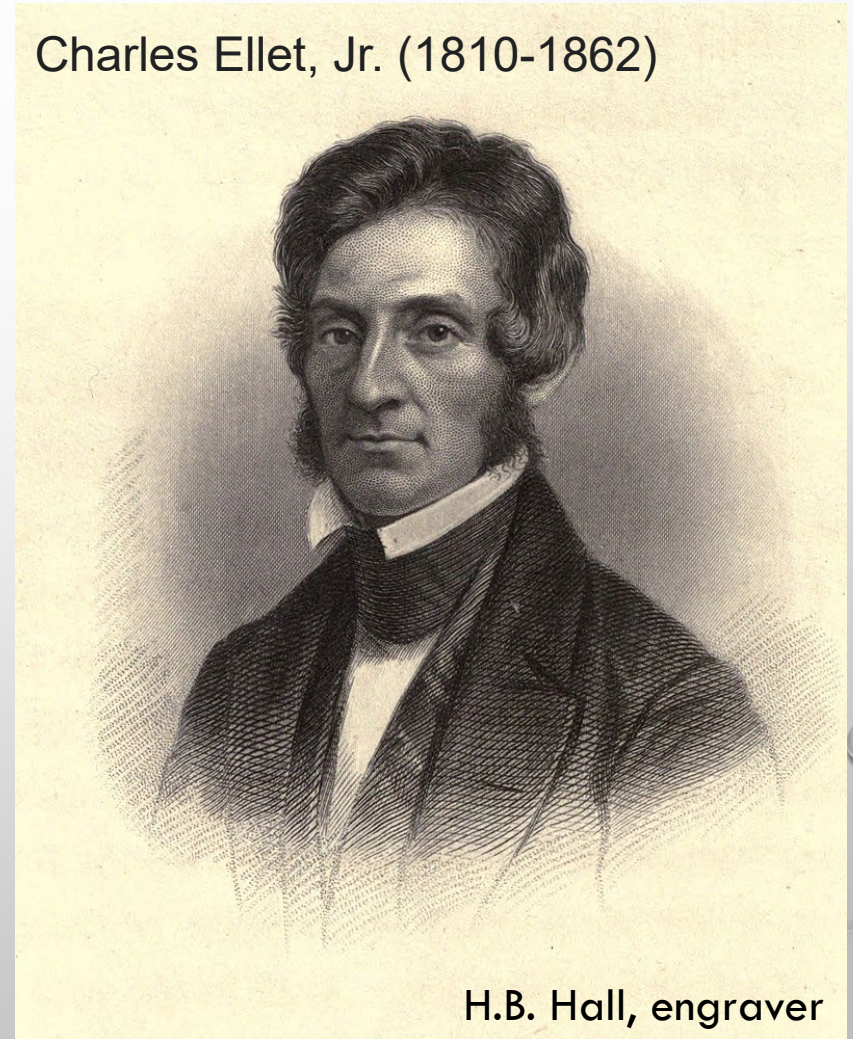
Major General Andrew Humphreys
(1810 – 1883)



M Brady

Diverse actions, including
maintaining and creating outlets
for floodwaters...(and also levees)

Charles Ellet, Jr. (1810-1862)

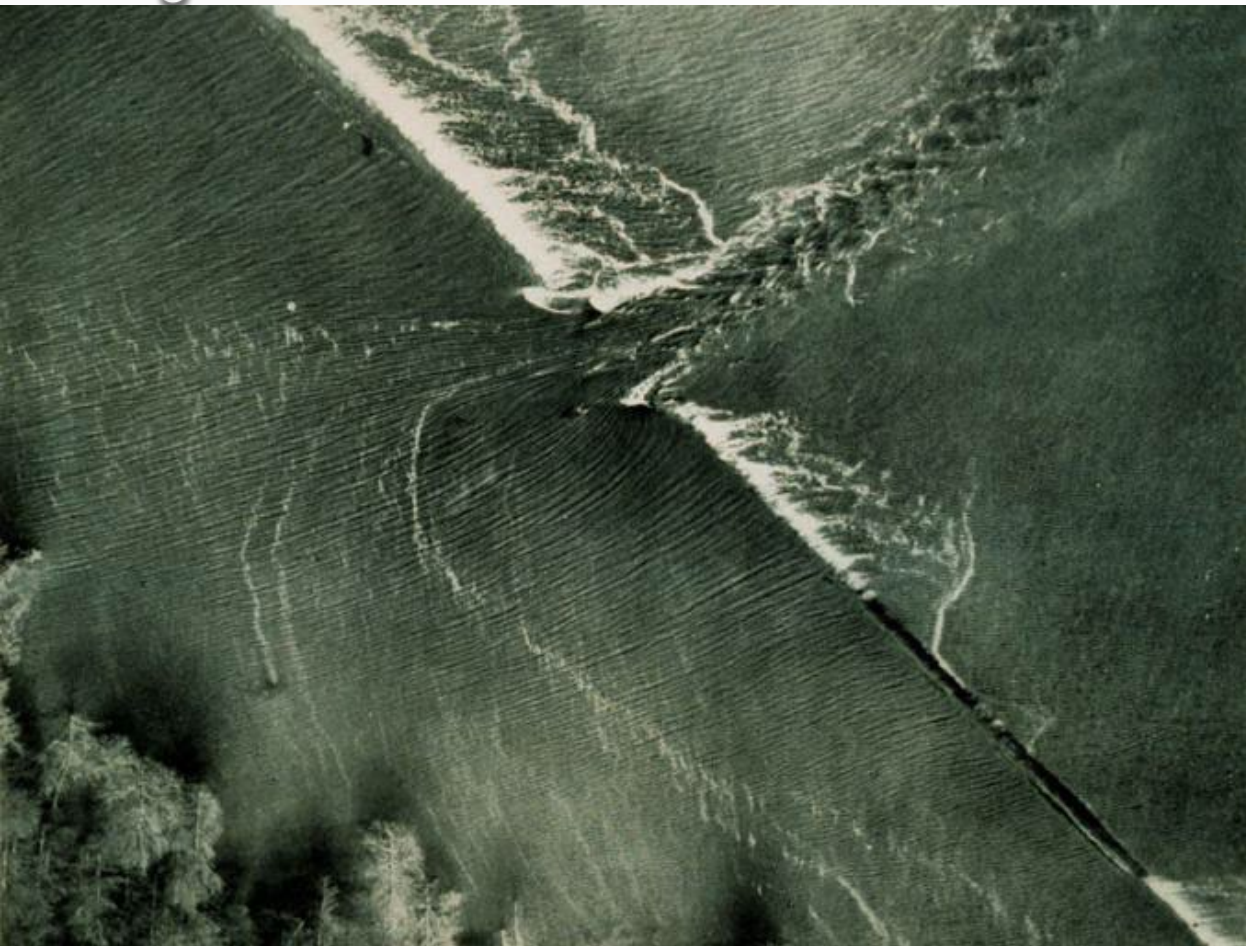


H.B. Hall, engraver

1927

“Levees only” prevailed

Two Floods

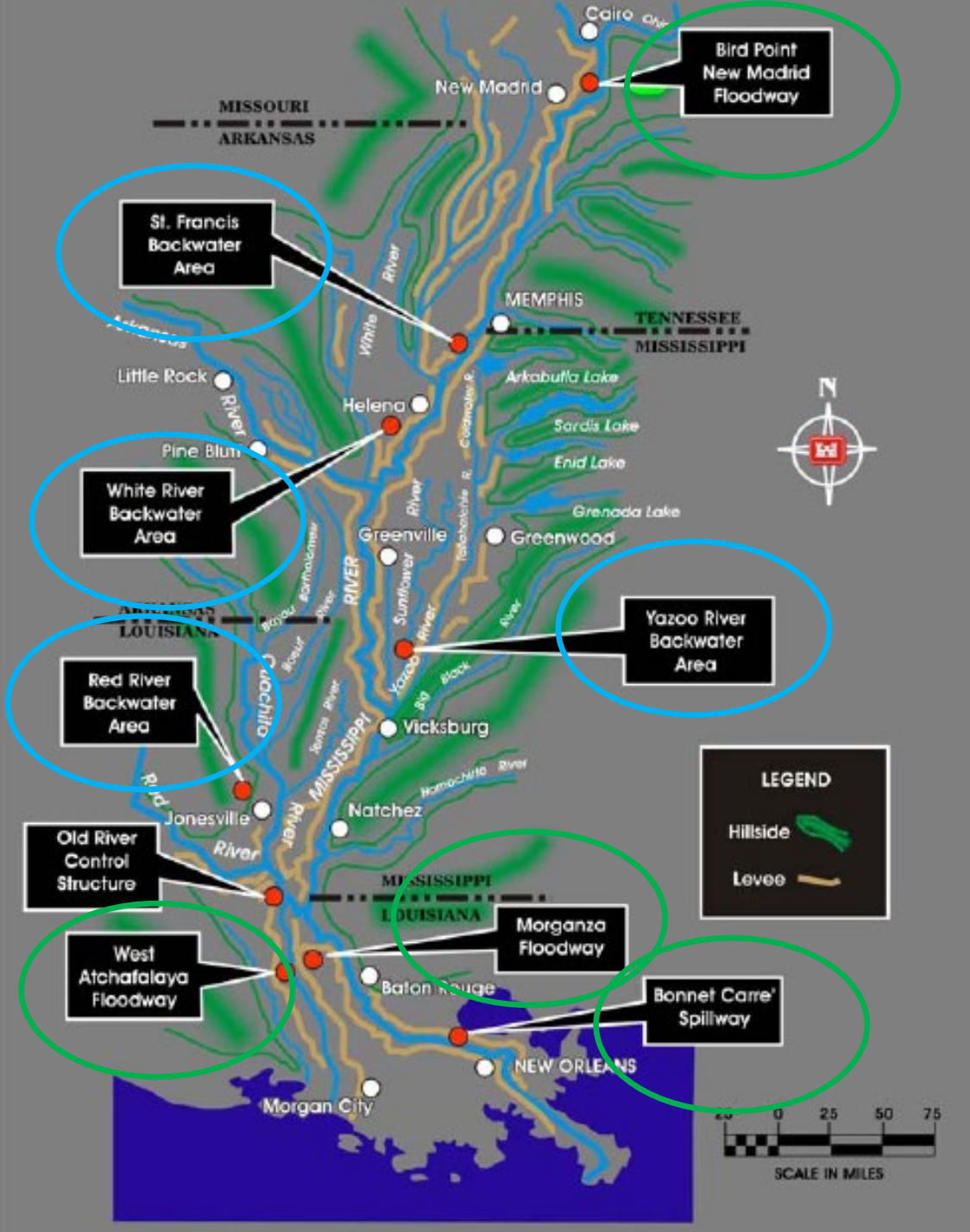


Levees during the 1927 flood



Mississippi River & Tributaries Project

- Four floodways
- Four “backwater areas”



A Tale of Two Floods

1927

- Fragmented, uncoordinated management
- “Levees only” approach to flood management



Catastrophic levee overtopping and failure

2011

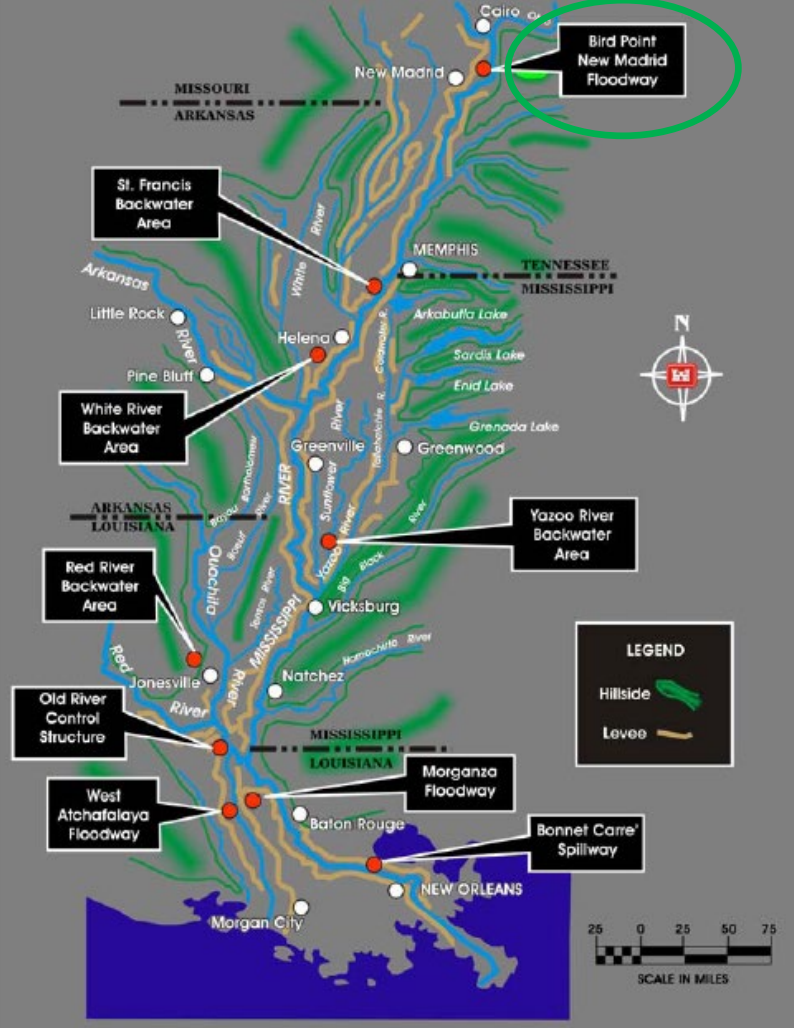
- Managed as a system
- Extensive use of storage and conveyance on floodplains



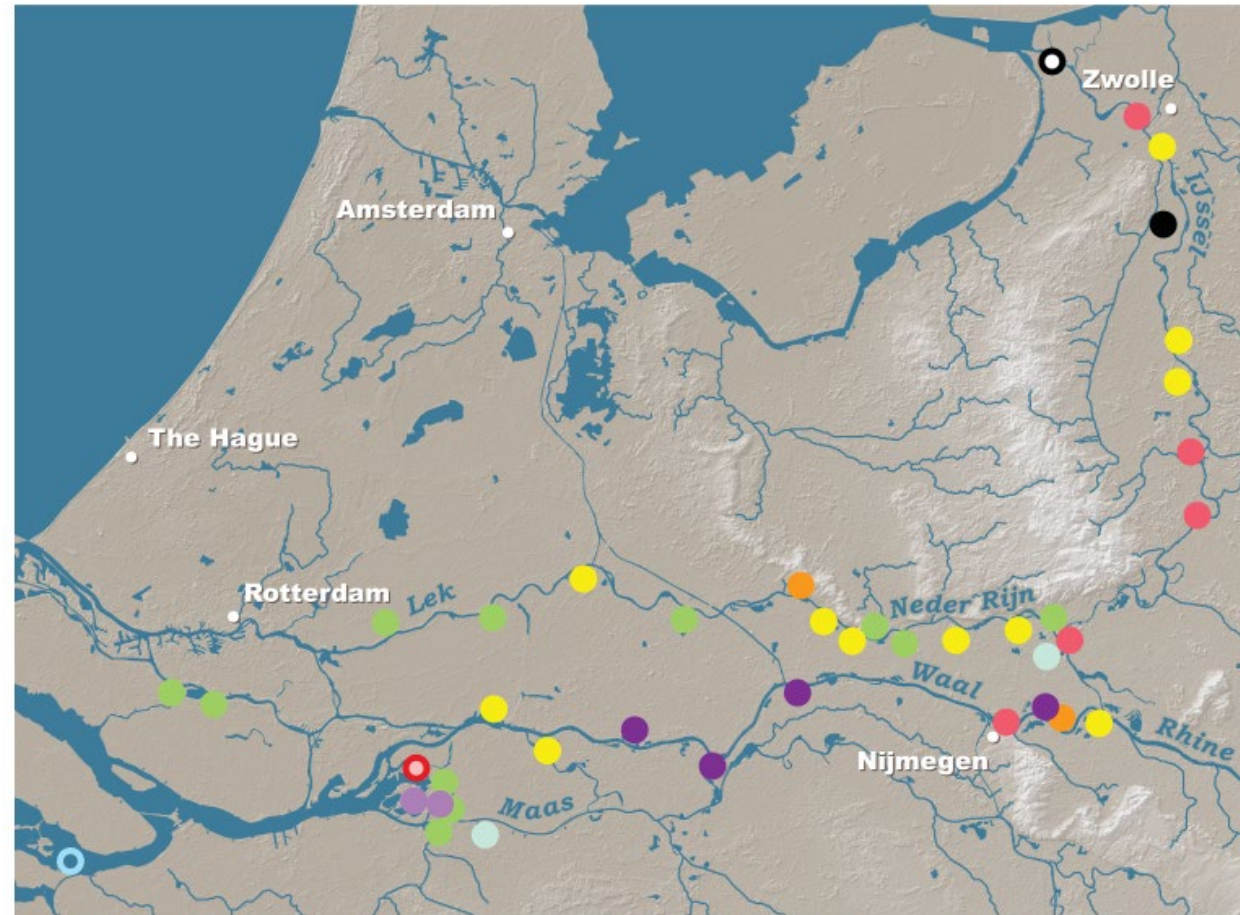
Intentional flooding of Morganza Floodway

New Madrid Floodway during flood of 2011

NEARLY 500,000 PEOPLE FLOODED BY WATER



“Room for the River” in the Netherlands



California's Sacramento Valley as a parallel to Mississippi – and the emergence of an “accidental model” of multiple benefits



Jonathan Eisen

Sacramento, Flood of 1860

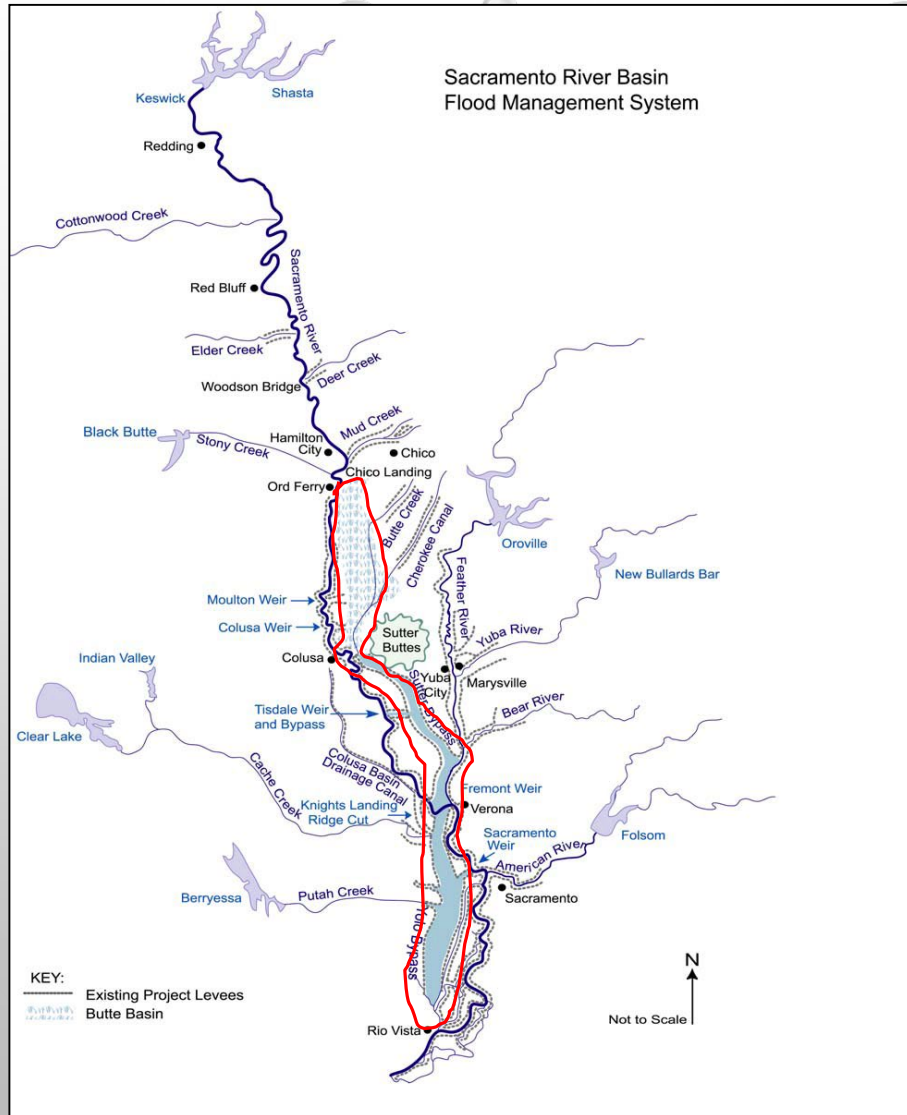
“It will be seen that Sacramento city can be easily protected against inundations, and that, too, at comparatively small expense.”

--*The Placer Times* (Sacramento newspaper), 1850



1870s: 'levees only' vs. floodplain storage and conveyance





Sacramento River Flood Management System

- Yolo and Sutter bypasses were a solution to a flooding problem
- There was no mention, or intention, of ecological restoration



CA Fish and Wildlife

CA DWR



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Floodplain rearing of juvenile chinook salmon: evidence of enhanced growth and survival

T.R. Sommer, M.L. Nobriga, W.C. Harrell, W. Batham, and W.J. Kimmerer

Abstract: In this study, we provide evidence that the Yolo Bypass, the primary floodplain of the lower Sacramento River (California, U.S.A.), provides better rearing and migration habitat for juvenile chinook salmon (*Oncorhynchus tshawytscha*) than adjacent river channels. During 1998 and 1999, salmon increased in size substantially faster in the



USFWS



Jeff Opperman

USFWS

The power of stories: fish growing on floodplains and multiple benefits

San Francisco Chronicle

JULY 28, 2016

Can flooded rice fields be a solution in California water war?

By Tara Duggan

California is the country's second-largest rice producer, after Arkansas, and the \$5 billion crop is particularly well suited to the Sacramento Valley's clay soil.

But that does little to ease the frustration fishers and ecologists feel as native salmon populations plunge because of warming water temperatures in the Sacramento River. The situation has driven environmental groups like the Natural Resources Defense Council to sue the U.S. Bureau of Reclamation for giving too much water to rice farms — and not saving enough for salmon.



fish habitat
feature

California's Yolo Bypass:

Evidence that flood control can be compatible with fisheries, wetlands, wildlife, and agriculture

ABSTRACT

Unlike conventional flood control systems that frequently isolate rivers from ecologically-essential floodplain habitat, California's Yolo Bypass has been engineered to allow Sacramento Valley floodwaters to inundate a broad floodplain. From a flood control standpoint, the 24,000 ha leveed floodplain has been exceptionally successful based on its ability to convey up to 80% of the flow of the Sacramento River basin during high



Increasing frequency of flooding in Yolo Bypass: the “Big Notch”



Fremont Weir; photo by Dan Brekke

DWR modeling:
“typical increase in
wetted days would
be 10-15 days”



How can natural infrastructure alternatives be more effectively centered in infrastructure planning?

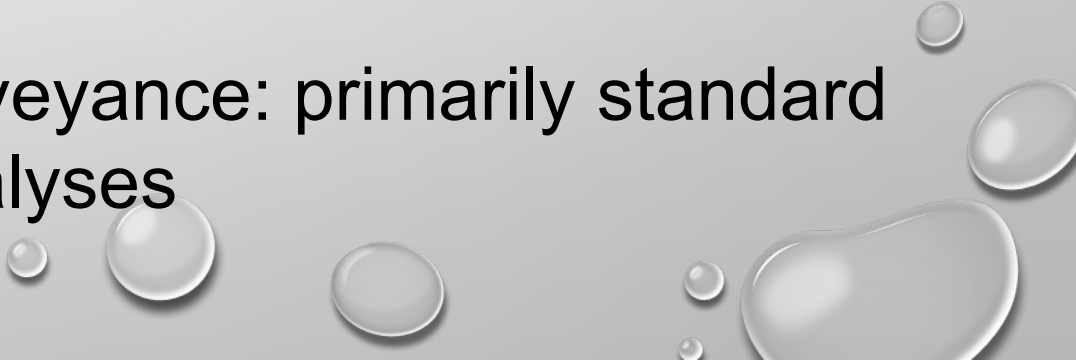
- In all three examples, the “natural infrastructure” option was selected as best option by flood managers
- 



How can natural infrastructure alternatives be more effectively centered in infrastructure planning?

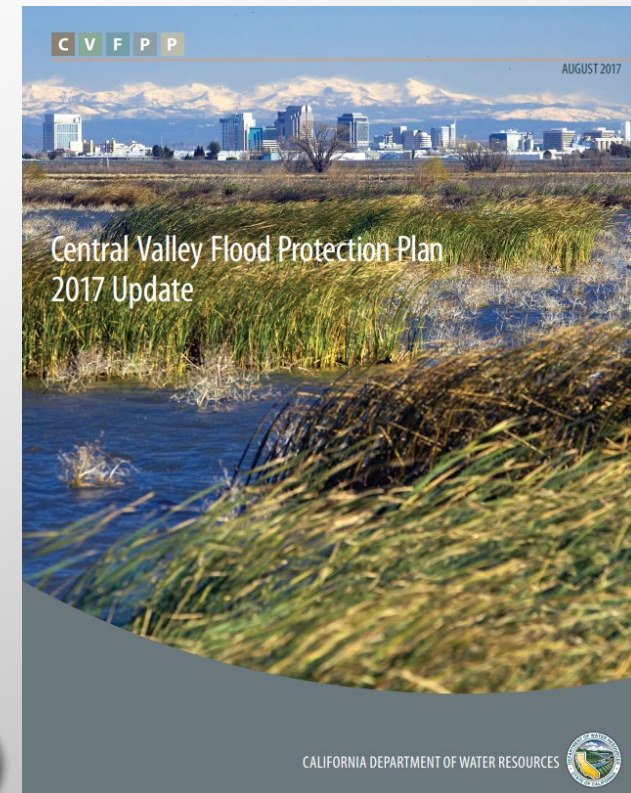
- In all three examples, the “natural infrastructure” option was selected as best option by flood managers

What data, technical, and scientific information is necessary to design effective natural infrastructure solutions?

- With floodplain storage and conveyance: primarily standard flood-management data and analyses
- 

Have political/institutional structures supported the use of natural infrastructure (i.e., multi-benefit or integrated watershed planning)?

- “Room for the Rivers” is central to flood-risk management in the Netherlands
- California Policy on “multi-benefit” flood management will guide new investments (the accidental model now built into policy)



Natural infrastructure solutions provide multiple benefits to society. In your experience, which benefits are most compelling to communities? To decision makers?



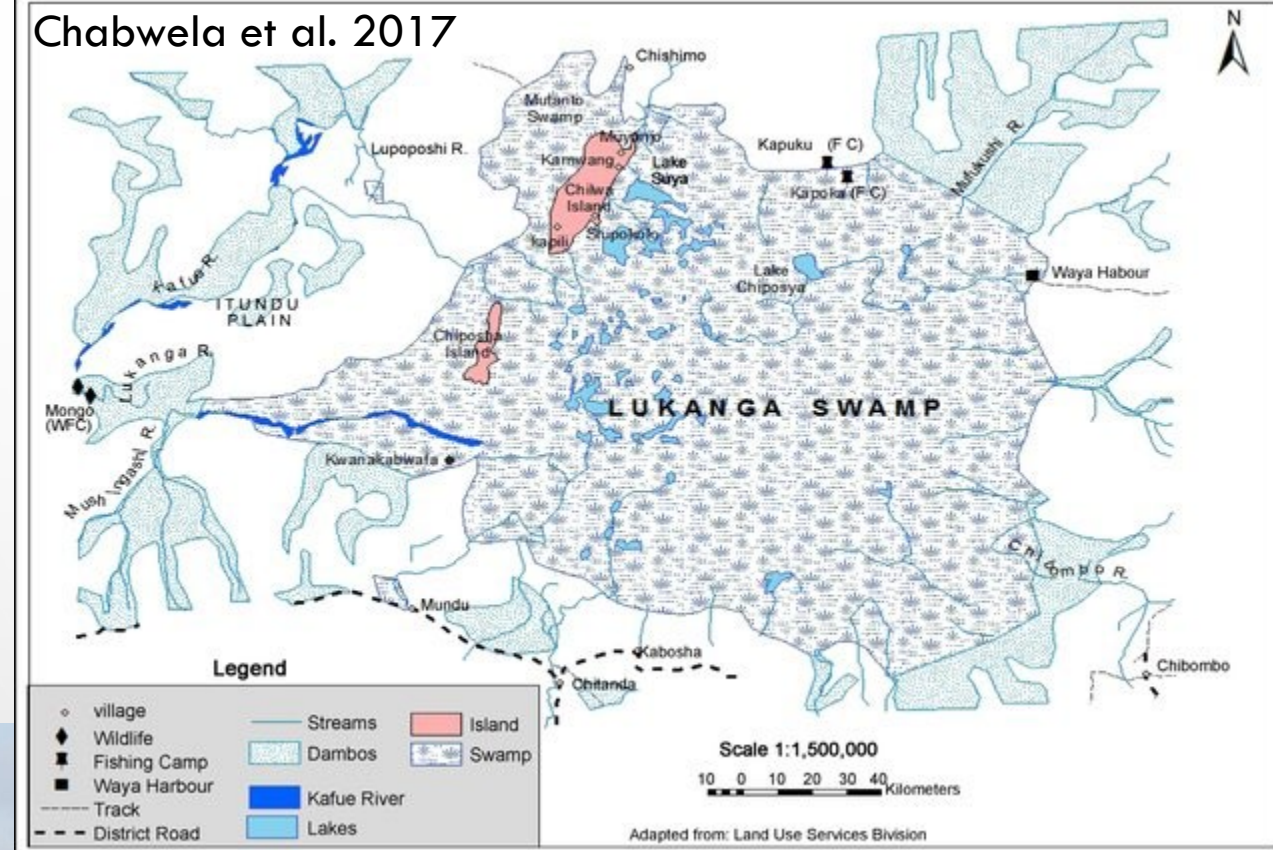
USGS



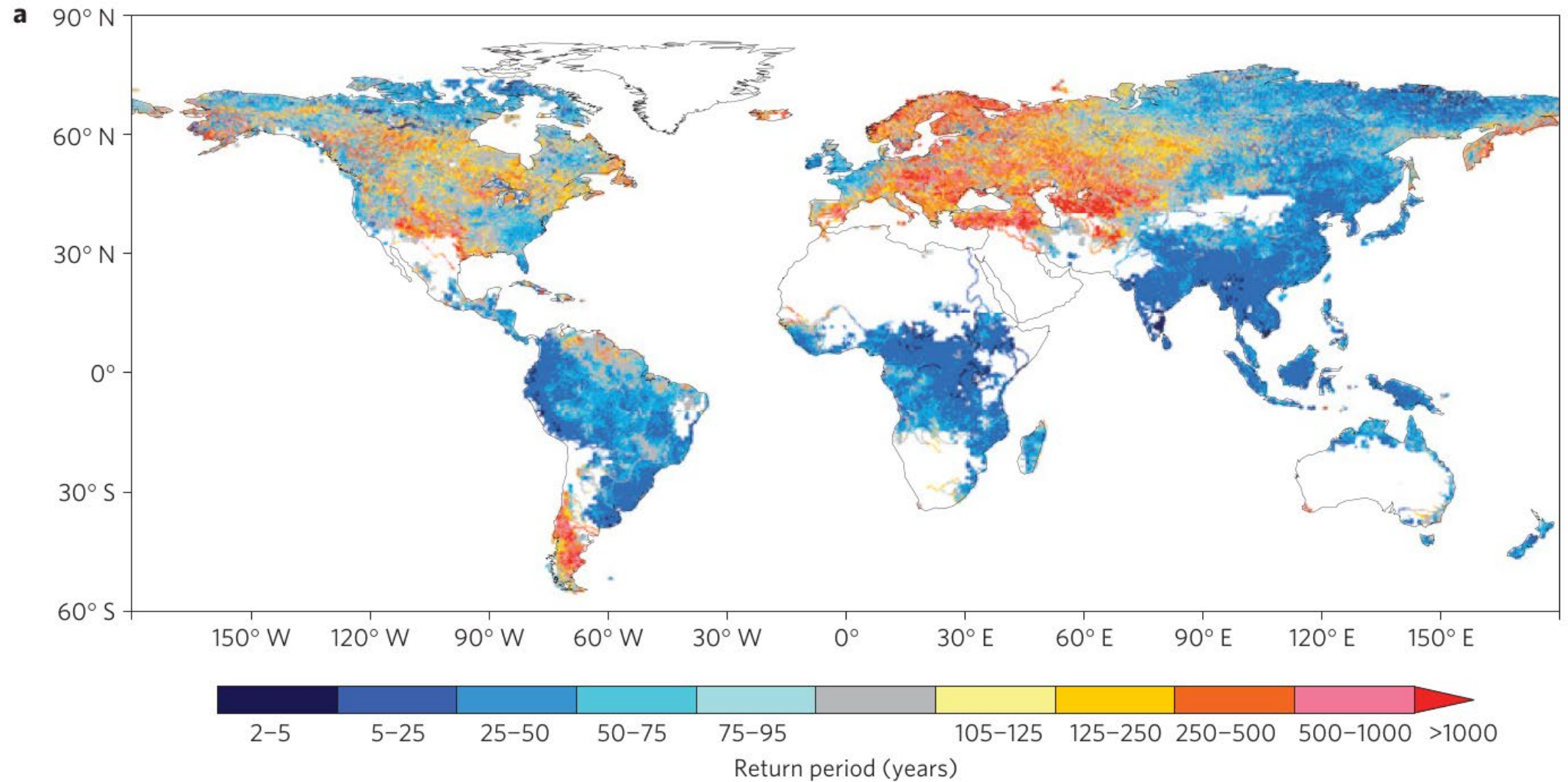
USACE

Green infrastructure as parks and open space in Cleveland, OH





Climate change will increase flood risk



Hirabayashi et al. 2013

River-Floodplain Connectivity as a Nature-Based Solution to Provide Multiple Benefits for People and Biodiversity

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Stephanie Duvail, PALOC (Local heritage, Environment, Globalisation) UMR 208, Institute of Research for Development – National Museum of Natural History, Sorbonne University, Paris, France

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Kris A Johnson, The Nature Conservancy, Minneapolis, MN, United States

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Introduction

Key Floodplain Processes and Benefits

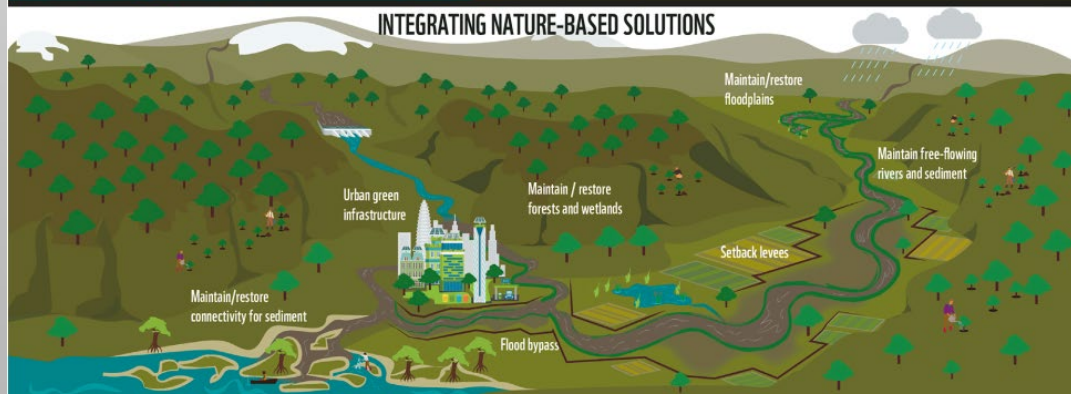
Hydrological, Geomorphic and Ecological Processes

Multiple Benefits of River-Floodplain Connectivity

Biodiversity

Water quality and quantity

Floodplain agriculture and pastoralism



One Earth

CellPress

Commentary

Nature-based solutions for managing rising flood risk and delivering multiple benefits

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<https://doi.org/10.1016/j.oneear.2022.04.012>

River floods are already the most damaging disaster type globally, with risk projected to rise in much of the world due to climate change, development in flood-prone areas, and/or deteriorating infrastructure. Nature-based solutions, such as using floodplains to manage floodwaters, can contribute to a diversified portfolio for managing flood risks.

Riverine floods are the weather-related disaster type that causes the most damage currently at risk but due to climate change, flood managers have identified a set of limitations with their use. Levees can